

High School Students' Epistemological Beliefs, Conceptions of Learning, and Self-efficacy for Learning Biology: A Study of Their Structural Models

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The current work reveals the data of the study which examines the relationships among epistemological beliefs, conceptions of learning, and self-efficacy for biology learning with the help of the Structural Equation Modeling. Three questionnaires, the Epistemological Beliefs, the Conceptions of Learning Biology and the Self-efficacy for Learning Biology, have been used to investigate 384 high school students' epistemological beliefs, conceptions of learning, and self-efficacy for learning biology, respectively. The results indicate that the students' epistemological beliefs about the source/certainty, justification, and development of biology knowledge have some direct and positive relations with some factors of conceptions of learning. Moreover, it has been found that those students' epistemological beliefs about justification and development, and their conceptions of learning about applying, understanding, and seeing in a new way directly and positively relate to the students' self-efficacy for learning. Only the source/certainty of knowledge directly and negatively relates to the students' self-efficacy. In addition, the students' epistemological beliefs play an indirect role in the students' self efficacy through the mediator of conceptions of learning. It can be said that all these information about the students' epistemological beliefs, conceptions of learning, and self-efficacy for biology learning are required for an effective teaching and learning process.

Keywords: biology, conceptions of learning, epistemological beliefs, self-efficacy for learning

INTRODUCTION

Students' learning plays a critical role in all educational systems because the

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purpose of these systems is to ensure the learning of students. Therefore, factors affecting students' learning have always been studied by researchers. Previous studies have identified that students' epistemological beliefs (Lin, Deng, Chai & Tsai, 2013; Özkan & Tekkaya, 2011), conceptions of learning (Bahcivan, 2014; Chiou, Lee & Tsai, 2013; Lin & Tsai, 2008; Sadi & Lee, 2015), and self-efficacy (Diseth, 2011; Kazempour, 2013; Senler & Sungur, 2010; Usher & Pajares, 2006) are very important factors affecting their learning processes. These studies suggest that epistemological beliefs and conceptions of learning are related to the increasing one's and understanding of knowledge (Hofer & Pintrich, 1997; Lee, Johanson & Tsai, 2008), and that self-efficacy for learning is also related to individuals' motivation and determination to achieve their learning goals (Bandura, 1997). As demonstrated in these studies, students' epistemological beliefs, conceptions of learning, and self-efficacy have an influence on their learning.

Research on epistemological beliefs

Nowadays, one of the common aims of studies conducted in the field of science education is to investigate students' personal epistemological beliefs, i.e., their beliefs about the nature of knowledge and knowing (Hofer & Pintrich, 1997; Schommer, 1990). In their comprehensive review, Hofer and Pintrich (1997) proposed that epistemological beliefs have four dimensions: "certainty of knowledge," "simplicity of knowledge," "source of knowing," and "justification of knowing." The first two dimensions are related to the nature of knowledge, whereas the last two are concerned with the nature of knowing. "Certainty of knowledge" is about whether knowledge is fixed or tentative. It indicates that, when knowledge is fixed, absolute truth exists with certainty; however, when knowledge is more fluid, it can evolve. "Simplicity of knowledge" is about whether knowledge is concrete and absolute or relative. "Source of knowing" is regarding whether knowledge resides in external authority or can be challenged by the individual. Finally, "justification of knowing" addresses the way in which knowledge is justified (Hofer & Pintrich, 1997; Lin et al., 2013).

Researchers have highlighted that epistemological beliefs may influence students' cognitive processes of thinking (Hofer & Pintrich, 1997), conceptions of learning (Chan, 2004; Otting, Zwaal, Tempelaar & Gijsselaers, 2010), their choice of learning approaches (Phan, 2008), and academic achievements (Cano, 2005; Schommer 1990, 1993). Therefore, science educators suggest that science instruction should aim to encourage students to have sophisticated epistemological views of science (Edmondson & Novak, 1993; Tsai, 1998). Moreover, research in the field of education shows that academic contexts (domains) and cultural differences may influence students' epistemological beliefs, ranging from naive to more

State of the literature

- Sophisticated epistemological beliefs may be positively related to students' higher-level conceptions of learning or high level of self-efficacy.
- Researchers have established and compared the students' epistemological beliefs, conceptions of learning, and self-efficacy for learning from different countries and cultures. Using with quantitative and qualitative methods, they assume that learners' cultural backgrounds have an effect on their learning processes.
- Generally, related studies focus on students' epistemological beliefs, conceptions of learning or self-efficacy in science but rarely on pure biology. However, the field of science includes not only biology but also astronomy, geology, physics, and chemistry.

Contribution of this paper to the literature

- Results of the study contribute to the literature by providing information on the relationships between Turkish high school students' epistemological beliefs, conceptions of learning, and self-efficacy in biology.
- The present study, in which the structural equation modeling is used, provides information on the direct and indirect relationships between the identified variables.
- In Turkey, there were no more studies stating the relational analyses between these three variables. This structural analysis provides information on the variables, which gives researchers and teachers' information required for an informed and effective teaching and learning process.

sophisticated (e.g., Buehl & Alexander, 2001). For example, Paulsen and Wells (1998) report that the beliefs of students majoring in the pure fields (natural sciences, the humanities, and the fine arts) had more sophisticated beliefs than those of students in the applied fields (business, education). Similarly, Hofer (2000) finds that students viewed science knowledge as more legitimate than psychology knowledge. More recently, Liu and Tsai (2008) found that students majoring in science education were significantly more likely to have naive views on the theory-laden and culture-dependent aspects of science than students majoring in fine arts, education, and humanities. Since students may have different epistemological views that reflect the intellectual discourse of school subjects to which they have been exposed (Smith & Wenk, 2006), more attention has been paid to the exploration of learners' epistemological beliefs in a specific domain, such as biology (Hofer & Pintrich, 1997).

