INVESTIGATING PRE-SERVICE SCIENCE TEACHERS' EPISTEMOLOGICAL BELIEFS IN THE DOMAIN OF ENVIRONMENT THROUGH COMPARING WITH OTHER DOMAINS

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ABSTRACT

INVESTIGATING PRE-SERVICE SCIENCE TEACHERS' EPISTEMOLOGICAL BELIEFS IN THE DOMAIN OF ENVIRONMENT THROUGH COMPARING WITH OTHER DOMAINS

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The main purpose of this study was to determine preservice science teachers' (PSTs) epistemological beliefs regarding the nature of knowledge and learning in the domain of environment through comparing with the domains of biology, physics, chemistry, and mathematics.

A total of 12 PSTs voluntarily participated in the study. The sample of this study was consisted of senior elementary PSTs who registered for an elective course titled "Laboratory Applications in Science and Environmental Education" in the fall semester of 2008-2009 at a public university, in Ankara. The major data of this study was collected by using a semi-structured interview protocol, developed by Schommer-Aikins (2008). The data of this study were analyzed through descriptive statistics and Miles and Huberman approach (1994).

The data analyses of this study were presented along with five dimensions of epistemological beliefs. The analysis of omniscient authority indicated that the

PSTs less trust in environmental experts' opinions, give more importance to informal education in the acquisition of environmental knowledge, and believe that environmental knowledge is justified more on the basis of direct observation. The analysis of stability of knowledge revealed that the PSTs conceived of environmental knowledge as more uncertain. The analysis of structure of knowledge pointed out that the PSTs consider environmental knowledge as more complex. The analysis of control of learning revealed that the PSTs believe that the large percentage of ability to learn can be acquired after the birth more in environment. The analysis of speed of learning indicated that the PSTs believe that much of learning takes less time in the domain of environment.

This study provided evidence that epistemological beliefs are multidimensional and domain-specific. Moreover, this study highlighted that the nature of environmental knowledge and learning are also an important issue to be addressed in environmental education.

Keywords: Environmental Education, Epistemological Beliefs, Domain-Specific Knowledge, Domain-Specific Learning, Teacher Education

ÖZ

FEN BİLGİSİ ÖĞRETMEN ADAYLARININ ÇEVRE ALANI HAKKINDA SAHİP OLDUKLARI KİŞİSEL EPİSTEMOLOJİK İNANÇLARININ DİĞER ALANLARLA KARŞILAŞTIRILARAK İNCELENMESİ

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Bu çalışmanın ana amacı; fen bilgisi öğretmen adaylarının bilginin ve öğrenmenin doğası hakkında çevre alanında sahip oldukları epistemolojik inançları biyoloji, fizik, kimya ve matematik alanları ile kıyaslayarak belirlemektir.

Bu çalışmaya toplamda 12 fen bilgisi öğretmen adayı gönüllü olarak katılmıştır. Bu çalışmanın örneklemini, Ankara'daki bir devlet üniversitesinin "Fen ve Çevre Eğitiminde Laboratuar Uygulamaları" adlı seçmeli dersine 2008-2009 bahar döneminde kayıt yaptıran 12 son sınıf ilköğretim fen bilgisi öğretmen adayı oluşturmaktadır. Bu çalışmadaki temel verileri toplamak için Schommer-Aikins (2008) tarafından geliştirilmiş yarı yapılandırılmış görüşme formları kullanılmıştır. Bu çalışmanın verileri, betimleyici analizler ve Miles ve Huberman yaklaşımıyla analiz edilmiştir.

Bu çalışmanın veri analizleri epistemolojik inançların beş boyutu doğrultusunda sunulmaktadır. Her şeyi bilen otorite ile ilgili analizler, fen bilgisi öğretmen adaylarının çevre alanındaki uzmanlara daha az güvendiğini, çevre bilgisinin edinilmesinde yaygın eğitime daha çok önem verdiklerini ve çevre bilgisinin doğrulanmasında daha çok doğrudan gözlemlerin olduğunu düşündüklerini göstermektedir. Bilginin değişmezliği ile ilgili analizler, fen bilgisi öğretmen adaylarının çevre bilgisini daha değişken olarak anladıklarını ortaya koymaktadır. Bilginin yapısı ile ilgili analizler, fen bilgisi öğretmen adaylarının çevre bilgisini karmaşık olarak düşündüklerini göstermektedir. Öğrenmenin kontrolü ile ilgili analizler, fen bilgisi öğretmen adaylarının öğrenme yeteneğinin büyük bir kısmının, çevre alanında daha çok sonradan elde edilebileceğini göstermektedir. Öğrenmenin hızı ile ilgili analizler, fen bilgisi öğretmen adaylarının öğrenmenin birçoğunun çevre alanında daha az zaman alacağını düşündüklerini ortaya koymaktadır.

