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Using Concept Cartoons to Identify the Epistemological Beliefs of Middle School Students

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ABSTRACT Epistemological beliefs, including the source of knowledge, the certainty of knowledge, the organization of knowledge, the control of learning, and the speed of learning, are important to identify since these beliefs impact students' learning processes and how they attribute meaning to life. Concept cartoons, that students find genuine and credible, are found to be effective assessment tools in revealing these beliefs. The present study aims to identify and compare 5th and 8th grade middle school students' epistemological beliefs utilizing concept cartoons. The study participants were 5th (N=38) and 8th grade (N=47) students enrolled in three different middle schools in the Çamlıhemşin district of Rize. In order to reveal the students' opinions, one concept cartoon for each dimension of epistemological belief was utilized. A scoring rubric was employed to analyze the student responses to the concept cartoons. According to the results of the t-tests on students' scores, the 5th and 8th grade students' epistemological beliefs in the dimensions of organization of knowledge, source of knowledge, and certainty of knowledge are similar. In contrast, 8th grade students' epistemological beliefs related to the speed of learning and the control of learning were found to be significantly higher than those of 5th-grade students. Among the mean values of the students' epistemological beliefs, source of knowledge beliefs were found to be the lowest.

Keywords Concept Cartoons, Epistemological Beliefs, Middle School Students

1. INTRODUCTION

The beliefs of individuals regarding the nature of knowledge, knowing, and learning are defined as epistemological beliefs (Deryakulu & Büyüköztürk, 2005; Schommer, 1990). As a personal attribute, epistemological beliefs can be defined as subjective beliefs regarding people's opinions about what concepts of knowledge and how the phenomena of knowing and learning are formed (Schommer, 1990). To explain the nature of knowledge and learning, Schommer (1994) proposed a multidimensional belief system covering five elements: the source of knowledge, the certainty of knowledge, the organization of knowledge, the control of learning, and the speed of learning. Each element is independent of the others, and each dimension has different impacts on learning and knowing (Schommer, 1990). In this belief system, an individual's belief, concerning, for example, 'certainty of knowledge' can be at any point on a spectrum between the two poles of naive and sophisticated (Schommer, 1994). Beliefs that knowledge is simple, that knowledge is innate, that learning takes place immediately and that knowledge is certain, i.e., of an unchangeable nature, are often intense among individuals with undeveloped epistemological beliefs (having a traditional understanding of science). In contrast, those with developed epistemological beliefs hold intense beliefs that knowledge is complex, that knowledge is formed with experience and effort, that learning takes place over time and that knowledge is changeable (Buehl & Alexander, 2001).

Schommer (1994) proposed a model, the Epistemological Belief System, which reflects the multiple and independent structure of epistemological beliefs and includes the following dimensions: the source of knowledge, the organization of knowledge, the certainty of knowledge, the speed of learning and the control of learning. The transition from naive to sophisticated epistemological beliefs, together with their features (Schommer, 1990), are presented in Table 1.

According to Schommer (1990), individuals' epistemological beliefs need not develop chronologically in a specific order. To illustrate, a student may hold a weak/naive belief that the source of knowledge is a specific authority, while at the same time holding a strong/

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Table 1 Validation Score of SmartChem

Epistemological Beliefs	**Naive** ⟷	**Sophisticated**
Source of knowledge	Knowledge is handed down by omniscient authority.	Knowledge is reasoned out /obtained through objective and subjective means.
Certainty of knowledge	Knowledge is absolute.	Knowledge is constantly evolving.
Organization of knowledge	Knowledge is compartmentalized.	Knowledge is highly integrated and interwoven.
Control of learning	Ability to learn is genetically predetermined.	Ability to learn is acquired through experience.
Speed of learning	Learning is quick or not-at-all.	Learning is a gradual process.

sophisticated belief in the dimension of certainty of knowledge, to the effect that knowledge can vary based on context, is undergoing continuous development and very little of the knowledge in the world remains unchanged. While they may believe that the learning ability is innate, they can also believe that learning is a staged process (Schommer, 1994).

