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The Relationships Among High School Students' Scientific Epistemic Beliefs, Conceptions of Learning Physics and Willingness to Perform Scientific Studies in Physics

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Abstract

The aim of this research is to investigate the relationships among high school students' scientific epistemic beliefs, conceptions of learning physics and willingness to perform scientific studies in physics. A total number of 526 (male=284, female=242) 9th grade high school students participated in the study. Correlation research was used, and the data were collected with the help of some questionnaires in the form of Likert-scale at just one point in time. To investigate the relationship among the variables Hierarchical Regression Analysis was performed. The results showed that students' scientific epistemic beliefs in certainty, development, and justification as well as their higher-level conceptions of learning physics – that are, increase of knowledge, applying and understanding and seeing in a new way – are significant and positive predictors of their willingness to perform scientific studies in physics in the final model. This result can imply that increase in students' such scientific epistemic beliefs and conceptions of learning physics can result in increase in their willingness to perform scientific studies in physics. Moreover, students' scientific epistemic beliefs and conceptions of learning physics can also be important variables in explaining their intentions or willingness to perform scientific studies in physics. The attempts that can improve both students' epistemic beliefs and conceptions of learning physics might result in increase in their willingness to perform scientific studies in physics.

Key words: Behavioural intention, conceptions of learning, physics education, scientific epistemic beliefs

INTRODUCTION

Attitudes and behavioral intentions can influence the observation of some behaviors. Some types of beliefs and attitudes can also predict the behavioral intentions (Ajzen, 2011). For example, pre-service science teachers' attitudes and beliefs can be a significant predictor of their behavioral intentions to science, technology, engineering and mathematics (STEM) teaching intentions (Lin & Williams, 2016). Moreover, students' scientific epistemic beliefs can be related to their attitudes towards science (Fulmer, 2014) and physics (Kapucu & Bahçivan, 2015).

Scientific epistemic beliefs concern with individuals' beliefs about nature of knowledge and knowing (Conley, Pintrich, Vekiri & Harrison, 2004). This type of belief is related to some domain specific physiological constructs. For example, it correlates with conceptions of learning physics and approaches to learning physics (Chiou, Lee & Tsai, 2013), conceptions of learning biology (Sadi & Dağyar, 2015), motivation in learning science (Lin, Deng, Chai & Tsai, 2013; Soltani & Askarizadeh, 2021), self-efficacy of learning science (Tsai, Ho, Liang & Lin, 2011), constructivist science learning environment perceptions (Yilmaz-Tuzun & Topcu, 2010), and science achievement (Mason, Boscolo, Tornatora & Ronconi, 2013; Pamuk, Sungur & Oztekin, 2017).

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Conceptions of learning refer to the beliefs or understandings about learning (Li, Liang & Tsai, 2013). These beliefs can be domains-specific and there can be differences among domain-specific conceptions of learning (Tsai, 2004). For example, Tsai (2004) studied on students' conceptions of learning science to categorize these conceptions. He categorized them under seven dimensions as memorizing, testing, calculating, increase, applying, understanding, and seeing in a new way. In another study, Tsai, and his colleges (2011) categorized these conceptions under two main dimensions as lower-level and higher-level. While lower-level conceptions of learning science refer to the conceptions about memorizing, testing, and calculating in science learning, higher-level of conceptions of learning science refer to the conceptions about increase of knowledge, applying and understanding and seeing in a new way in science learning (Tsai et al., 2011). According to Richardson (2011), students' conceptions of learning relate to their study behavior and approaches to learning. In science domain, students' conceptions of learning also correlate with their approaches to learning (Lee, Johanson & Tsai, 2008; Prasadini, Abd Hamid, Khatibi & Azam, 2018). Similarly, students' conceptions of learning physics relate to their approaches to learning physics (Chiou et al., 2013). Furthermore, students' conceptions of learning can predict their academic achievement (Peterson, Brown & Irving, 2010). Briefly, these conceptions can be significant predictor of learning behavior/intentions and achievement (Alamdarloo, Moradi & Dehshiri, 2013; Richardson, 2011; Peterson et al., 2010).