Bu çalışma, epistemolojik inançların çok boyutlu ve alan odaklı olduğunu gösteren kanıtlar sunmaktadır. Buna ek olarak, çevre bilgisi ve öğrenmesinin doğasının da çevre eğitiminde vurgulanması gereken önemli bir husus olduğunu göstermektedir.

Anahtar Kelimeler: Çevre Eğitimi, Epistemolojik İnançlar, Alana Özgü Bilgi, Alana Özgü Öğrenme, Öğretmen Eğitimi

I dedicate this study to my dearest parents

Veysel ADIBELLİ and Hanife ADIBELLİ

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PST : Pre-service Science Teacher

R : Researcher

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CHAPTER 1

INTRODUCTION

Societies throughout the world are aware of that the enormity of environmental problems, such as global climate change, air and water pollution, and the loss of biodiversity, have been increasing sharply in recent years. Moreover, as is known to all, these environmental problems reached a dimension threatening human health more seriously than in any period of time in human history (Alp, 2005). This can be understood from the increasing number of human diseases around the world during the past decade in such it is currently estimated that 40% of the world deaths are due to environmental degradation (Pimentel et al., 2007). Thus, many countries seek solutions to the increasing environmental problems not only at national but also at international level (Alp, 2005). Prevention of these environmental problems can be realized by means of promoting environmentally responsible behavior since the World Commission on Environment and Development (WCED) (1987) pointed out that many environmental problems are caused by human activities. In this respect, environmental education seems as the most valid answer to these increasing environmental problems (UNESCO-UNEP, 1978) since the ultimate goal of environmental education is to shape human behavior in desirable ways (Culen, 2001; Hungerford & Volk, 2001). Thus, most of the studies in environmental education gave importance to investigate responsible environmental behavior. Some of these studies focused on the development of models that subsume the best predictors of responsible environmental behavior (e.g., Hungerford & Volk, 2001; Hines, Hungerford, & Tomera, 1986-87 as cited in Culen, 2001; Marcinkowski, 1988) and some on the potential affects of specific instruction on behavior that incorporated numerous variables from these hypothesized models (e.g., Bogner, 1998; Hsu, 2004; Ramsey, 1993). These studies pointed out that knowledge as one of the important factors to develop responsible environmental behavior. Moreover, recent environmental education programmes also highlighted knowledge as a core issue to be addressed. In the following part, it is explained in detail how knowledge is integrated into these responsible environmental behavior models and environmental education programmes.

1.1 The Place of Knowledge in Responsible Environmental Behavior Models and Environmental Education Programmes

In the long history of environmental education, a variety of models have been proposed to explain human behavior related to environment. In early research on environmental education, it was assumed that increasing individual's knowledge would result in responsible environmental behavior since researchers believed that making individuals more knowledgeable would lead to favorable attitude which, in turn, cause desired changes in their behavior related to environment (Culen, 2001; Hungerford & Volk, 2001). This traditional thinking regarding responsible environmental behavior is named as the knowledge-attitude-behavior (K-A-B) model (Marcinkowski, 2001) and this model was commonly accepted by the researchers until the early 80s to explain human behavior related to environment. In related to the K-A-B model, some researchers claimed that it is not valid (Culen, 2001; Hungerford & Volk, 2001) since if it was functioning, there would not be such number of human caused environmental problems in the world (Culen, 2001). However, this does not mean that knowledge is not crucial for responsible environmental behavior. On the contrary, a great body of research revealed that knowledge is essential but not sufficient for having responsible environmental behavior (e.g., Hungerford & Volk, 2001; Marcinkowski, 2001). Thus, many researchers investigated a plenty of variables that would lead to responsible environmental behavior and then proposed many other models regarding responsible environmental behavior (Hungerford & Volk, 2001). Unlike the traditional model of K-A-B, these models revealed that there are different types of knowledge that contribute to responsible environmental behavior such as knowledge of environmental action strategies (e.g. Hines et al., 1987 as cited in