Research on conceptions of learning

Conceptions of learning (COL) can be described in terms of learners and teachers. For example, the concept has been defined as the beliefs of teachers about their preferred ways of teaching and learning (Chan & Elliott, 2004), and the beliefs of learners about their learning experiences and preferred learning methods (Liang & Tsai, 2010). In other words, COL are about how individuals interpret and reflect upon their learning experiences (Lin, Tsai & Liang, 2012). Moreover, the definition of COL has been adapted to the field of science; in that context, it refers to learners' ideas and beliefs about learning science (Bahcivan & Kapucu, 2014).

In order to understand the nature of COL, the classifications of COL made by researchers must be examined. First, the categorization of the COL, called the "phenomenographic" method, was conducted by Saljo (1979). He categorized the collected data about the meaning of learning according to college students, and found five different COL: increase knowledge, memorization, acquisition of facts and procedures that can be retained and/or utilized in practice, abstraction of meaning, and an interpretative process aimed at the understanding of reliability. In addition, Tsai (2004) conducted a phenomenographic study involving 120 university students and seven subcategories; the study aimed to identify the students' conceptions of learning science: memorization, exam preparation, calculation of problems and application, increase of knowledge, application, understanding and creation of a different perspective.

The categories of COL identified by the previous studies were almost the same (Chiou, Lee & Tsai, 2013; Li, Liang & Tsai, 2013). Generally speaking, the first category identifies students' preference for using memorization techniques in order to learn science. The second category identifies students' primary goal in learning as achieving high scores and passing exams. The third category refers to students' conceptions of learning, which they define as practicing calculation and solving problems. The fourth category refers to students' desire to increase their knowledge. The fifth category identifies the students' characterization of COL as the application of topics related to science to daily life. The sixth category refers to a true understanding of cumulative knowledge. Finally, the seventh category refers to gaining a new way of interpreting natural phenomena (Tsai, 2004).

Tsai (2004) stated that there is a hierarchy of these categories the first three being lower-level COL and the last four being higher-level. Based on these categories, he made suggestions regarding how to encourage students to adopt "higher-level conceptions of learning." Lower-level COL are (1) memorizing, (2) preparing for tests/exams, and (3) calculating and practicing, whereas higher-level COL are (4) increasing one's knowledge, (5) application, (6) understanding, and (7) seeing in a new way.

Research on self-efficacy for learning

The history of self-efficacy dates back to Bandura's social learning theory, which was renamed as social cognitive theory in 1986. Bandura (2001) specifies that self-efficacy affects people's feelings and ideas about themselves, and provides motivation to learn; in doing so, it makes changes in their behaviors. Social cognitive theory states that an individual's belief about his or her capabilities to learn, organize, understand, and behave in specific situations in order to reach their goals is called self-efficacy of individuals (Bandura, 2001). Moreover, Zimmerman (2000), Bandura and Schunk (1981) define self-efficacy as individuals' judgment of their capabilities to organize and execute courses of action required to attain designated goals and types of performance. According to Bandura (1997), information about self-efficacy of the individual comes from four principal sources: (a) mastery experiences, (b) observation, (c) social persuasion, and (d) physiological states. An individual's self-efficacy can be affected by his or her personal experiences or other people's experiences of success and failure; verbal persuasion that the individual can achieve a task; and physiological states such as stress, emotions, moods, and physical reactions.

In education, self-efficacy refers to learners' judgments of their own academic capabilities, and sense of competence related to their academic performance (Bandura, 1997). Previous studies have found that self-efficacy plays a critical role in students' learning, and their motivational, cognitive, and behavioral outcomes (Pintrich & Schunk, 2002). Researchers have determined that if students have a high level of self-efficacy, their learning performance and academic success are higher than students with a low level of self-efficacy (Usher & Pajares, 2006). In order to for a student to exhibit a model behavior, his or her self-efficacy beliefs must be sufficient to achieve a successful performance (Bandura, 1997). Furthermore, when students become successful in classes, their self-efficacy beliefs rise. Similarly, according to other studies in the fields of the sciences, self-efficacy for learning is needed for students to be successful in science classes (Kupermintz, 2002; Pintrich & Schunk, 2002). Students' self-efficacy beliefs are related to their past learning experiences, so conceptions of learning science could be one of the major sources of the increase in students' self-efficacy in science classes (Lin & Tsai, 2013).

Relationship between epistemological beliefs, conceptions of learning and self-efficacy for learning

Studies have found that it is generally claimed that students' epistemological beliefs are related to their COL or students' self-efficacy for learning (Chiou & Liang, 2012; Hofer, 1994; Liang, Lee, & Tsai, 2010; Lin & Tsai, 2013; Lin et al, 2013; Otting et al., 2010; Paulsen & Feldman, 1999; Zhu, Valcke & Schellens, 2008). These studies have shown that sophisticated epistemological beliefs may be positively related to students' higher-level conceptions of learning or students' high self-efficacy; however, absolutists may relate epistemological beliefs to students' lower-level conceptions of learning or students' low self-efficacy for learning. Chiou and Liang (2012) demonstrate that Taiwanese students' conceptions of learning science are associated with their self-efficacy for science learning. Similarly, Tsai and Lee (2013) discuss the relationships between Taiwanese high school students' science learning self-efficacy and their COL. According to these studies, students who are prone to believing in the importance of increasing one's knowledge, applying, understanding, and seeing scientific knowledge in a new way are also prone to possessing higher confidence in learning science. In contrast, students who associate learning with memorizing, preparing for tests, or calculating and practicing tend to hold lower science learning self-efficacy. Furthermore, Hofer (1994) presents clear empirical

evidence indicating that college students' epistemological beliefs are related to their self-efficacy in mathematics. Additionally, Lin et al. (2013) specify that there is a relationship between high school students' epistemological beliefs and their motivation for learning science.