There are limited numbers of studies concerning the relationships among students' scientific epistemic beliefs, conceptions of learning, behavioral intentions, and behavior. Most of these studies are also not domain specific, and the remaining ones are also mostly related to science learning or teaching domain. There are also a few studies concerning the relationships among these physiological constructs in physics, chemistry, and biology domains. Although it is very difficult to distinguish the nature of these domains too much, physics may be the most difficult or disliked or hands on domain perceived by students (Barmby & Defty, 2006; Oliveira & Oliveira, 2013; Kapucu, 2014). These perceptions may influence students' behavioral intentions towards physics. Furthermore, students' scientific epistemic beliefs and conceptions of learning physics can be significant predictor of their behavioral intentions towards physics. Their willingness to perform scientific studies in physics can also be considered as their behavioral intentions towards physics. Hence, it is aimed to test whether high school students' scientific epistemic beliefs and conceptions of learning physics significantly predict their willingness to perform scientific studies in physics in this study. In line with this aim, the following research questions are addressed:

a) Do high school students' scientific epistemic beliefs significantly predict their willingness to perform scientific studies in physics?
b) Do high school students' scientific epistemic beliefs and lower-level conceptions of learning physics together significantly predict their willingness to perform scientific studies in physics?
c) Do high school students' scientific epistemic beliefs, lower-level conceptions of learning physics and higher-level conceptions of learning physics together significantly predict their willingness to perform scientific studies in physics?

METHOD

The Correlation research was used in the study. This type of research can be used to investigate the relationships among two or more variables and to predict possible outcomes (Fraenkel, Wallen & Hyun, 2011). A total number of 526 (male=284, female=242) 9th grade high school students from one of the cities in Turkey participated in the study. They are chosen from three different public high schools that can represent the general profile of the students in the city center. In Turkey, the curricula that are prepared by Ministry of National Education are also implemented in almost all public high schools.

Data were collected with the help of some questionnaires in the form of Likert-scale (1 → 5) at just one point in time. They were designed as a single form before applying them to students. Two whole questionnaires "Epistemological Beliefs Questionnaire (EBQ)" (Conley et al., 2004) and "Conceptions of Learning Science Questionnaire" (Lee et al., 2008), and one of the dimensions of "Scientific Attitude Inventory (SAI)" (Moore & Foy, 1997) – that is, "Willingness to Perform Scientific Studies (WPSS)" – were used to collect the data. Özkan (2008) adapted EBQ, Bahçivan and Kapucu (2014) adapted COLS and Demirbaş and Yağbasan (2006) adapted SAI into Turkish. The items in COLS and WPSS were revised considering physics domain. Hence, COLS was renamed as "Conceptions of Learning Physics Questionnaire (COLP)" and WPSS was renamed as "Willingness to Perform Scientific Studies in Physics (WPSS-P)".

EBQ has four dimensions: source, certainty, development, and justification. These dimensions are related to beliefs about knowledge transferred by authority (source), right answer (certainty), developing aspect of science (development), and justification of knowledge (justification) (Conley et al., 2004). COLS consists of two main dimensions namely, lower-level conceptions of learning science and higher-level conceptions of learning science. The lower-level conceptions include the dimensions memorizing, testing and calculate and practice, and the higher-level conceptions include the dimensions increase of knowledge, applying and understanding and seeing in a new way. While the lower-level ones are related to beliefs about learning science by memorizing knowledge, taking tests, and practicing problems, higher-level ones are related to learning science by acquiring knowledge about natural phenomena and scientific facts, applying knowledge and skills to new situations or problems, and understanding scientific knowledge (Tsai et al., 2011). WPSS is one of the dimensions of SAI and concerns with the individuals' willingness to perform scientific studies, behave like scientists and become scientist (Moore & Foy, 1997).

The students' responses to some items of EBQ and WPSS-P were first recoded by reversing them. Then, normality of the data was tested by examining skewness and kurtosis values. Some outliers (N=12) were removed from the analysis so that a total number of 514 participants' responses were used. Next, confirmatory factor analysis was performed to test the construct validity of the instruments. CMIN/df, RMSEA, GFI, CFI and TLI values were examined. Acceptable values for these are as follows: CMIN/df (.00 – 3.00), RMSEA (.00 – .08), GFI (>.90), CFI (>.90) and TLI (>.90) (Byrne, 2010). Additionally, factor loadings of each item in the questionnaires were calculated. Reliability analysis was also performed, and the Cronbach's alpha values were determined. The acceptable values of Cronbach's alpha are over .70 (Pallant, 2010). Students' mean scores in each variable of the questionnaires were also calculated and the Pearson's correlations among the variables were determined.