Culen, 2001; Hungerford & Volk, 2001), knowledge of ecology (e.g. Hungerford & Volk, 2001), and knowledge of the consequences of behavior (e.g. Hungerford & Volk, 2001). Additionally, they highlighted that one's beliefs to make changes and reasoning regarding environmental knowledge may also be crucial variables in the development of action promoting better environmental quality. Considering these variables, it can be concluded that environmental education should focus on what individuals understand and believe about environment and environmental issues in addition to their content knowledge. Conceptualization of environmental knowledge in these responsible environmental behavior models has been elaborated in recent year environmental education programmes. The widely accepted model for environmental education programme in the twenty-first century highlighted the importance of socially acquired knowledge and the complexities of inter-relationships among environmental knowledge (Palmer, 1998). This suggests that in environmental education there is a need for investigation of environmental knowledge in different aspects instead of seeing it just ecological knowledge. At this point, it is surprising that one's understanding regarding the nature of environmental knowledge and learning (i.e., epistemological beliefs) have not gained enough importance and popularity in environmental education; although, the development of one's understanding regarding the nature of scientific knowledge has been stated as the most common objective for science education (Kimball 1967-68 as cited in Abd-El-Khalick, 2000). Consequently, in the present study the PSTs' epistemological beliefs regarding the environment and environmental issues (i.e., personal epistemological beliefs) were investigated. At this point, it comes to mind that what is meant by personal epistemology in the present study. In the next three parts, the nature of personal epistemological beliefs is presented in detail.

1.2 Personal Epistemological Beliefs

Epistemological beliefs are the beliefs regarding the nature of knowledge and learning (Schommer, 1993; Schommer-Aikins, Brookhart, & Hutter, 2000) and every person has his/her own epistemological beliefs which constitute their personal epistemological beliefs. Although a numerous researchers defined personal epistemology based on a variety of perspective, from philosophical stance it is concerned with "how individual develop conceptions of knowledge and knowing and utilize them in developing understanding of the world" (Hofer, 2002, p.4). Historically, personal epistemology started to be studied by Perry and his research team in the early 1950s (Hofer, 2001; Hofer & Pintrich, 1997). According to Perry's model, students believe that knowledge is simple, certain, and handed down by authority up to entering college. During the college years, students go through epistemic changes and believe that knowledge is complex, tentative, and acquired through reason and empirical evidence (Perry, 1998). Building on Perry's model, many other researchers proposed the models of personal epistemology (e.g., Baxter Magolda, 2004; Belenky, Clinchy, Goldberger, & Tarule, 1986, King & Kitchener, 1994, Kuhn, 1991 as cited in Hofer, 2001) however, these initial models were built upon the assumption that personal epistemology is uni-dimensional. According to unidimensional models, personal epistemology involves epistemological beliefs dimensions such as beliefs regarding the stability, structure, and source of knowledge and all these beliefs within individual's system develop at the same rate. In other words, these unidimensional models offer a stage like developmental personal epistemology in that an individual's beliefs about knowledge and knowing move through hierarchical stages from naïve to sophisticated epistemological beliefs. In contrast to earlier works on personal epistemology, a variety of researchers provided considerable evidences that personal epistemology is multidimensional (e.g., Schommer, 1990; Schraw, Dunkle, & Bendixen, 1995; Hofer, 2004). They provided considerable evidences that if individuals' beliefs regarding one dimension develop, this does not always mean that their beliefs about other dimensions will also develop (e.g. Schommer, 1990; Schommer-Aikins, 2008). For instance, Schommer-Aikins (2008) revealed that undergraduate students' beliefs about the dimensions of the structure, certainty, and justification of mathematical knowledge were not as developed as their beliefs about the dimensions of control and speed of mathematical learning. In other words, one may be at the different level of sophistication across dimensions of epistemological beliefs. In light of the research on unidimensional and multidimensional personal epistemology and the most recent studies on epistemological beliefs, in this study to investigate personal epistemological beliefs the multidimensional approach was used for a better understanding of one's epistemological beliefs. Thus, in the present study personal epistemological beliefs were investigated on the basis of multidimensional approach.

Although multidimensional approach of personal epistemology was widely accepted by numerous researchers, there are a variety of classifications regarding dimensions of personal epistemological beliefs (King & Kitchener, 2004; Schommer, 1990). Some researchers proposed that beliefs regarding the nature of knowledge and knowing constitute the dimensions of personal epistemology (e.g., Hofer & Pintrich, 1997), yet others also include beliefs regarding learning into the dimensions of personal epistemology (e.g., Schommer-Aikins, 2008). For instance, Schommer (1990) investigated college and university students' epistemological beliefs through conducting questionnaire. In her study, she hypothesized five epistemological beliefs dimensions which were Omniscient Authority (authority to observation and reason), Certain Knowledge (tentative to unchanging), Simple Knowledge (isolated to integrated), Quick Learning (quick or gradual) and Innate Ability (fixed at birth or lifelong improvement). In her questionnaire, Schommer included two dimensions related to beliefs regarding learning, namely quick learning and innate ability. According to Schommer-Aikins (2008), studying not only beliefs regarding knowledge but also beliefs regarding learning would provide deeper understanding of learners' epistemological beliefs since both types of beliefs are not independent from each other. Thus, in this study Schommer's five dimensions which include beliefs regarding knowledge and learning were accepted to investigate personal epistemological beliefs. In addition to the dimensions of personal epistemological beliefs, there are controversies regarding whether personal epistemological beliefs are domain-general or domain-specific which are provided in detail in the next part.