Another study conducted by Liang et al. (2010) found that students who have sophisticated epistemological beliefs tend to have deeper motivation. In addition to studies that indicate that students' self-efficacy is related to their epistemological beliefs and conceptions of learning (Bahcivan & Kapucu, 2014; Eren, 2009; Hofer, 1994), some studies also suggest that students' COL are influenced by their individual beliefs about the nature of knowledge and knowing (Dahl, Bals, & Turi, 2005; Schreiber & Shinn, 2003, as cited in Zhu, Valcke & Schellens, 2008). Therefore, there is a relationship between students' epistemological beliefs and their COL (Chan, 2004; Otting et al., 2010; Zhu et al., 2008). Chan's (2004) path analysis shows that there is a significant relation between epistemological beliefs and COL. These results reflect the significant roles of epistemological beliefs in learning and conceptions of learning. Furthermore, Chan and Elliott (2004) investigate the relationship between Hong Kong pre-service teachers' epistemological beliefs and COL. Zhu et al. (2008) use a structural equation model to focus on the relationship between university students' epistemological beliefs, COL, and approaches to study.

The results of these studies indicate that students' epistemological beliefs, COL, and self-efficacy for learning may be associated with one another. However, these studies have not determined the relationship between all three variables together. Therefore, the question of what is the relationship between all three variables when together becomes important. A handful of studies have tried to answer this question (Tsai, Ho, Liang & Lin, 2011). Tsai et al. (2011) investigated the relationships between Taiwanese high school students' scientific epistemological beliefs, COL, and self-efficacy for learning science. However, different countries have different cultures and different cultural backgrounds of students, meaning that relationships between the variables can differ from country to country (Purdie, Hattie & Douglas, 1996; Sadi & Lee, 2015). This point is supported by Lin et al. (2013), who investigate the differences in high school students' epistemological beliefs and motivation in Taiwan and China. They suggest that culture may have an impact on students epistemological beliefs and self-efficacy for learning science.

However, Tsai et al. (2011) present different findings. They conclude that these differences may be related to school culture and educational values in Taiwan. Generally, related studies focus on students' epistemological beliefs, COL, or self-efficacy in science (Lin & Tsai, 2013), but rarely on pure biology (Chiou, Liang & Tsai, 2012; Lin, Liang & Tsai, 2012). Moreover, the field of science includes not only biology but also astronomy, geology, physics, and chemistry (Sadi & Uyar, 2013). Unlike other science disciplines biology is the science of the living world and does not rely heavily on mathematics (Mayr, 2001). In this respect, it can be said that biology is seldom the specific focus of these studies. There are no studies conducted in Turkey that examine the relationships between all three variables together with regard to biology. In the literature, the studies with a population from Turkey examine the conceptions of learning of science-mathematics students or science teachers through qualitative or quantitative methods (Bahcivan, 2014; Sadi & Lee, 2015), and investigate students' epistemological beliefs with respect to such factors as their gender and grade levels (Kurt, 2009; Ozkan & Tekkaya, 2011; Ozkal, 2007). Ozkal (2007) investigates the relationships between Turkish high school students' scientific epistemological beliefs, attitudes towards science, perceptions of their learning environment, knowledge, and gender. In addition, the connection between conceptions of learning science and self-efficacy, and the connection between epistemological beliefs and self-efficacy of pre-service elementary science teachers

is researched (Bahçıvan & Kapucu, 2014; Sunger, 2007; Topcu & Yılmaz, 2007). Sunger (2007) investigates the relationship between pre-service teachers' self-efficacy beliefs, epistemological beliefs, and attitudes towards science teaching. Consequently, these studies differ from the present study in terms of their purpose, participants, culture, variables, scientific fields, and methods.

Differently from the present study, in which the structural equation modeling (SEM) is used, educational studies have presented the relationships between variables by using correlation or crosstab analyses, and qualitative or experimental methods. However, these analyses cannot explain how these variables influence each other, whether directly or indirectly (Sadi & Uyar, 2013). Structural equation modeling is used to determine multivariate relations among variables through path analysis (Veenman, Van Hout-Wolters, & Afflerbach, 2006). Therefore, the present study focuses on structural relations among the variables. Consequently, the purpose of the present study is to utilize structural equation modeling, which illustrates the relationships between epistemological beliefs, COL, and self-efficacy of Turkish high school students in the field of biology. The guiding research question in the present study is, "What are the structural relations among Turkish high school students' epistemological beliefs, COL, and self-efficacy in biology?"

Research focus

As discussed in the literature review above, the previous studies have revealed that students with high level of self-efficacy have more sophisticated epistemological beliefs (Hofer, 1994), higher nature of knowledge (Chen & Pajares, 2010) and higher confidence in their preferred ways of learning (Lin & Tsai, 2013). Also, if students believe in their learning experiences, they rely on their knowledge more than other students who do not (Otting et. al, 2010). Therefore, the present study has investigated whether or not there are direct and positive relations among the dimensions of the students' epistemological beliefs (source/certainty, development and justification); the conceptions of learning categories (the lower-level conceptions of learning are memorizing, preparing for exams, calculating and practicing; the higher-level conceptions of learning are increasing one's knowledge, applying, understanding and seeing in a new way) and self-efficacy of the high school students in learning biology. Moreover, the indirect connections between the students' epistemological beliefs and the students' self-efficacy through the mediator of the students' conceptions of learning have been formed. The proposed structure of the model is summarized schematically in Figure 1.