Students' epistemological beliefs assume a key role in learning, constructing knowledge, and transferring it to daily life. Defining students' epistemological beliefs, understanding their views and behaviors, evaluating their abilities and needs are important for teachers in order for them to adjust their teaching strategies appropriately (Hammer, 1997). Hence, over the last thirty years, there has been an increasing interest in the identification of epistemological beliefs as they have an influential role in students' learning processes and on how they attribute meaning to life (Boz, Aydemir, & Aydemir, 2011; Cano, 2005; Chan & Elliot, 2002; Cheng, Chan, Tang, & Cheng, 2009; Deniz, 2014; Schommer, Crouse, & Rhodes, 1992; Topçu & Yılmaz-Tüzün, 2009; Tsai, 1998; Üztemur & Dinç, 2018; Yang, 2005; Yılmaz-Tüzün & Topçu, 2010). Furthermore, when the association between students' epistemological beliefs and their learning and achievement is considered, evaluating these beliefs assumes critical importance. Tsai (1998) conducted observations of and interviews with 8th grade students in a laboratory to examine whether their learning activities varied based on their epistemological beliefs. As a result of the study, it was revealed that students with a traditional understanding of science followed a step-by-step procedure compatible with the steps given in the course textbook to carry out the work required in the laboratory, and regarded the experiments performed in the laboratory as a facilitating means to memorize scientific concepts.

On the other hand, students with advanced epistemological beliefs discussed the implications of the experimental work results with their peers. They found laboratory settings highly guiding and mostly preferred learning-centered, free environments. Concerning the source of knowledge, Üztemur and Dinç (2018) reported that naive students tended to obey experts, whom they perceived as an absolute authority, and take full confidence in their knowledge. Moreover, the more sophisticated students in the research attempted to make meaning of their own experiences during the knowledge acquisition process. Researchers revealed that a great majority of middle school students regarded experts and objects in the external world as sources of knowledge, and that they perceived themselves as passive receivers of knowledge.

Research studies conducted to identify epistemological beliefs revealed that students' beliefs regarding knowledge became more complex as they proceeded to higher school periods (Brownlee, Purdie, & Boulton-Lewis, 2001; Schommer, 1998; Schommer, Calvert, Gariglietti, & Bajaj, 1997; Şekercioğlu & Yıldırır, 2018). Schommer and colleagues (1997), demonstrated that, compared to first-year high school students, senior high school students held stronger beliefs in the uncertainty and complexity of knowledge and weaker beliefs in innate learning ability and speed learning. In a study by Balantekin (2013), conducted with middle school students, it was concluded that the higher the grade level, the more developed the scientific epistemological belief. Mason, Boldrin, & Zurlo (2006) observed that high school students held more sophisticated epistemological beliefs than middle school students. Another study, by Boz, Aydemir, & Aydemir (2011), revealed that younger students held naive beliefs about the source and certainty of knowledge. They considered an external authority, such as the teacher or textbooks, as a source of knowledge. However, in contrast with other research results, these researchers concluded that as students proceed in their primary school program, their beliefs became less complicated in terms of development and justification of knowledge.

On the other hand, other studies do not report less developed epistemological beliefs as grade level or age increases (Deniz, 2014, Meral & Çolak, 2009; Oğuz, 2008; Wang, Zhou, & Shen, 2016). For example, Meral & Çolak (2009), found that the scores freshman and senior university students obtained on a scientific epistemological belief scale did not vary by year in university. In another study by Wang, Zhou, & Shen (2016), conducted with middle and high school students in China, it was concluded that grade level and age did not significantly affect epistemological beliefs.