1.3 Domain- General and Domain-Specific Epistemological Beliefs

Before discussing the domain-generality and domain-specificity of personal epistemology, it is paramount to clarify what we mean by domain knowledge. Researchers are frequently inconsistent in their use of the term "domain knowledge" in such they used various other names for the term of "domain knowledge" including "subject matter domain" (e.g. Voss, Blais, Means, Greene, & Ahwesh, 1986) and "content-specific knowledge" (e.g. Peterson, 1988). Alexander (1992) defined "domain knowledge" as a body of knowledge that individuals have about a particular field of study. In this study, Alexander's (1992) definition was accepted.

The initial research on personal epistemology was studied with an implicit assumption that epistemological beliefs are domain-general (Muis, Bendixen, Haerle, 2006). In this approach, it is claimed that if individuals conceive of knowledge as certain and simple, they would believe this to be true for all domains, mathematics, physics, history, and so on. However, Estes, Chandler, Horvath, and Backus (2003) proposed that the domain-generality of epistemological beliefs should be questioned due to following reasons. First, there are few evidences supporting that epistemological beliefs are domain general. Second, epistemological beliefs across domains can not be the same since each domain investigates different phenomena and uses different methods to acquire knowledge. Third reason to question the domain-generality of epistemological beliefs is that most recently there are more agreements on the domain specificity of cognition in general. Agreeing on Estes, many researchers accepted that epistemological beliefs can differ substantially across domains, that is, epistemology beliefs are domain-specific (e.g., Estes et al., 2003; Hofer, 2000; Paulsen & Wells, 1998; Schommer-Aikins, Duell, & Parker, 2003; Stodolsky, Salk, and Glaessner, 1991; Tsai, 2006). For instance, Tsai (2006) indicated that high school adolescents considered biology as more tentative than physics. That is, students have different epistemological beliefs about the nature of biology and physics. In addition to studies claiming that one's epistemological beliefs are domain-specific, there are other studies proposing that epistemological beliefs are both domain-general and specific (e.g., Buehl & Alexander, 2001; Schommer-Aikins, 2002). In brief, the existing of above studies regarding the domain generality-specificity of epistemological beliefs highlighted that much more research is needed to determine whether epistemological beliefs are domain-general, domain-specific, or both domain-general and domain-specific. Thus, in this study it was questioned whether one's epistemological beliefs can show some variations in different domains. In the history of personal epistemology research, this question was investigated through two ways as between subject designs and within subject designs. In the next part, these designs approaches were explained in detail.

1.4 Between-Subjects Design and Within-Subjects Design

In literature, researchers investigated the issue of domain generality-specificity of personal epistemological beliefs through between subject designs and within subject designs. The majority of studies conducted either on the basis of between-subjects design (e.g., Lonka & Lindblom-Ylänne, 1996; King, Wood, & Mines, 1990) or within-subjects design (e.g., Stodolsky, et al., 1991; Hofer, 2000) provided considerable evidences that epistemological beliefs vary across domains. In between-subjects design, the researchers examined domain-specificity between students across domains or disciplines (Buehl & Alexander, 2001; Muis et al., 2006). In relation to between subject design, Buehl and Alexander (2001) claimed that these studies generally measured students' epistemological beliefs using the instruments assessing their general beliefs regarding knowledge rather than their beliefs regarding particular academic knowledge or domain knowledge. Thus, in these studies there is a lack of clarity regarding the reason of observed differences in personal epistemological beliefs (Buehl & Alexander, 2001). On the contrary, in the within-subjects design, the researchers investigated students' epistemological beliefs regarding various domains through either conducting the instruments where domains were integrated into the items or questions or wanting students to keep a particular domain in their minds while responding the questions or items. That is, this design provides an opportunity to assess individuals' domain-specific epistemological beliefs in more direct way. Therefore, in parallel with the aim of the present study, which was to investigate personal epistemological beliefs in the domain of environment through comparing with other domains, the within-subjects design was conducted.