In the first pattern of the structural model, the links show that the students' epistemological beliefs about the source/certainty, justification and development of biology knowledge negatively relate to the conceptions of learning about

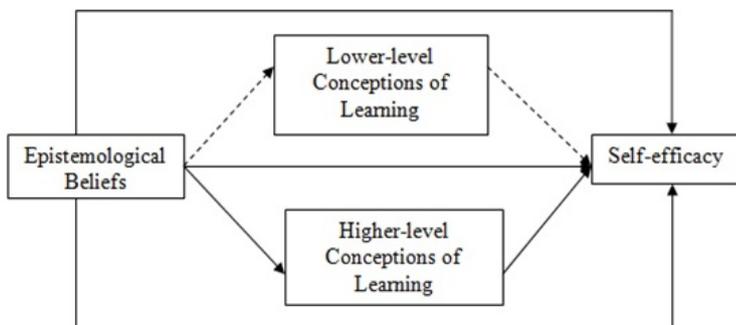


Figure 1. The direct and indirect relationships model

Note: The dotted lines represent negative relationships; the solid lines represent positive relationships between the variables.

memorizing, preparing for exams, and calculating and practicing. In addition, the other links show that the students' epistemological beliefs about the source/certainty, justification and development of biology knowledge positively relate to the conceptions of learning about increasing one's knowledge, applying, understanding, and seeing in a new way. These links have been developed based on the literature review. The students, who believe that knowledge is fixed, are likely to hold the traditional conceptions of learning, such as memorizing and preparing for exams. However, the students, who do not believe that knowledge comes from the authority, and the teacher is an expert adhere to the constructivist conceptions of learning, such as increasing one's knowledge and applying. (Otting et al., 2010). Tsai et al. (2011) has stated that the students, who believe that the scientific knowledge can evolve and change, and needs to be proved with different experiments have the higher-level conceptions of learning (increasing one's knowledge, applying, and understanding); however, the students who think that the scientific knowledge is static, and unchangeable have the lower-level conceptions of learning (memorizing, preparing for exams, and calculating and practicing).

In the second pattern, the links have been formed as the students' epistemological beliefs about the source/certainty, justification and development of biology knowledge positively relate to the students' self-efficacy for biology learning as directly or indirectly. Previous studies have generally suggested that there is a relation between epistemological beliefs and self-efficacy of the students (Paulsen & Feldman, 1999; Tsai et al., 2011). Tsai et al. (2011) has specified that the students' epistemological beliefs about the source, development and justification has an indirect connection with the students' self-efficacy through the students' conceptions of learning, and only certainty has both direct and indirect connections with the students' self-efficacy according to their study's findings.

In the last pattern, based on the related literature, the links present that the students' conceptions of learning about memorizing, preparing for exam, and calculating and practicing negatively relate to the students' self-efficacy in biology. Also, other links are formed as the students' conceptions of learning about increasing one's knowledge, applying, understanding, and seeing in a new way positively relate to the students' self-efficacy in learning biology. In the literature, it has been generally suggested that there is a positive relation between the higher-level conceptions of learning and self-efficacy of the students, and there is a negative relation between the lower-level conceptions of learning and self-efficacy in learning biology (Bahcivan & Kapucu, 2014; Lin & Tsai, 2013). Phan (2008) has specified that the students, who usually use the surface strategies have low self-efficacy, whereas the students with high self-efficacy tend to use the deep strategies as the higher-level conceptions of learning (increasing one's knowledge, applying, understanding, and seeing in a new way).

METHODOLOGY

The study is based on survey design to explore relationships between students' self-efficacy, epistemological beliefs and conceptions of learning biology during the spring semester of 2014 in Anatolian High Schools in Turkey.

Participants

The participants in this study included 384 high school students (198 males and 186 females) in Turkey. All of the students had taken biology courses before participating in this study. All participants were administered three instruments to unravel their self-efficacy, epistemological beliefs and conceptions of learning

biology after the permission was received from their teachers and school management.

Instrument and procedures

In order to investigate both direct and indirect relationships among students' epistemological beliefs, conceptions of learning and self-efficacy for biology learning, three instruments were used.

Assessing students' epistemological beliefs toward biology

Epistemological beliefs were measured by the 26-item of "Epistemological Beliefs Questionnaire" (EBQ) developed by Conley et al. (2004). The Turkish version of the EBQ (Ozkan, 2008) was used to collect the data. The EBQ was designed to be rated on a five-point Likert type response format, from 1 (strongly disagree) to 5 (strongly agree). The original questionnaire has four dimensions; however, in order to determine the factor structure of the EBQ, exploratory factor analysis was conducted and the results showed three factors structure, which are the source/certainty, development, and justification (Ozkan, 2008). In the original questionnaire, the source dimension (5 items) is related with beliefs about knowledge residing in external authorities (e.g. whatever the teacher says in a science class is true). The certainty dimension (6 items) consists of items concerning beliefs about the right answer (e.g. all questions in science have one right answer). The development dimension (6 items) is related with beliefs about science as an evolving and changing subject (e.g. sometimes scientists change their minds about what is true in science). The justification dimension (9 items) refers to a belief about the role of experiments and how individuals justify knowledge (e.g. good answers are based on evidence from many experiments). According to Conley et al. (2004), the source and justification dimensions reflect beliefs about the nature of knowing and the certainty and development dimensions reflect beliefs about the nature of knowledge.

Assessing students' conceptions of learning biology

In order to identify students' conceptions of learning through quantitative methods, Lee et al. (2008) developed the "Conceptions of Learning Science" (COLS) questionnaire. Since in this study the aim was to identify the students' conceptions of learning biology (COLB), COLS questionnaire was adapted to biology. The original questionnaire is formed by 35 items and seven factors (memorizing (5 items), preparing for exam (6 items), calculating and practicing (5 items), increasing one's knowledge (5 items), applying (5 items), understanding (4 items), and seeing in a new way (5 items)). In "memorizing" factor, students prefer to learn science by "memorizing" definitions, formulas and terms. In "preparing for exam" factor, students' main goal is to get high grades in the exams. In "calculating and practicing" factor, students' conceptions of learning are usually related to solving scientific problems and making quantitative calculations. In "increasing one's knowledge" factor, students prefer to learn in order to increase their knowledge. In "applying" factor, students define the purpose of learning as applying the acquired knowledge to daily life. In "understanding" factor, students aim to learn scientific knowledge and forming links between concepts in a meaningful way. In "seeing in a new way" factor, students gain a new perspective by learning and find new ways of thinking. These factors have a certain hierarchy and the first three factors are defined as "lower-level conceptions of learning" and the last four factors are "higher-level conceptions of learning" (Li et al., 2013). In the current study, "Conceptions of Learning Science" questionnaire adapted to Turkish version (Sadi & Uyar, 2014) was revised for biology and analyses for its validity and reliability were conducted.