As a last step, the hierarchical regression analysis was performed. The order of entry of variables into this analysis can be decided considering the logical or theoretical backgrounds (Tabachnick & Fidell, 2013). Therefore, dependent and independent variables in the study were first determined according to theoretical backgrounds. Ajzen (2011) explained individuals' behavioral intentions and behaviors by associating them with their beliefs. According to Ajzen (2011), beliefs can influence behavioral intentions and behaviors. The variable used in the study willingness to perform scientific studies in physics can be considered as behavioral intention. Therefore, it was evaluated as dependent variable. Two types of beliefs which are scientific epistemic beliefs and conceptions of learning have been also investigated. As these two types of beliefs may be influential in explaining behavioral intention, they are considered as independent variables. Moreover, scientific epistemic beliefs can be considered as core beliefs. They are fundamental and central, so it is difficult to change them (Hammond, 2016). They can also influence conceptions of learning (i.e., beliefs about nature of learning) (Ho & Liang, 2015; Tsai et al., 2011). Beliefs about learning can be more peripheral and they can be affected by contextual factors (Hammond, 2016). In the light of above discussions, it is also logical that core beliefs may be more influential than peripheral beliefs in explaining behavioral intentions. Hence, in this study students' scientific epistemic beliefs were considered as a first predictor of willingness to perform scientific studies in physics. Then, lower-level concepttions of learning physics and higher-level concepttions of learning physics as second and third predictors were respectively forced into the regression model. To summarize, the framework of the data collection and analysis is also presented in Figure 1.

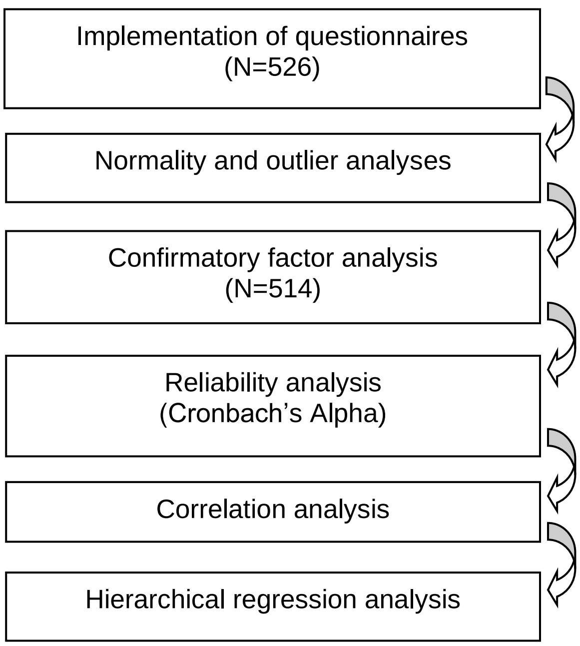

Figure 1. The framework of the data collection and analysis

RESULT AND DISCUSSION

As mentioned above, confirmatory factor analyses were run for construct validity of the questionnaires. The first questionnaire EBQ had four dimensions and 26 items. However, two items E5 and E22 were removed from the analysis since they did not fit the factor structure. Factor analysis results and each dimension's Cronbach's alpha and mean values for EBQ are shown in Table 1.

Table 1. Factor analysis, reliability analysis and descriptive statistics analysis results for EBQ

Factors	Item	Factor loadings	Cronbach's alpha	$\bar{x}$
Source	E1	.762	.809	3.66
	E6	.736		
	E10	.696		
	E15	.520		
	E19	.682		
Certainty	E2	.555	.785	3.53
	E7	.553		
	E12	.491		
	E16	.673		
	E20	.726		
	E23	.709		
Development	E4	.601	.787	3.93
	E8	.612		
	E13	.714		
	E17	.549		
	E21	.646		
	E25	.580		
Justification	E3	.526	.808	4.13
	E9	.670		
	E11	.511		
	E14	.685		
	E18	.552		
	E24	.637		
	E26	.737		
CMIN/df = 1.728 (p = .000); RMSEA = .038; GFI = .937; CFI = .950; TLI = .943; Overall Cronbach's alpha = .827				

As shown in Table 1, all the fit indices are in acceptable range and the majority of the factor loadings are over .60. Therefore, it can be claimed that confirmatory factor analysis provides acceptable factor structure. The Cronbach's alphas are also over. 70 so that the reliability of the questionnaire is acceptable. The highest and lowest mean scores are 4.13 (justification) and 3.53 (certainty), respectively.