1.5 Situating Pre-Service Science Teachers to Environmental Education and Epistemological Beliefs

In accordance with related literature on environmental education and personal epistemology, this study investigated the PSTs' beliefs regarding the nature of knowledge and learning in the domain of environment through comparing with the domains of biology, physics, chemistry, and mathematics. In the present study, especially the PSTs were selected as a sample since there is a growing body of studies investigating how teachers' epistemological beliefs affect their curriculum implementation and instructional approaches (Howard, McGee, Schwartz, & Purcell, 2000). These studies revealed that teachers' epistemological beliefs can affect their ways of teaching (e.g., Windschitl, 2002), how they approach curriculum changes (e.g., Prawat, 1992), their use of textbooks (e.g., Freeman & Porter, 1989), and their students' reading practices (e.g., Anders & Evans, 1994). These findings highlight that teachers' epistemological beliefs play an important role in the effectiveness of education as well as environmental education. Additionally, teachers play a key role in attaining the goals of the environmental education (WCED, 1987). At this point, it is necessary to investigate future teachers' especially pre-service science teachers' epistemological beliefs regarding the nature of knowledge and learning in environment.

1.6 Significance of the Study

The reasons to conduct the present study were explained in two dimensions, environmental education and personal epistemology:

1. Although knowledge was accepted as crucial to realize the major goal of environmental education, namely the development of responsible environmental behavior, knowledge was investigated only in terms of content knowledge in the long history of environmental education. Thus, investigation of the PSTs' beliefs regarding the nature of environmental knowledge and learning would yield different perspective to better understand environmental knowledge dimension. For instance, if a PST considers experts as a source of knowledge less in environment than other domains and hold less trust in environmental experts this PST may prefer not to apply environmental experts' advices to resolve environmental problems.

2. There is need for research in environmental education since majority of the people believed that environmental education either does not depend on research in terms of subject matter, theory, and practice or being based on inadequate research (Smith-Sebasto, 2001). In related to this issue, Smith-Sebasto (2001) argued that the recommendations for research in education offered by The Office of Educational Research and Improvement in the U.S. Department of Education in 1997 are appropriate for environmental education research as well. According to these recommendations, research in education should focus on "improving understanding about individual and developmental differences among learners" and "examining the similarities and differences in learning in different areas of the school curriculum" (as cited in Smith-Sebasto, 2001). In this respect, the present study would make a positive contribution to research in education, especially environmental education since the present study aimed to investigate the PSTs' epistemological beliefs regarding the nature of knowledge and learning in the domain of environment through comparing with the domains of mathematics, physics, chemistry, and biology. Thus, it would provide valuable information regarding how the PSTs prefer to learn in a specific domain and indicate particular obstacles to learning in these domains. For instance, a PST who believes that environmental knowledge consists of isolated bits would not construct linkages among environmental knowledge and so s/he would probably learn in environment through memorizing environmental concepts. This suggests that the

problem in environmental learning may be related to the PSTs' epistemological beliefs rather than their lack of content knowledge.

3. In literature there are a variety of studies that examined epistemological beliefs in the domains of mathematics (Buehl & Alexander, 2004; Buehl, Alexander, & Murphy, 2002), psychology (Estes et al., 2003; Hofer, 2000), history (e.g. Buehl & Alexander, 2004; Buehl et al., 2002), biology (Estes et al., 2003; Paulsen & Wells, 1998), chemistry (e.g., Hofer, 2000; Smith, Royce, Ayers, & Jones, 1967 as cited in Muis et al., 2006), and physics (Hammer, 1994; Stathopoulou & Vosniadou, 2007). However, there are a few studies regarding the domain of environment (Öztürk, 2009; Ozturk et al, 2008) and these studies aimed to determine the relationships between epistemological beliefs and environmental behavior by conducting general-epistemological beliefs questionnaire. Thus, investigating directly the PSTs' epistemological beliefs in the needed domain would have valuable contribution to better understanding of domain generality-specificity of epistemological beliefs.

4. The investigation of epistemological beliefs in the domain of environment through comparing with other domains may have potential contributions to the development of questionnaires or interviews regarding domain-specific epistemological beliefs since researchers had difficulty in measuring epistemological beliefs (Debacker, Crowson, Beesley, Thoma, & Hestevold, 2008; Hofer & Pintrich, 1997).