Assessing students' self-efficacy beliefs for learning biology

The Motivated Strategies for Learning Questionnaire (MSLQ) was developed by Pintrich, Smith, Garcia and Mckeachie (1991). The Turkish version of the MSLQ (Sungur, 2004) was used to collect the data. MSLQ is a self-report instrument to measure motivational orientations and self-regulated learning strategies. These two scales are modular and can be used to fit what the researcher wants to search in his/her study. In this study, only one subscale of motivation section (self-efficacy for learning) was used to assess the students' self-efficacy beliefs for learning biology (8 items). This part of the MSLQ was named as Self-efficacy for Learning Questionnaire (SEQ) by the researchers. The SEQ was designed to be rated on a seven-point Likert type response format, from 1 (not at all true of me) to 7 (very true of me).

Data collection

The three questionnaires were distributed to the students with the permission of the Provincial Education Directorate, the school managements and the teachers. The students in this study volunteered to respond to the questionnaires. These students answered the three questionnaires at the same time and all students knew that their names would be kept confidential. Teachers made all necessary disclosures before the administration of the survey.

Data analysis

This study, first, used exploratory factor analysis to respectively examine the factor structure of the EBQ, COLB questionnaire and SEQ. The correlations between the EBQ, COLB questionnaire and SEQ factors were analyzed. Then, the structural relationships between the factors of the EBQ, COLB questionnaire and SEQ were evaluated via SEM analysis. According to the path model of the study, the predictor variable is the students' epistemological beliefs, the mediator variable is the students' conceptions of learning and the outcome variable is the students' self-efficacy for learning.

RESULTS

Before conducting the factor analysis of EBQ, COLB Questionnaire and Self-efficacy for Learning Questionnaire (SEQ), the data gathered from the high school students were tested using Kaiser-Meyer-Olkin (KMO) and Bartlett sphericity tests to see whether the data is suitable for factor analysis. For factorability KMO is expected to be higher than 0.50 (Field, 2000). Since the value obtained from KMO test was 0.895 for EBQ, 0.822 for COLB and 0.848 for SEQ, which are close to 1, it was seen that the data could be modeled by factor analytic model (Tavsancil, 2005). Also, according to the results of Bartlett sphericity test, chi-square (χ^2) was 2924.357 ($p < 0.01$) for EBQ, 3995.38 ($p < 0.01$) for COLB and 629.638 ($p < 0.01$) for SEQ and null hypothesis was rejected and thus, the data was suitable for factor analysis (Cokluk, Sekercioglu & Buyukozturk, 2010).

According to the results of exploratory factor analysis (EFA) which was made to analyze construct validity of the three questionnaires, the 7th item of the EBQ, the 21th and the 35th items of the COLB were eliminated since these items loaded on more than one factor or their factor loadings were under 0.40. Also, the original form of EBQ has four distinct factors and two factors, namely development and justification, were also encountered with the sample. However, the items of other two factors, the source and certainty, were merged into a single factor according to the results of the EFA. Moreover, the original version of the COLB Questionnaire has 7 factors and 34 items which are collected under seven factors in the current study. Finally, in the MSLQ, all 8 items were used to assess the students' self-efficacy beliefs

for learning biology since the items loaded on the same factor and their factor loadings were not under 0.40.

Moreover, the Cronbach alpha reliability coefficient regarding the reliability of the EBQ was found to be 0.81. The Cronbach alpha reliability coefficient ranged from 0.76 to 0.85 for each factor. Secondly, the overall Cronbach's alpha coefficients for COLB was calculated as 0.73 and the reliability coefficient ranged from 0.67 to 0.80 for seven factors. Finally, the Cronbach alpha reliability coefficient was 0.79 for SEQ. In social sciences, it is enough to have a general reliability coefficient over 0.60 in order to consider the test points reliable (Ozdamar, 1999).

Pearson correlation analysis was carried out to explore the relationships that might exist among the students' epistemological beliefs, conceptions of learning and self-efficacy. Table 1 shows correlation coefficients among the variables of the study.

According to Table 1, the students' self-efficacy in learning biology was significantly and positively correlated with the higher-level conceptions of learning about applying ($r=0.22, p<.05$), understanding ($r=0.18, p<.05$), seeing in a new way ($r=0.20, p<.05$) and also the students' epistemological beliefs about the justification ($r=0.16, p<.05$) and development ($r=0.13, p<.05$). However, the students' self-efficacy was significantly but negatively correlated with the source/certainty ($r=-0.11, p<.05$). Moreover, epistemological beliefs of the students about the source/certainty were significantly and negatively correlated with calculating and practicing ($r=-0.14, p<.05$); justification ($r=0.13, p<.05$) and development ($r=0.11, p<.05$) were significantly and positively correlated with preparing for exam.