The second questionnaire used in the study was COLP including six dimensions and 31 items. Factor analysis results and each dimension's Cronbach's alpha and mean values for COLP are shown in Table 2.

Table 2. Factor analysis, reliability analysis and descriptive statistics analysis results for COLP

Factors	Item	Factor loadings	Cronbach's alpha	x̄
Memorizing	COLP1	.666	.829	2.32
	COLP6	.748		
	COLP14	.660		
	COLP25	.730		
	COLP31	.716		
Testing	COLP2	.791	.853	2.40
	COLP7	.747		
	COLP10	.647		
	COLP17	.697		
	COLP20	.618		
	COLP30	.723		
Calculate and practice	COLP5	.697	.826	3.34
	COLP11	.627		
	COLP15	.835		
	COLP22	.716		
	COLP27	.610		
Increase of knowledge	COLP4	.710	.881	3.90
	COLP18	.733		
	COLP19	.859		
	COLP21	.797		
	COLP26	.775		
Applying	COLP3	.676	.769	3.89
	COLP12	.684		
	COLP16	.697		
	COLP29	.647		
Understanding and seeing in a new way	COLP8	.800	.877	3.97
	COLP9	.776		
	COLP13	.749		
	COLP23	.761		
	COLP24	.719		
	COLP28	.629		
CMIN/df = 1.668 (p = .000); RMSEA = .036; GFI = .920; CFI = .959; TLI = .954; Overall Cronbach's alpha = .831				

According to Table 2, all the fit indices imply acceptable model for COLP. The factor loadings are also strong and the minimum factor loading value is .610. The reliability results also show that the Cronbach's alphas are over the cut of value .70. The students' mean scores in higher-level conceptions of learning physics are also higher than their mean scores in lower-level conceptions of learning physics.

The last questionnaire used in the study was WPSS-P including ten items. Factor analysis results and each dimension's Cronbach's alpha and mean values for WPSS-P are shown in Table 3.

Table 3. Factor analysis, reliability analysis and descriptive statistics analysis results for WPSS-P

Factor	Item	Factor loadings	Cronbach's alpha	x̄
Willingness to perform scientific studies in physics	WPSS-P1	.687	.892	3.92
	WPSS-P2	.572		
	WPSS-P3	.752		
	WPSS-P4	.661		
	WPSS-P5	.754		
	WPSS-P6	.688		
	WPSS-P7	.668		
	WPSS-P8	.672		
	WPSS-P9	.619		
	WPSS-P10	.650		
CMIN/df = 2.392 (p = .000); RMSEA = .052; GFI = .970; CFI = .978; TLI = .970; Overall Cronbach's alpha = .892				

As given in Table 3, all the fit indices establish acceptable model. The factor loadings are also between .572 and .754. The Cronbach's alpha is .892 and mean score is 3.92.

The Pearson's correlations among the variables were also examined. In Table 4, these correlations are shown.

Table 4. The Pearson's correlations among the variables

		1	2	3	4	5	6	7	8	9	10	11
1.	Source	1										
2.	Certainty	.15**	1									
3.	Development	.05	.25**	1								
4.	Justification	.10*	.18**	.53**	1							
5.	Memorizing	.05	-.25**	-12*	-.05	1						
6.	Testing	-.03	-.19**	-.09*	-.07	.44**	1					
7.	Calculate and practice	.18**	-.23**	.11*	.13**	.32**	.25**	1				
8.	Increase of knowledge	-.08	.04	.36**	.32**	-.15**	-.10*	.04	1			
9.	Applying	.01	.16**	.36**	.35**	-.12**	-.10*	.08	.54**	1		
10.	Understanding and seeing in a new way	.02	.11*	.36**	.33**	-.15**	-.12**	.06	.47**	.45**	1	
11.	Willingness to perform scientific studies in physics	.02	.25**	.39**	.33**	-.23**	-.18**	-.08	.38**	.38**	.37**	1