According to Brownlee, Curtis, Spooner-Lane, & Feucht (2017), very little is known about what children

believe regarding knowledge and knowing. Furthermore, it is difficult to successfully measure children's epistemological beliefs because the scales commonly used to assess teenagers' and adults' epistemological beliefs can be open to misunderstandings and misinterpretations when used with children (Brownlee, Curtis, Spooner-Lane, & Feucht, 2017). Owing to the difficulty of identifying young children's epistemological beliefs, researchers in Turkey tend to focus mostly on prospective teachers' epistemological beliefs (e.g., Deniz, 2014; Meral & Çolak, 2009; Tanriverdi, 2012). On the other hand, in studies conducted to reveal middle school students' epistemological beliefs used Likert type scales (Boz, Aydemir, & Aydemir, 2011; Cano, 2005; Conley, Pintrich, Vekiri, & Harrison, 2004; Schommer-Aikins, Duell, & Hutter, 2005; Topçu & Yılmaz-Tüzün, 2009; Yılmaz-Tüzün & Topçu, 2010). However, Chan & Elliott (2002) have claimed that standard scales cannot identify epistemological beliefs in a reliable way owing to cultural differences.

As for interviews, there are very few studies that have utilized interviews to identify middle school students' epistemological beliefs (Duran & Mıhladız, 2014; Feucht, 2017; Yang & Tsai, 2010). Some studies claim that more interactive techniques such as draw-write-explain are more effective in revealing middle school students' epistemological beliefs (Brownlee, Curtis, Spooner-Lane, & Feucht, 2017; Üztemur & Dinç, 2018). Hence, in the present study, concept cartoons, with child-friendly drawings reflecting opinions related to science in familiar and daily contexts, have a high potential in revealing children's opinions (Atasoy & Ergin, 2017; Chin & Teou, 2009; 2010; Keogh & Naylor, 1999; Naylor & Keogh, 2000; Sexton, Gervasoni, & Brandenburg, 2009). Concept cartoons are drawings in the form of pictures, which include dialogues among three or four people who exchange opinions about a daily situation or event (Naylor & Keogh, 2000; Atasoy & Ergin, 2017). Concept cartoons help identify students' opinions and function as a platform in which students can argue opposing ideas in a non-threatening environment, thus encouraging them to engage in arguments (Naylor, Keogh & Downing, 2007). Since there is limited text in cartoons, students with weak linguistic abilities can comprehend the opinions being described. Normally, children wanting to explain their views are ready to express them (Keogh & Naylor, 1998). Since concept cartoons entail visual elements, and as the dialogues among the cartoon characters enable the children to feel that their opinions are of value, students try to answer questions genuinely. Moreover, since students can comprehend concept cartoons more easily when compared to multiple-choice items, this makes concept cartoons more effective in identifying alternative concepts (Uzoğlu, Yıldız, Demir, & Büyükkasap, 2013).

In a study by Küçük (2017), both interviews and concept cartoons were utilized to reveal middle school students' epistemological beliefs. The data from both the concept cartoons and the interviews were consistent to a large degree. The students in the study, who were given a concept cartoon worksheet, were expected to select a speech bubble that included an opinion that was closest to theirs and then write an explanation of the reason underlying their choice.

While the students' choices of speech bubbles reflected a higher level of epistemological belief, their written explanations displayed lower epistemological beliefs. This condition was attributed to the fact that the speech bubbles in cartoons facilitated students' decision making. However, written explanations require specific mental organizations, so students experienced difficulties writing answers (Atasoy & Küçük, 2020). Kabapınar (2005) claims that concept cartoons can minimize the negative effect anxiety can have on students about giving "incorrect answers." According to Kabapınar, a student is not one who expresses a faulty opinion but merely supports it. Thus, s/he can participate in activities with freedom and comfort.

1.2. The Aim of the Study

The present study aims to identify and compare 5th and 8th grade middle school students' levels of epistemological beliefs utilizing concept cartoons.

1.3. The Research Question

What is the impact of middle school students' grade levels on their epistemological beliefs?

2. METHOD

The present study utilized concept cartoons to identify the epistemological beliefs of 5th and 8th grade middle school students. Three different levels of statements (weak/naive, moderate, and strong/sophisticated) as regards three dimensions of epistemological beliefs (source of knowledge, the certainty of knowledge, organization of knowledge, control of learning and speed of learning) were investigated.

2.1. The Participants of the Study

The sample students were selected via random sampling - one of the probability-based sampling methods (Büyüköztürk, Kılıç Çakmak, Akgün, Karadeniz, & Demirel, 2019). The number of participants was identified based on the number of middle schools in the town. The participants were 5th (N=38) and 8th grade (N=47) students enrolled in three different middle schools in the Çamlıhemşin district of Rize in Turkey. They voluntarily participated in the study during the 2019-2020 academic year. The participants have common socio-cultural characteristics.