Path model

In the study, the LISREL 8.72 program in the SIMPLIS programming language was used to test the structural model (path model). The Comparative Fit Index (CFI), Goodness-of-Fit Index (GFI), Normed Fit Index (NFI), Non-Normed Fit Index (NNFI) and the Root Mean Squared Error of Approximation (RMSEA) were used in the analyses to get evidences of adequate model-to-data fit (Hoper, Coughlan & Mullan, 2008; Hu & Bentler, 1999). The most commonly reported fit indexes are the CFI, GFI, NFI, NNFI and the RMSEA and it is generally accepted that values of 0.90 or greater indicate well-fitting models for the CFI, GFI, NFI and the NNFI. Also, in a well-fitting model, the RMSEA's upper limit should be less than 0.08 (Hoper et al., 2008).

According to the proposed model above, the structural model was generated, and its fit index' values were found as RMSEA=0.044, CFI=0.92, NFI=0.90, NNFI=0.91 GFI=0.89. The structural equation modeling of the study is given schematically in Figure 2.

Table 1. Correlation coefficients among the variables of the study

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. Self-efficacy	-	-0.09	-0.02	-0.02	0.08	0.22**	0.18**	0.20**	-0.11*	0.16**	0.13**
2. Memorizing		-	0.30*	-0.07	-0.06	-0.34*	-0.15*	-0.14*	-0.06	0.03	-0.05
3. Preparing for exam			-	-0.38*	-0.02	-0.03	-0.06	-0.03	0.10*	0.13*	0.11*
4. CP				-	0.24**	0.05	0.15**	0.10*	-0.14**	-0.07	-0.05
5. IK					-	0.33**	0.45**	0.47**	-0.04	0.02	0.02
6. Applying						-	0.43**	0.47**	0.09	0.10	0.18**
7. Understanding							-	0.54**	0.07	0.04	0.08
8. SW								-	0.08	0.11*	0.07
9. Source/Certainty									-	-0.12*	-0.08
10. Justification										-	-0.80**
11. Development											-

**Correlation is significant at the .01 level; *Correlation is significant at the .05 level

Notes: CP, calculating and practicing; IK, increasing one's knowledge; SW, seeing in a new way.

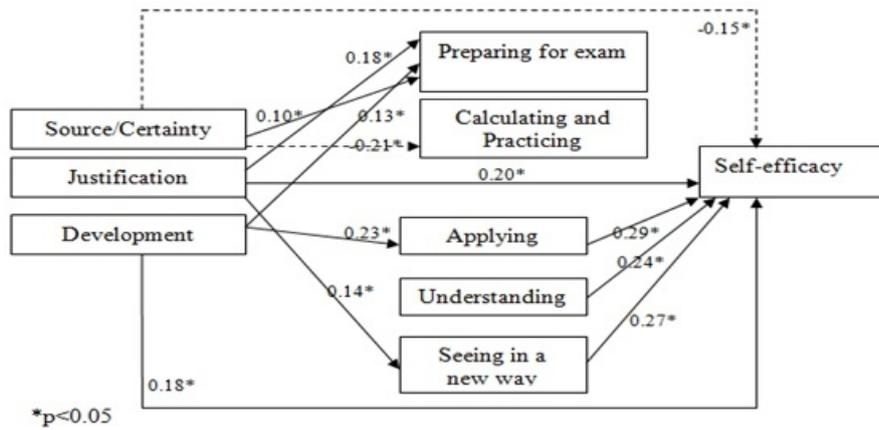


Figure 2. The structural equation model

Note: The dotted lines represent directly, significantly, and negative relationships, the solid lines represent directly, significantly, and positive relationships between the variables.

As seen from the structural model (Figure 2), students' epistemological beliefs about the source/certainty of biology knowledge significantly, directly and positively relate to COLB about preparing for exam ($\beta=0.10$); however, it has a significant, direct, and negative relationship with calculating and practicing ($\beta=-0.21$). Besides, the students' epistemological beliefs about the justification ($\beta=0.18$) and development ($\beta=0.13$) significantly, directly, and positively relate to preparing for exam. In addition, there are positive relations between justification and seeing in a new way ($\beta=-0.14$) and there is a significant and direct relation between development and applying ($\beta=-0.23$). The relations which are not included in Figure 2 were not found significant ($p>.05$).

According to the structural model, it has been found that the students' epistemological beliefs about the justification ($\beta=0.20$) and development ($\beta=0.18$) of knowledge significantly, directly, and positively relate to self-efficacy of the students' biology learning; however, the source/certainty of knowledge ($\beta=-0.15$) significantly and directly but negatively relate to self-efficacy for learning.

Finally, the students' COLB about applying ($\beta=0.29$), understanding ($\beta=0.24$), and seeing in a new way ($\beta=0.27$) significantly and positively relate to the students' self-efficacy in biology. Among the students' COLB about memorizing, increasing one's knowledge and other variables of the study, there is no significantly relation. The insignificant relations have been excluded from Figure 2.

In the study, in addition to the direct relations, the indirect relations were constructed as different path models. Therefore, the students' epistemological beliefs about the source/certainty ($\beta=-0.15$; RMSEA=0.049, CFI=0.92, NFI=0.85, NNFI=0.92 GFI=0.89), justification ($\beta=0.19$; RMSEA=0.052, CFI=0.93, NFI=0.87, NNFI=0.92 GFI=0.90) and development ($\beta=0.21$; RMSEA=0.044, CFI=0.91, NFI=0.86, NNFI=0.92 GFI=0.89) played indirect roles in the students' self-efficacy of biology learning through the mediator of the COLB, when all categories get together. However, the indirect relations have been excluded from Figure 2 due to the direct connections.

DISCUSSION AND CONCLUSIONS

The present study was conducted to investigate the relationships between Turkish high school students' epistemological beliefs toward biology, conceptions of learning biology, and self-efficacy for learning biology. Firstly, the relationship between high school students' epistemological beliefs and COLB is researched. The structural equation modeling analysis reveals that students' epistemological beliefs

about source/certainty, justification, and development of biology knowledge directly, significantly, and positively relate to one of the lower-level COLB, preparing for exam. Moreover, the source/certainty of biology knowledge is associated with calculation and practice, and preparing for exam, directly and significantly but negatively. According to the structural model, one of the lower-level COLB, memorization, is not significantly related to the dimensions of students' epistemological beliefs. However, students' epistemological beliefs in the dimension of justification are directly and significantly associated with the higher-level COLB about seeing in a new way. The development dimension relates to application, one of the higher-level COLB categories.