**p < .01
*p < .05

As shown in Table 4, there are weak or no correlations between scientific epistemic beliefs and lower-level conceptions of learning physics. However, there are some positive and significant relationships between the dimensions of scientific epistemic beliefs (development and justification) and higher-level conceptions of learning physics. The dimension development positively and significantly correlates with increase of knowledge (r=.36, *p*<.01), applying (r=.36, *p*<.01) and understanding and seeing in a new way (r=.36, *p*<.01). Similarly, the dimension justification positively and significantly correlates with increase of knowledge (r=.32, *p*<.01), applying (r=.35, *p*<.01) and understanding and seeing in a new way (r=.33, *p*<.01). The dimensions development (r=.39, *p*<.01) and justification (r=.33, *p*<.01) also positively and significantly correlates with willingness to perform scientific studies in physics. In addition, while lower-level conceptions of learning physics negatevely correlate with willingness to perform scientific studies in physics, higher-level conceptions of learning physics positively and significantly correlate with this dimension. The dimensions increase of knowledge (r=.38, *p*<.01), applying (r=.38, *p*<.01) and understanding and seeing in a new way (r=.37, *p*<.01) positively and significantly correlate with willingness to perform scientific studies in physics.

As a last step, hierarchical regressions analysis was run. Three models were obtained. In Table 5, these models are presented.

Table 5. Hierarchical regression analysis results

Independent variables	B	β	t	R^2	R^2 change
Model 1				.192	.192
Source	-.025	-.032	-.796		
Certainty	.124	.156	3.747**		
Development	.231	.258	5.386**		
Justification	.184	.167	3.530**		
Model 2				.220	.028
Source	-.009	-.012	-.296		
Certainty	.080	.101	2.314*		
Development	.227	.254	5.313**		
Justification	.191	.173	3.700**		
Memorizing	-.087	-.118	-2.568*		
Testing	-.044	-.061	-1.367		
Calculate and practice	-.032	-.048	-1.075		
Model 3				.302	.082
Source	.009	.012	.305		
Certainty	.083	.104	2.489*		
Development	.140	.157	3.324**		
Justification	.103	.093	2.044*		
Memorizing	-.056	-.076	-1.727		
Testing	-.032	-.044	-1.038		
Calculate and practice	-.049	-.073	-1.729		
Increase of knowledge	.109	.149	3.093**		
Applying	.106	.130	2.746**		
Understanding and seeing in a new way	.105	.130	2.886**		

**p < .01
*p < .05

As shown in Table 5, the dimensions certainty, development, and justification in EBQ contribute positively and significantly to the dependent variable, F (4, 509) = 30.257; *p*<.01, in model 1. The dimensions in EBQ together account for 19.2% of the variation in willingness to perform scientific studies in physics. Then, lower-level conceptions of learning physics in COLP were forced into the equation in model 2. The dimension memorizing contributes negatively and significantly to the dependent variable. The lower-level conceptions of learning physics explain an additio-nnal 2.8% variation in willingness to perform scientific studies in physics. This change in R^2 is significant, F (3, 506) = 6.087. Lastly, the higher-level conceptions of learning physics in COLP were introduced into the equation in model 3. The dimensions increase of knowledge, applying, and understanding and seeing in a new way contribute positively and significantly to the dependent variable. They explain an additional 8.2% variation in willingness to perform scientific studies in physics. This change in R^2 is also significant, F (3, 503) = 19.572. Consequently, the independent variables significantly explain the 30.2% of the variation in willingness to perform scientific studies in physics, F (10, 503) = 21.737; *p*<.01, in model 3. The dimensions certainty (β=.104; t=2.489), development (β=.157; t=3.324) and justification (β=.093; t=2.044) in EBQ and the dimensions increase of knowledge (β=.149; t=3.093), applying (β=.130; t=2.746), and understanding and seeing in a new way in COLP (β=.130; t=2.886) positively and significantly contribute to the willingness to perform scientific studies in physics. According to the beta coefficients, the dimension development is the strongest positive predictor of willingness to perform scientific studies in physics, when the other variables are controlled.