2.2. Data Collection

In the present study, concept cartoons based on multiple epistemological beliefs, which Küçük (2017) developed for 8th grade students, were utilized as data

Table 2 The Scoring Rubric used in the analysis of concept cartoons

The epistemological belief level of the speech bubble	Written explanation	Score
Naïve	Incomprehensible/irrelevant explanations, or no explanations at all	1
Naive	Appraising the choice made or finding it more right/logical	1
Naive	Using, partially or entirely, the statement in the speech bubble or a similar statement to provide explanations	1
Naive	Explaining unique opinions/providing unique examples	2
Moderate	Incomprehensible/irrelevant explanations, or no explanations at all	3
Moderate	Appraising the choice made or finding it more right/logical	3
Moderate	Using, partially or entirely, the statement in the speech bubble or a similar statement to provide explanations	3
Moderate	Explaining unique opinions/providing unique examples	4
Sophisticated	Incomprehensible/irrelevant explanations, or no explanations at all	5
Sophisticated	Appraising the choice made or finding it more right/logical	5
Sophisticated	Using, partially or entirely, the statement in the speech bubble or a similar statement to provide explanations	5
Sophisticated	Explaining unique opinions/providing unique examples	6

collection tools. Concept cartoons have been constructed on daily life situations to reflect different epistemological dimensions (source of knowledge, organization of knowledge, the certainty of knowledge, control of learning, and speed of learning). In the speech bubbles of the concept cartoons, there are three views graded by the levels of epistemological beliefs: weak/naive, moderate/ developing, and strong/sophisticated. The concept cartoons were examined by two science teachers to ensure their suitability and comprehensibility for the 5th-grade students. Based on their recommendations, the statements were revised (Appendix A). The students were provided with a worksheet (see Appendix B for a sample), and they were asked to choose the speech bubble that was closest to their own opinion and write an explanation about the reason.

2.3. Data Analysis

A scoring rubric was prepared for data analysis. During the rubric preparation, students' choices of the speech bubbles in the concept cartoons were initially categorized as naive, moderate, or sophisticated. The preliminary examinations of the written explanations gave rise to the categories in Table 1. While deciding upon these categories, the written explanations were evaluated concurrently with a science education expert. Subsequently, a science education expert, as well as the researcher, took part in the process of categorizing all of the students' written explanations. These researchers worked independently of each other while doing the groupings. The inter-rater consistency was found to be .80. These data sets were later compared, and the incompatible data were discussed and negotiated.

These categories were scored so that comparisons could be made between 5th and 8th grade students based on various variables (Table 2). The opinion of a measurement/assessment expert was received during this scoring process. Accordingly, scores proceeding from the naive to the sophisticated level of epistemological belief were assigned (naive level of epistemological belief: 1 point; moderate level of epistemological belief: 3 points; a sophisticated level of epistemological belief: 5 points). The reason for the 2-point difference between the levels is based on the notion that although the level of epistemological belief may be low, the written explanation is worth scoring. Hence, this will enable one to differentiate between individuals with a low level and those with a moderate epistemological belief. As for the scoring of the written explanations, importance was attributed to distinct expression, different from the words in the speech bubbles. Hence, points were not given to student explanations that were entirely or partially similar to the statements in the concept cartoons. However, those explanations that were unique with original examples and opinions were given 1 point. As for explanations that included statements such as the best/the most accurate/the most logical/the most rational/the most comprehensive to describe the chosen speech bubble, were not given any points as they did not include any statement expressing a belief. Rubric scores were used in t-tests to determine whether there was a significant difference between epistemological beliefs in terms of grade levels. The mean values of the students' levels of epistemological beliefs by grade level are displayed in a bar graph (Figure 1).