5. The previous studies regarding personal epistemology had a limitation that the data are generally analyzed in dichotomous ways i.e., naïve versus sophisticated rather than in terms of a progression of views (Smith & Wenk, 2006). Thus, through investigating the underlying reasons behind naïve and sophisticated epistemological beliefs the present study provides more elaborated perspective on personal epistemological beliefs. Moreover, investigating underlying reasons behind the PSTs' naïve epistemological beliefs may provide information for

teacher educators or curriculum developers about how they can modify their instruction or teacher education program to support more sophisticated epistemological beliefs. Considering the central role of teachers in environmental education, training the PSTs who will be educators of future generations is crucial to raise citizens behaving environment in desired ways.

6. Buehl (2003) stated that there are few studies on epistemological beliefs conducted in countries other than the United States and those conducted in different countries revealed that the nature and function of epistemological beliefs may change across culture. Thus, the present study investigating Turkish PSTs' epistemological beliefs may yield additional insights into personal epistemology from cultural perspective.

1.7 Purpose of the Study

In response to the existing literature on personal epistemology and environmental education, the present study aimed to examine the PSTs' epistemological beliefs in the domain of environment through comparing with the domains of biology, physics, chemistry, and mathematics.

1.8 Research Questions

The present study investigated the PSTs' domain-specific epistemological beliefs through addressing the following primary and secondary research questions:

What are the PSTs' epistemological beliefs in the domain of environment through comparing with the domains of biology, physics, chemistry, and mathematics?

- What are the PSTs' epistemological beliefs regarding omniscient authority in the domain of environment through comparing with other domains?

- What are the PSTs' epistemological beliefs regarding stability of knowledge in the domain of environment through comparing with other domains?

- What are the PSTs' epistemological beliefs regarding structure of knowledge in the domain of environment through comparing with other domains?

- What are the PSTs' epistemological beliefs regarding control of learning in the domain of environment through comparing with other domains?

- What are the PSTs' epistemological beliefs regarding speed of learning in the domain of environment through comparing with other domains?

CHAPTER 2

LITERATURE

This chapter aims to present a brief review of related literature on the definitions, history, goals, and characteristics of environmental education, the place of knowledge in responsible environmental behavior models, the definitions and history of epistemological belief models, and the domain-generality or domain-specificity of epistemological beliefs.

2.1. Environmental Education

The number of man-made environmental problems such as the level of water and air pollution, depletion of natural resources, and disturbance of natural balance is increasing sharply through the rapid development of science, technology, and industrialization. Moreover, these man-made changes in environment reached a point that poses dangers to well-beings of all living things (UNEP, 1972). The United Nations Conference on the Human Environment, conducted at Stockholm in 1972, proclaimed that the protection and improvement of the human environment should be a major issue of all people around the world. This conference also declared that environmental education is one way to address environmental problems to people around the whole world (UNEP, 1972). Although environmental education gained its international recognition in the United Nations Conference on the Human Environment in 1972, the roots of environmental education in history stem from the mid 50s. In earlier years, the researchers focused on the definitions related to environmental education. Disinger (2001) claimed that it is important to investigate the definition of environmental education since there are some individuals who believed that “if you can name something, you own some knowledge of it" or "knowledge is better displayed if you can provide operational definition" (p.17). However, the study reviewing the history and background of environmental education revealed that there is no generally accepted definition and substantive structure of environmental education. In this study, Harvey (1976) reached a conclusion that it is more appropriate to use the term of man-environment relationship education or people-environment relationship education instead of environmental education. Harvey's and other researchers' attempts to define environmental education appeared to be mediated by the Tbilisi Declaration in 1977 since the Tbilisi declaration was the world's first International Conference on Environmental Education. This conference was organized by the United Nations Education, Scientific, and Cultural Organization (UNESCO) in cooperation with the United Nations Environment Program (UNEP). For this conference, 265 delegates and 65 representatives convened in Tbilisi, Georgia in 1977. As the first director of UNESCO and having a role in preparation of the Tbilisi International Conference on Environmental Education, Stapp (1997) defined environmental education as follows:

> *Environmental education is a process aimed at developing a world population that is aware of and concerned about the total environment and its associated problems, and has the attitudes, motivations, knowledge, commitment and skills to work individually and collectively towards solutions of current problems and the prevention of new ones* (Stapp et al., 2001, p.36).

In addition to the United Nations Conference on the Human Environment, held in Stockholm in 1972, the Tbilisi Declaration also emphasized the important role of environmental education in the preservation and improvement of the world's environment which was followed by numerous international conferences and symposiums on environmental education. One of these international conferences was the Rio Conference on Environment and Development which stressed the importance of environmental education for young people (UNEP, 1992). Among these conferences on environmental education, the contributions of the Tbilisi Declaration were much more than others since in addition to the definition and role of environmental education, in the Tbilisi Declaration the goals and objectives for environmental education were also constructed by 66 member states, 2 non-member states and 20 non-governmental organizations.