The results presented above are in line with the theoretical ideas of Ajzen (2011). This study showed that some beliefs of students can explain their behavioral intentions. In addition, as discussed before, students' core beliefs (i.e. scientific epistemic beliefs) were more influential than peripheral beliefs (i.e. conceptions of learning physics) in explaining their behavioral intention (i.e. willingess to perform scientific studies in physics).

The results of this study are also consistent with the results of some studies focusing the relationships among epistemological beliefs, conceptions of learning and attitude / behavior / behavioral intention. Like in this study, Kapucu and Bahçivan (2015) found significant relationships between students' justification beliefs and their attitudes towards physics. Moreover, Lin and Williams (2016) found that pre-service science teachers' salient beliefs significantly contribute their intentions to engage in STEM teaching. Some studies (Chiou et al., 2013; Lee et al., 2008; Prasadini et al, 2018) also focusing on the relationships between students' scientific epistemic beliefs and approaches to learning in science domains support the findings of this study. Students' approaches to learning can be considered as their intentions to study and learn (Uiboleht, Karm & Postareff, 2018). For example, in the study of Chiou et al. (2013) students' conception of learning physics in the dimension seeing in a new way significantly and positively predicted their approaches to learning physics in the dimensions deep motive and deep strategy. Similar to this finding, students' conceptions of learning physics in the dimension understanding and seeing in a new significantly and positively predicted their willingness to perform scientific studies in physics in this study.

CONCLUSION

Three models were obtained in this study. In model 1, students' beliefs about certainty, development, and justification in EBQ positively and significantly predicted their willingness to perform scientific studies in physics. This result can imply that the higher the student' beliefs about certainty, development and justification, the higher their willingness to perform scientific studies in physics will be. Then, lower-level conceptions of learning physics were forced into the equation in model 2. Although the change in R^2 was significant, the variation in explaining students' willingness to perform scientific studies in physics was very low. Only the dimension memorizing negatevely and significantly contributed to the regression model. This can mean that the lower the students' conceptions of learning in memorizing, the higher their willingness to perform scientific studies in physics will be. In model 3, the higher-level concepttions of learning physics were introduced into the equation. All the higher-level conceptions increase of knowledge, applying, and understanding and seeing in a new way significantly and positively contributed the regression model. This result can imply that increase in students' higher-level conceptions of learning physics may contribute the increase in their willingness to perform scientific studies in physics. However, the dimension memorizing did not contribute the model yet. Among the variables used in the model 3, the students' beliefs in development and justification are the most powerful predictors of their willingness to perform scientific studies in learning physics. In other words, increase in students' beliefs in the development of scientific ideas and knowledge over time and the importance of experiments to explore scientific knowledge may imply increase in their willingness to studying physics, doing experiments, behaving like scientists, and exploring scientific knowledge in physics laboratory. Similarly, increase in students' higher level-conceptions of learning such as believing in physics learning as exploring the natural phenomena, applying the knowledge to solve the problems in life, acquiring new knowledge and viewing natural phenomena in new ways may contribute to increase in their willingness to perform scientific studies in physics.

Finally, students' scientific epistemic beliefs and conceptions of learning physics can be important variables in explaining their intentions or willingness to perform scientific studies in physics. The positive developments in both students' epistemic beliefs and conceptions of learning physics might result in increase in their willingness to perform scientific studies in physics. In future studies, researchers can investigate the predictive powers of some other remaining variables to explain this important outcome variable. Moreover, in final regression model in this study, students' lower-level conceptions of learning physics and beliefs in source cannot explain their willingness to perform scientific studies in physics. Believing in too much the knowledge attained by the authority or not having more positive source beliefs and having average lower-level conceptions may lead to these results.

REFERENCES

Ajzen, I. (2011). The theory of planned behaviour: Reactions and reflections, *Psychology & Health*, *26*(9), 1113–1127. http://dx.doi.org/10.1080/08870446.2011.613995.

Alamdarloo, G. H., Moradi, S., & Dehshiri, G. R. (2013). The relationship between students' conceptions of learning and their academic achievement. *Psychology, 4*(1), 44–49. http://dx.doi.org/10.4236/psych.2013.41006.