3. RESULTS

Based on the t-test results presented in Table 3, no significant difference is observed between the grade levels in the dimensions of organization of knowledge, source of knowledge, and certainty of knowledge. In other words, 5th and 8th grade students' epistemological beliefs in these dimensions are at similar levels. On the other hand, 8th grade students' epistemological beliefs regarding the

Table 3 The t-test results of the comparisons of epistemological belief dimensions by grade level

	Grade 8			Grade 5				
	n	M	SD	n	M	SD	df	t
Organization of Knowledge	47	4,23	1,20	38	4,21	1,14	83	0,092
Source of Knowledge	47	2,36	1,34	38	2,29	1,49	83	0,235
Certainty of Knowledge	47	3,66	1,54	38	3,58	1,65	83	0,232
Speed of Learning	47	4,17	1,37	38	3,32	1,71	83	2,498*
Control of Learning	47	4,60	0,99	38	4,05	1,25	83	2,233*

dimensions of the speed of learning (t (83)=2.498, p < .05) and control of learning (t (83)=2.233 p < .05) are at a statistically significantly higher level than those of 5th-grade students.

As can be observed in Figure 1, 5th and 8th grade students' epistemological beliefs in the dimension of the organization of knowledge are slightly above the moderate level. According to these students, knowledge is not simple or structured. The students who have a high level of epistemological belief in this dimension believed that knowledge is complex and has an integrated structure. That is, information learned each year in school has strong relationships with what was learned in previous years.

In the dimension of the source of knowledge, it was found that all the students' epistemological beliefs were at a moderate level. Students believe that sources of information are primarily external, such as encyclopedias, books, the Internet, or experts.

Concerning the dimension of the certainty of knowledge, the beliefs of 5th and 8th grade students were found to be at a moderate level. For example, Pluto was regarded as a planet in the past, but today it is removed from among the planets. Students with a moderate level of e pistemological beliefs indicate that they assume "knowledge is not certain; it cannot be known directly and can change from person to person."

In the dimensions of the speed of learning and control of learning, 8th-grade students hold stronger epistemological beliefs than 5th-grade students. In the dimension of control of learning, these students think that Aziz Sancar's success is not solely based on his innate talent. These students believe that learning comes with experience and is a changeable ability.

4. DISCUSSION

As a result of the data analysis in the present study, the epistemological beliefs of 5th and 8th grade students were found to be at similar levels concerning the dimensions of organization of knowledge, source of knowledge, and certainty of knowledge. On the other hand, in terms of the dimensions of speed of knowledge and control of knowledge, 8th grade students were found to hold more sophisticated epistemological beliefs when compared to the 5th-grade students. That is to say, 8th-grade students believe that it is not possible to immediately learn all the knowledge presented in most lessons; they believe that

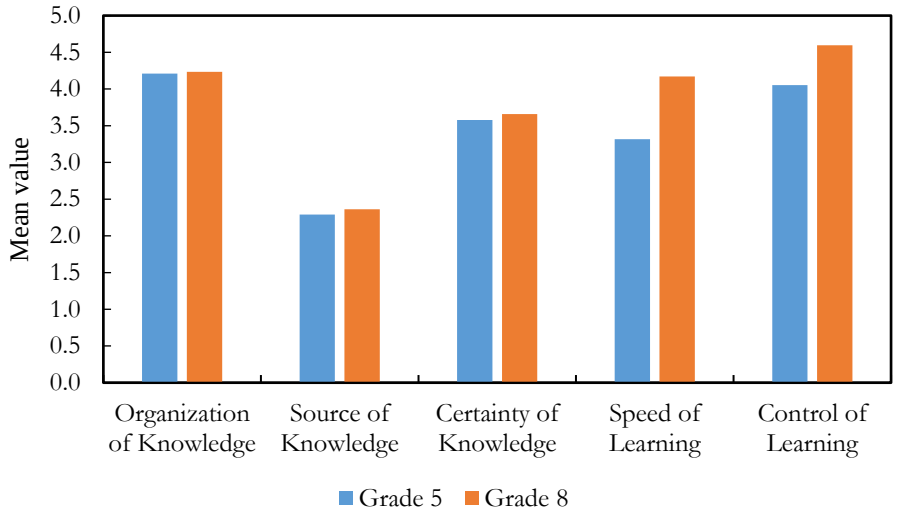

Figure 1 The distribution of the mean values of students' epistemological beliefs by grade level