Previous studies generally find that students' epistemological beliefs may affect their COLB (Chan & Elliott, 2004; Mamede, Schmidt & Geoffrey, 2006; Otting et al., 2010; Tsai et al, 2011). However, unlike the findings obtained from the present study, these previous findings show that between students' epistemological beliefs and their lower-level COL, there is a significant and negative relation. In Otting et al.'s (2011) study, students' epistemological beliefs about learning effort/process were positively related to the higher-level COL, and negatively related to the lower-level COL. According to previous studies' findings, students who believe that knowledge is simple (less sophisticated) rather than complex (more sophisticated), or handed down by authority (less sophisticated) rather than derived from reasons (more sophisticated), or certain (less sophisticated) rather than tentative (more sophisticated) are more inclined to use COL such as memorizing, preparing for exam, and calculating and practicing. In the present study, a significant and negative relation is found between the source/certainty of biology knowledge, and calculation and practice as one of the lower-level COLB. Also, significant relations were found between the dimensions of students' epistemological beliefs and another lower-level COLB, preparing for exam. According to these findings, Turkish high school students' beliefs about the source/certainty, justification, and development are not associated with their COLB such as memorization; however, these beliefs relate to preparing for exam, and calculation and practice. At the lower level of epistemological beliefs about the source/certainty of knowledge, students believe that knowledge originates outside the self and resides in external authority, and that absolute truth exists with certainty. With sophisticated epistemological beliefs about the source/certainty of knowledge, students believe that knowledge is constructed by the knower in interaction with others, and is tentative and ever-evolving (Kurt, 2009). Accordingly, the more Turkish students have higher-level of epistemological beliefs about the source/certainty of knowledge, the less they adopt the COLB of calculation and practice. This suggests that students who consider knowledge as static and certain may usually solve scientific problems and make quantitative calculations. Although there is seldom mathematical computation in biology, students may have answered the related questionnaires based on some biology topics that are related to mathematics, such as genetics, mitosis, meiosis, or population genetics. Accordingly, Turkish students who believe that knowledge is dependent on specific, static, and certain stages, events, or formulas may do lots of calculating and practicing to gain knowledge.

Atilboz (2004) investigates ninth grade students' levels of understanding of mitosis and meiosis issues in biology. The results reveal that students had difficulties with understanding the basic processes of mitosis and meiosis because of a lack of understanding of related issues. Students tended to memorize the names of the stages and events, or calculate and practice the related problems. However, for a better interpretation of these findings, the results must be supported by data obtained from qualitative research methods, such as interviews. On the other hand, the findings show that the main goal of the students with higher levels of epistemological beliefs about the source/certainty, justification, and development in

biology is achieving high grades in school exams, as opposed to other students with lower level of beliefs. This suggests that students who consider biology knowledge as static, unchanging, and coming from an authority may not usually have COL of preparing for exam.

Previous studies find that students who are less sophisticated, (e.g., think that biology knowledge is fixed, simple, certain, unchangeable, etc.) may adopt lower COL in biology (Chan & Elliott, 2004) because they believe that knowledge is appropriate for memorization, or calculation and practice; they may believe that “their main goal at school is getting high scores in the exams.” For this reason, in order to achieve their goal, they may tend to memorize, or calculate and practice the knowledge that is presented by teachers in their biology learning. As is clear from the findings of the present study, this situation is slightly different for Turkish high school students, due to a positive relation between students’ epistemological beliefs and their COLB about preparing for exam. These differences may be connected with the Turkish education system, which is based on several country-wide standardized entrance examinations for students who want to be admitted to top-ranked high schools and universities. For example, for admission to high-ranking high schools, a sufficient score on the Transition from Primary to Secondary Education examination (TEOG) is needed. As well, for all undergraduate programs in Turkey, students must achieve a sufficient score on the Student Selection and Placement Examinations (YGS and LYS). Moreover, admission to both the high schools and undergraduate programs is based on the students’ composite scores, which take into account the examination scores and high school grade point averages, or their secondary school grade point averages (MEB, 2015; YOK, 2015). Therefore, in Turkey, students are expected to achieve higher scores in all country-wide high school and undergraduate exams. Consequently, even though students in Turkey believe that knowledge is relative, changeable, and developable, they have a tendency towards learning biology through preparation for exams.

Additionally, previous studies find that students’ epistemological beliefs significantly and positively relate to higher-level COL (Chan, 2007). These findings indicate that if students have more sophisticated beliefs, (e.g., knowledge is relative, contingent, and contextual,) they prefer to learn in order to increase their knowledge, apply their knowledge in their daily life, build relations between concepts and knowledge, and find new ways of thinking. The present study finds that there is a significant and positive link between students’ epistemological beliefs about the justification of knowledge, and students’ COL of seeing in a new way, and also between development and application of knowledge. Except for these links, no positive or negative relationships are found between epistemological beliefs and higher-level COL. These results indicate that the more students evaluate and justify science knowledge, the more they find new ways of thinking. Moreover, the more students believe in the developing and changing the nature of science, the more they apply that knowledge to their daily lives.