Bahçivan, E., & Kapucu, S. (2014). Adaptation of conceptions of learning science questionnaire into Turkish and science teacher candidates' conceptions of learning science. *European Journal of Science and Mathematics Education*, *2*(2), 106–118. http://dx.doi.org/10.30935/scimath/9404.

Barmby, P., & Defty, N. (2006). Secondary school pupils' perceptions of physics. *Research in Science & Technological Education*, *24*(2), 199–215. http://dx.doi.org/10.1080/02635140600811585.

Byrne, B. M. (2010). *Structural equation modeling with AMOS : Basic concepts, applications, and programming (Multivariate Applications Series)*. New York: Taylor & Francis Group.

Chiou, G. L., Lee, M. H., & Tsai, C. C. (2013). High school students' approaches to learning physics with relationship to epistemic views on physics and conceptions of learning physics. *Research in Science & Technological Education*, *31*(1), 1–15. http://dx.doi.org/10.1080/02635143.2013.794134.

Conley, A. M., Pintrich, P. R., Vekiri, I., & Harrison, D. (2004). Changes in epistemological beliefs in elementary science students. *Contemporary Educational Psychology*, *29*(2), 186–204. https://doi.org/11016/j.cedpsych.2004.01.004.

Demirbaş, M., & Yağbasan, R. (2006). Fen bilgisi öğretiminde bilimsel tutumların işlevsel önemi ve bilimsel tutum ölçeğinin Türkçe'ye uyarlanma çalışması. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi*, *19*(2), 271–299. Retrieved from https://toad.halileksi.net/sites/default/files/pdf/bilimsel-tutum-olcegi-toad.pdf

Fulmer, G. W. (2014). Undergraduates' attitudes toward science and their epistemological beliefs: Positive effects of certainty and authority beliefs. *Journal of Science Education and Technology, 23*(1), 198–206. http://dx.doi.org/10.1007/s10956-013-9463-7

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2011). *How to design and evaluate research in education (8th ed.)*. Boston: McGraw – Hill.

Ho, H. N. J., & Liang, J. C. (2015). The relationships among scientific epistemic beliefs, conceptions of learning science, and motivation of learning science: A study of Taiwan high school students. *International Journal of Science Education*, *37*(16), 2688–2707. http://dx.doi.org/10.1080/09500693.2015.1100346

Kapucu, S. (2014). Salient Beliefs of Pre-Service Primary School Teachers Underlying an Attitude “Liking or Disliking Physics". *Science Education International*, *25*(4), 437–458. Retrieved from http://www.icaseonline.net/sei/december2014/p5.pdf

Kapucu, S., & Bahçivan, E. (2015). High school students' scientific epistemological beliefs, self-efficacy in learning physics and attitudes toward physics: A structural equation model. *Research in Science & Technological Education*, *33*(2), 252–267.http://dx.doi.org/10.1080/02635143.2015.1039976.

Lee, M. H., Johanson, R. E., & Tsai, C. C. (2008). Exploring Taiwanese high school students' conceptions of and approaches to learning science through a structural equation modeling analysis. *Science Education*, *92*(2), 191–220. http://dx.doi.org/10.1002/sce.20245.

Li, W. T., Liang, J. C., & Tsai, C. C. (2013). Relational analysis of college chemistry-major students' conceptions of and approaches to learning chemistry. *Chemistry Education Research and Practice*, *14*(4), 555–565. http://dx.doi.org/10.1039/C3RP00034F.

Lin, T. J., Deng, F., Chai, C. S., & Tsai, C. C. (2013). High school students' scientific epistemological beliefs, motivation in learning science, and their relationships: A comparative study within the Chinese culture. *International Journal of Educational Development*, *33*(1), 37–47. http://doi.org.10.1016/j.ijedudev.2012.01.007

Lin, K. Y., & Williams, P. J. (2016). Taiwanese preservice teachers' science, technology, engineering, and mathematics teaching intention. *International Journal of Science and Mathematics Education*, *14*(6), 1021–1036. http://dx.doi.org/10.1007/s10763-015-9645-2.