learning takes place over time in a staged manner utilizing disciplined study and doing activities and exercises. Considering the impact of grade level on epistemological beliefs, most research studies report beliefs concerning knowledge and knowing become more complex as students proceed to higher grade levels (Brownlee, Purdie & Boulton-Lewis, 2001; Paulsen & Wells, 1998; Schommer, 1998; Şekercioğlu & Yıldırır, 2018). Schommer-Aikins et al. (1997) revealed that as high school students proceeded in their educational years, they believed less in the complexity and uncertainty of knowledge, the speed of learning, and innate talent. On the other hand, Wang, Zhou, & Shen (2016) found that with middle and high school students, grade level and age did not create a significant variation in epistemological beliefs. Other studies conducted with older aged groups such as university students or prospective teachers also reported little difference in epistemological beliefs by class year (Meral & Çolak, 2009; Oğuz, 2008).

In the dimension of the source of knowledge, 5th and 8th grade students' naive levels of epistemological beliefs derive from their belief that external sources such as encyclopedias, books, the Internet or experts are generally more reliable for obtaining or accessing knowledge. This may be due to the preparation for the centralized exams in the country. Students who believe that knowledge is authority driven may prefer to memorize this knowledge. Thus, they believe that they can learn more information in a shorter time. Similarly, in research studies previously conducted by Aşut & Köksal (2013) and Gök (2014), it was revealed that middle school students held naive levels of epistemological beliefs in the dimension of the source of knowledge. Üztemur and Dinç (2018) revealed that a majority of middle school students considered experts and objects in the external world as sources of knowledge and perceived themselves as passive knowledge receivers during the knowledge acquisition process.

In the present study, while students held naive epistemological beliefs in the dimension of the source of information, they held firmer epistemological beliefs in other dimensions. Similarly, Schommer (1994) reported that while students believed that learning ability was innate, they also believed that learning was a staged process. This derives from the fact that each dimension is independent of each other. Furthermore, each dimension has different effects on learning and knowing (Schommer, 1990).

Distinct from the available literature, concept cartoons were utilized in the present study to identify levels of epistemological beliefs. Among other alternatives regarding epistemological beliefs, concept cartoons are believed to be a convenient method for middle school students. It merely requires them to mark the speech bubble, indicating the opinion closest to their own. The accompanying explanations for their choice provide an in-depth understanding of their epistemological beliefs. Thus, the concept cartoon method is more advantageous for identifying the epistemological beliefs of primary or middle school students when compared to other commonly utilized scales (Brownlee, Curtis, Spooner-Lane, & Feucht, 2017).

Thus, with the use of concept cartoons, it was observed that the mean values that students obtained did not reach high levels of 5 or 6 points. This stems from the fact that students do not possess an in-depth understanding that producing a written explanation requires. Moreover, the fact that 5th-grade students are at initial stages of abstract thinking may prevent them from explaining their epistemological thoughts because writing requires specific mental organization. If students have not formed mental constructs regarding epistemological beliefs, it would be difficult for them to express this in writing.

5. CONCLUSION

The present study revealed that epistemological beliefs on the dimensions of organization of knowledge, source of knowledge, and certainty of knowledge were similar across the grade level. At the same time, they showed variation in the dimensions of the speed of learning and control of learning with students in upper-grade levels having more advanced epistemological beliefs than the students in lower grade levels.

That 5th and 8th grade students believed that external sources were more reliable stems from a weak level of epistemological belief in the dimension of the source of knowledge.

In identifying epistemological beliefs, concept cartoons are regarded as advantageous as difficulties that may arise due to grade level can be avoided. However, writing an explanation could be considered a disadvantage since abstract thinking in students at lower grade levels has not been sufficiently developed.