In the present study, the relationship between students’ epistemological beliefs toward biology and their self-efficacy in biology learning is also investigated. According to the current literature, students’ epistemological beliefs positively relate to their self-efficacy (Chen & Pajares, 2010; Kizilgüneş, 2007). In the present study, aside from these direct links, the indirect connections between students’ epistemological beliefs about the source/certainty, justification, and development of biology knowledge, and students’ self-efficacy through the mediator of students’ COLB is determined. Direct, significant, and positive relations have been found between students’ self-efficacy for biology learning and epistemological beliefs, except for the source of knowledge. There are positive and direct relations between the justification of knowledge and students’ self-efficacy, and between the

development of knowledge and self-efficacy in learning biology. This suggests that if students believe in the evolving and changing nature of science, and believe that knowledge is constructed through examination of evidence and the opinions of experts - in short, if students have more sophisticated beliefs in development and justification of knowledge - they may develop high self-efficacy in learning biology. However, there is a significant negative relation between the source of knowledge and students' self-efficacy. Similarly, Paulsen and Feldman (1999) find that if students believe that the structure of knowledge is certain and fixed, they feel more confident in their capacity to learn. Tsai et al. (2011) also found a negative relation between the source of knowledge and Taiwanese students' self-efficacy. They clarify that Taiwanese school culture, like that of Turkey, is highly influenced by country-wide standardized examinations. Since standardized examinations are very important for students' futures in Turkey, science teachers in high schools may prepare school exams that have fixed and certain answers, in order to prepare their students for the country-wide standardized examinations.

Topcu and Yilmaz (2007) research the relationships between the pre-service science teachers' epistemological and self-efficacy beliefs. They find the teachers feel most confident about their science teaching when the scientific knowledge they teach is certain and unchangeable. Students who consider scientific knowledge to be tentative may consider multiple answers to questions; however, students who consider science knowledge to be certain may not, and may simply memorize the static knowledge given by their teacher (Tsai et al., 2011). Therefore, students who consider science knowledge to be tentative and uncertain may fail on standardized tests, which affects their self-efficacy for learning science. According to the current literature, if students pass their exams successfully, their level of self-efficacy is higher than students who fail the exams (Baker & White, 2003; Diseth, 2009; Usher & Pajares, 2006). Diseth's (2009) path model shows a structural relationship between high school students' academic achievement and their self-efficacy in learning science. The results reveal that students' academic achievement is an predictor of their self-efficacy.

Lastly, the present study investigates whether or not students' COLB relate to their self-efficacy in biology. According to the results obtained, the higher-level COLB of application, understanding, and seeing in a new way are directly associated with self-efficacy of students in biology learning. It means that if students use this knowledge in their daily lives, establish a relationship between old and new knowledge, and gain a new perspective to their learning, they have higher level of self-efficacy. These findings are supported by those of previous studies (Chiou & Liang, 2012; Ferla, Valcke & Schuyten, 2008; Lin & Tsai, 2013). Lin and Tsai (2013) investigate the relationships between Taiwanese high school students' COLS and their science learning self-efficacy. Their path analysis results derive from the structural equation modeling method, which shows that the COL of understanding and seeing in a new way are a positive predictor of students' self-efficacy. However, the results of the present study show that students' lower-level COLB do not determine their self-efficacy for biology learning. This finding is different from those of previous studies that found that there is a negative relationship between lower-level COL and students' self-efficacy (Lin & Tsai, 2013; Tsai et al, 2011). Lin and Tsai (2013) find a negative relation between the COL about preparing for exam and self-efficacy for learning science. Accordingly, students who consider learning science in terms of preparing for exam tend to hold lower level self-efficacy for learning science. In the present study, although direct connections are not found between lower-level COLB and students' self-efficacy, the mediator effects of COLB are found between students' epistemological beliefs and their self-efficacy for biology learning. The mediating effects of COLB are also supported by previous studies (Tsai et al., 2011). According to Tsai et al. (2011), COLS directly relate to students' self-efficacy.

Students' COL also has a role as a mediating variable between students' epistemological beliefs and self-efficacy for learning science. In short, it can be said that lower-level and higher-level COL play a role in affecting students' self-efficacy.

The findings above show that higher-level COL about increasing one's knowledge and all lower-level COL do not significantly predict students' self-efficacy. In terms of increasing one's knowledge, this factor is related to higher-level COL; therefore, when all four higher-level COL are present, a significant relationship between self-efficacy and higher-level COL is identified (Phan, 2008). Students learn because they want to increase their knowledge. Memorizing, preparing for exam, and calculating and practicing are also about students' preferences for learning; in other words, they prefer to learn by memorizing definitions or formulas and by solving problems with quantitative calculations in order to achieve high scores on the examinations. When the unique case of Turkish high school students' is considered, it can be said that they want to increase their knowledge to pass admission exams to attend universities (Varli, 2008). As a result, in order to be successful in standardized examinations, students may have to memorize many terms and formulas, and calculate many problems. Therefore, the findings obtained may relate to this. Generally, the more students have the COL of application, understanding, or seeing in a new way, the higher their self-efficacy (Lin & Tsai, 2013). However, in Turkey, both students with high self-efficacy and those with low self-efficacy want to increase their knowledge in order to be successful in the examinations by memorizing, and by calculating and practicing. This goal is common among Turkish students, whether they have low or high self-efficacy for biology learning. This may explain the aforementioned findings.

Consequently, epistemological beliefs provide information about students' beliefs and opinions about knowledge, COL provide information about how students learn, self-efficacy for learning provides information about students' motives to learn. All these pieces of information are required for an educated and effective teaching and learning process. Therefore, it is recommended that teachers and other educators design their teaching and learning processes with regard for students' epistemological beliefs, COL, and self-efficacy for learning. Teachers and other educators should be trained in the effects of these factors on students' learning. As well, students need better education to have more sophisticated beliefs and higher-level COL.

The present study is limited to generalizing its findings. Participation was limited to 384 high school students in one Turkish city, so there are also limitations in terms of cultural contexts. Future studies should apply the same research methods in different school climates. Also, it is assumed that all participants responded sincerely to the questionnaires. Future studies should use different materials to verify the findings of the present study, or use different research methods such as interviews or observation methods.

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