Mason, L., Boscolo, P., Tornatora, M. C., & Ronconi, L. (2013). Besides knowledge: A cross-sectional study on the relations between epistemic beliefs, achievement goals, self-beliefs, and achievement in science. *Instructional Science*, *41*(1), 49–79. http://dx.doi.org/10.1007/s11251-012-9210-0.

Moore, R. W., & Foy, R. L. H. (1997). The scientific attitude inventory: A revision (SAI II). *Journal of Research in Science Teaching, 34*(4), 327–336. https://doi.org/10.1002/(SICI)10982736(199704)34:4%3C327::AID-TEA3%3E3.0.CO;2-T.

Sadi, O., & Dağyar, M. (2015). High school Students' epistemological beliefs, conceptions of learning, and self-efficacy for learning biology: a study of their structural models. *Eurasia Journal of Mathematics, Science & Technology Education, 2015, 11*(5), 1061–1079. https://doi.org/10.12973/eurasia.2015.1375a.

Soltani, A., & Askarizadeh, G. (2021). How students' conceptions of learning science are related to their motivational beliefs and self-regulation. *Learning and Motivation*, *73*, 101707. https://doi.org/10.1016/j.lmot.2021.101707.

Oliveira, P. C., & Oliveira, C. G. (2013). Using conceptual questions to promote motivation and learning in physics lectures. *European Journal of Engineering Education*, *38*(4), 417–424. http://doi.org/ 10.1080/03043797.2013.780013.

Özkan, Ş. (2008). *Modeling elementary students' science achievement: The interrelationships among epistemological beliefs, learning approaches, and self-regulated learning strategies.* Doctoral dissertation, Middle East Technical University, Ankara.

Pallant, J. (2010). *SPSS survival manual: A step by step guide to data analysis using SPSS*. Maidenhead: Open University Press/McGraw-Hill.

Pamuk, S., Sungur, S., & Oztekin, C. (2017). A multilevel analysis of students' science achievements in relation to their self-regulation, epistemological beliefs, learning environment perceptions, and teachers' personal characteristics. *International Journal of Science and Mathematics Education*, *15*(8), 1423–1440. http://doi.org/10.1007/s10763-016-9761-7.

Peterson, E. R., Brown, G. T., & Irving, S. E. (2010). Secondary school students' conceptions of learning and their relationship to achievement. *Learning and Individual Differences*, *20*(3), 167–176. http://doi.org/10.1016/j.lindif.2009.12.004

Prasadini, L., Abd Hamid, J., Khatibi, A., & Azam, S. F. (2018). Sri Lankan senior secondary students' conceptions of learning and approaches to learning science : Is there any relationship? *European Journal of Education Studies*, *4*(10), 203–213. http://doi.org/10.46827/ejes.v0i0.1808.

Richardson, J. T. (2011). Approaches to studying, conceptions of learning and learning styles in higher education. *Learning and Individual differences*, *21*(3), 288–293. http://doi.org/10.1016/j.lindif.2010.11.015.

Tabachnick, B. G., & Fidell, L. S. (2013). *Using* multivariate *statistics (6th ed., international ed.)*. Upper Saddle River, NJ: Pearson Education.

Tsai, C. C. (2004). Conceptions of learning science among high school students in Taiwan: A phenomenographic analysis. *International Journal of Science Education*, *26*(14), 1733–1750. http://doi.org/10.1080/0950069042000230776

Tsai, C. C., Ho, H. N. J., Liang, J. C., & Lin, H. M. (2011). Scientific epistemic beliefs, conceptions of learning science and self-efficacy of learning science among high school students. *Learning and Instruction*, *21*(6), 757–769. http://doi.org/10.1016/j.learninstruc.2011.05.002.

Uiboleht, K., Karm, M., & Postareff, L. (2018). The interplay between teachers' approaches to teaching, students' approaches to learning and learning outcomes: a qualitative multi-case study. *Learning Environments Research*, *21*(3), 321–347. http://doi.org/10.1007/s10984-018-925.7-1

Yilmaz-Tüzün, Ö., & Topcu, M. S. (2010). Investigating the relationships among elementary school students' epistemological beliefs, metacognition, and constructivist science learning environment. *Journal of Science Teacher Education*, *21*(2), 255–273. http://doi.org/ 10.1007/s10972-009-9163-6