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APPENDIX

Appendix A

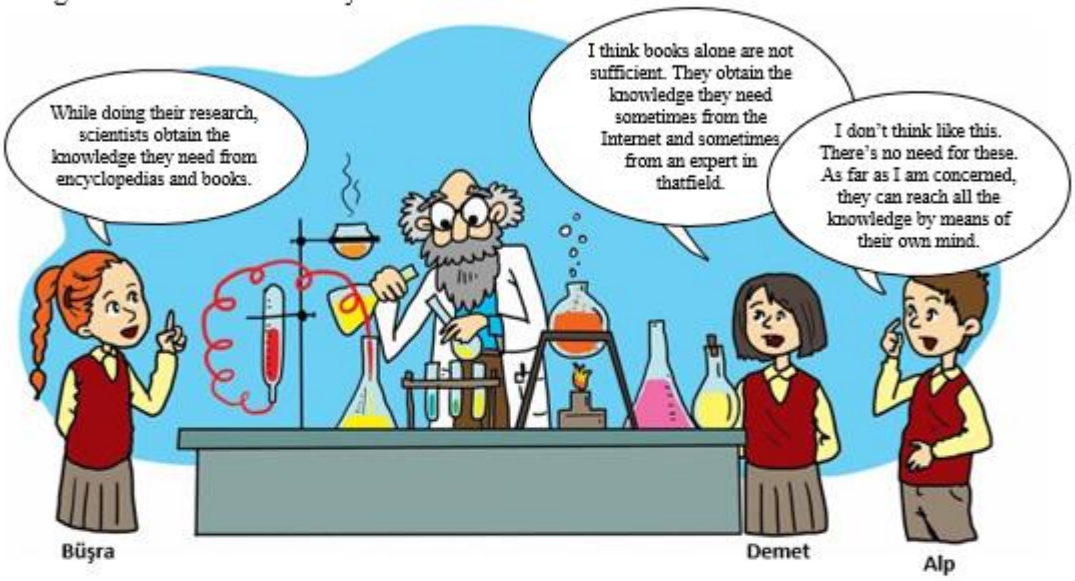
Statements with different levels of epistemological belief within the speech bubbles in the concept cartoons

Epistemological beliefs	Statements in the Speech Bubbles and their Levels		
	Naive	Moderate	Sophisticated
Source of knowledge	While doing their research, scientists obtain the knowledge they need from encyclopedias and books.	I think books alone are not sufficient. They obtain the knowledge they need sometimes from the Internet and sometimes from an expert in that field.	I don't think like this. There's no need for these. As far as I am concerned, they can reach all the knowledge by means of their own mind.
Organization of knowledge	I think knowledge is simple. There is no link between what we learned in the previous grade and what we are learning this year.	Even though what we are learning this year is different, some of them are related to what we learned in previous years.	I think that if we hadn't learnt the knowledge in lower grades, we could not learn this knowledge today. There is a strong relationship between all the knowledge that we have learnt.
Certainty of knowledge	I believe that it is very difficult for scientific knowledge to change as they are formed based on experiments and observations.	Knowledge is like fashion. Scientists are continuously changing scientific knowledge with new ones. For example, while Pluto used to be considered a planet, today it is removed from among the planets.	I don't think like this. A pear falls down when it parts from a tree. This does not change. However, in explaining the reason behind this, today Newton's explanation is valid, not Aristo's.
Speed of learning	I think one can only learn a lesson during the lessons. If you haven't, then whatever you do, you won't be able to learn it.	You might be right; lessons are learnt immediately. But if they are not learnt, one can learn them by studying carefully, and by revising and doing exercises.	As far as I am concerned, it is not possible to learn a subject during the lesson. With a disciplined study, learning takes place over time in a staged manner by doing activities and exercises.
Control of learning	I read a text on Aziz Sancar. I think he is a very intelligent scientist. That's why he is successful.	To be a successful scientist, there is no need to be intelligent. I think he must have worked hard and become successful.	Perhaps he is working hard. But it is also a fact that without inborn talent, one cannot be a scientist by working hard. He must be successful owing to his talent and hard work.

Appendix B

A sample concept cartoon (Source of knowledge)

In the cartoon, Büşra, Demet and Alp express different views regarding source of knowledge. Read these and make your own decision.



Whose opinions do you agree with? Mark the appropriate speech bubble.

Büşra ☐

Demet ☐

Alp ☐

Explain the reasons and justify why you hold these beliefs.

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