The goals that the Tbilisi Declaration endorsed for environmental education as follows:

> • *to foster clear awareness of, and concern about, economic social, political and ecological interdependence in urban and rural areas;*
> • *to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment;*
> • *to create new patterns of behavior of individuals, groups and society as a whole towards the environment* (UNESCO-UNEP, 1978, p.3).

The Tbilisi Declaration also categorized the above-mentioned goals under five objectives:

> • *Awareness: to help social groups and individual acquire awareness and sensitivity to the total environment and its allied problems.*
> • *Sensitivity: to help social groups and individual gain a variety of experiences in, and acquire a basic understanding of environment and associated problems.*
> • *Attitudes: to help social groups and individual acquire a set of values and feelings of concern for the environment and motivation for actively participating in environmental improvement and protection.*
> • *Skills: to help social groups and individual acquire skills for identifying and solving environmental problems.*
> • *Participation: to provide social groups and individuals with an opportunity to be actively involved at all levels in working toward resolution of environmental problems* (UNESCO-UNEP, 1978, p.3).

The above-mentioned goals and objectives of the environmental education suggest that promoting responsible environmental behavior is the ultimate goal of environmental education (Culen, 2001; Hungerford & Volk, 2001). Thus, most of the studies conducted on environmental education gave importance to investigate responsible environmental behavior. Some of these studies focused on the development of models that subsume the best predictors of responsible environmental behavior (e.g., Hungerford & Volk, 2001; Hines, Hungerford, & Tomera, 1986-87 as cited in Culen, 2001; Marcinkowski, 1988) and some on the potential affects of specific instruction on behavior that incorporated numerous variables from these hypothesized models (e.g., Bogner, 1998; Hsu, 2004; Ramsey, 1993). For the present study, it is needed to examine responsible environmental behavior models which involve environmental knowledge since they will provide information regarding to what extent the nature of environmental knowledge and learning was integrated into environmental education. Thus, in the following part detailed information regarding responsible environmental behavior models will be provided in line with the aim of the study.

2.2. The Place of Knowledge in Responsible Environmental Behavior Models

According to Marcinkowski (1988, p.124), responsible environmental behavior can be defined as "the variety of behaviors indicated by individuals, groups, and other entities which are aimed at remediating environmental issues (i.e., both bio-physical and socio-political dimensions of issues). In related to responsible environmental behavior, numerous models were proposed by many researchers in the last three decades. The oldest and simplest model explaining responsible environmental behavior linked environmental knowledge to environmental attitudes (awareness and concern) and environmental attitudes to responsible environmental behavior (Hungerford & Volk, 2001; Kollmus & Agyeman, 2002). This early model of responsible environmental behavior was known as the knowledge-attitude-behavior (K-A-B) model (Marcinkowski, 2001). The model can be represented graphically as in Figure 2.1.

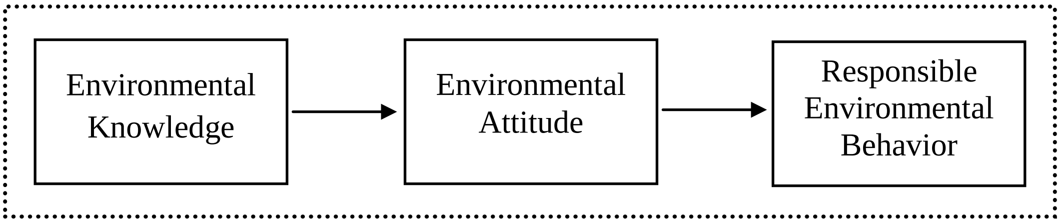

Figure 2.0.1 The K-A-B model (Adapted from Hungerford & Volk, 2001 and Kollmus & Agyeman, 2002).

The K-A-B model assumed that people's behaviors can be shaped in desired ways by just making them more knowledgeable (Kollmuss & Agyeman, 2002). That is, this model suggests that the amount of environmental knowledge that an individual has play a crucial role in showing responsible environmental behavior.

Although the K-A-B model was very pervasive in the field of environmental education, in 80s some researchers reported that the relationships among knowledge, attitude, and behavior are more complex than those are implied in the K-A-B model (Marcinkowski, 2001). Moreover, Culen (2001) argued that if this model explained responsible environmental behavior, there would be a decrease in the numbers of man-made environmental problems around the world in the last three decades. Concerning the K-A-B model, Marcinkowski (2001) also provided similar approach in such he claimed that the model is not enough to guide environmental practices after a number of reviews of the research literature within and outside the field. These findings suggest that environmental knowledge seems to be a variable affecting responsible environmental behavior; however, knowledge itself is not enough. In this respect, a number of researchers investigated a number of variables that can be associated with responsible environmental behavior (Hungerford & Volk, 2001). These investigations provided a number of environmental behavior models; however, the most prevalent ones were developed by Hines et al. in 1986-1987 and Hungerford and Volk in 1990. The Hines et al model, which included the best predictor(s) of responsible environmental behavior, was the product of a meta-analysis of environmental behavior research (as cited in Hungerford & Volk, 2001). According to Kollmuss and Agyeman (2002), Hines et al. (1986-87) found the following variables related to responsible environmental behavior:

- Knowledge of issues which was defined as “one’s understanding of specific environmental issues” (Ramsey, 1993, p.31).
- Knowledge of action strategies which was referred to knowing how you have to act to decrease your affect on the environmental problem (Kollmuss & Agyeman, 2002).
- Locus of control which was defined as an individual’s perception of their ability to result in change in a particular situation through their own behavior. The individuals who have internal locus of control believe that their actions can result in change; however, those who have external locus of control feel that others’ actions bring about change rather than their own actions (Kollmuss & Agyeman, 2002).
- Attitudes
- Verbal commitment which was defined as an individual’s intention to act or behave in specific manner (Marcinkowski, 2001).
- Individual sense of responsibility was defined as an individual’s feelings of duty or obligation toward the environment (Marcinkowski, 2001).

The Hines et al. model can be represented graphically as in Figure 2.2.

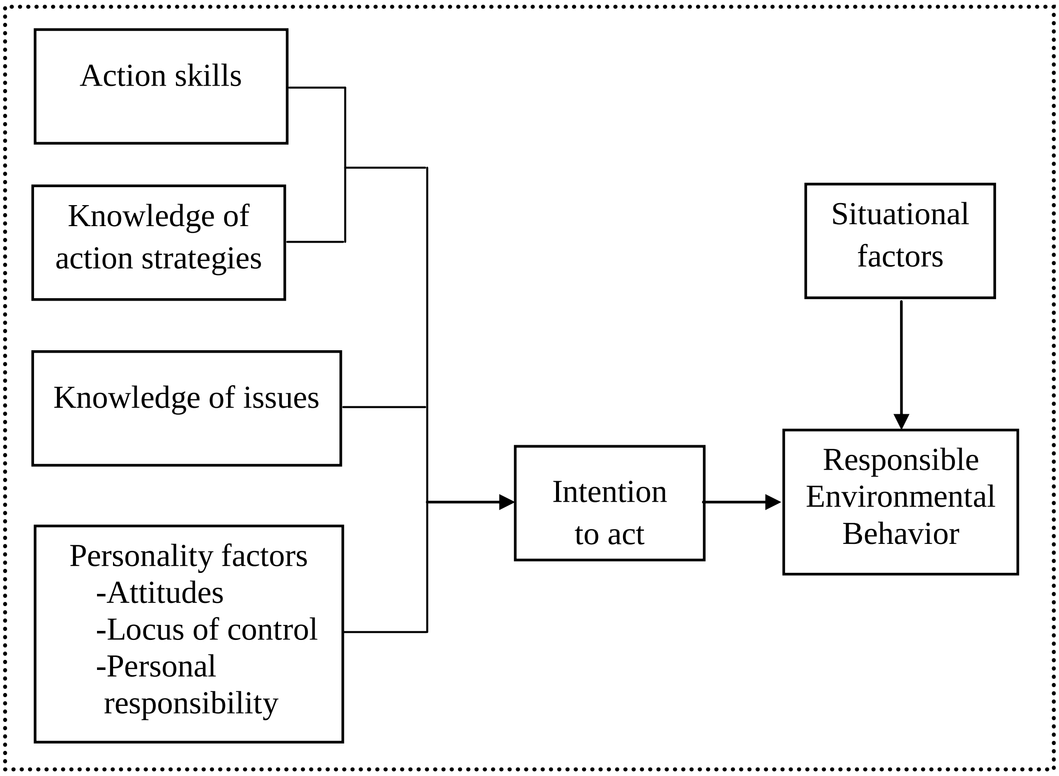

Figure 2.2 The Hines model of responsible environmental behavior (Adapted from Hungerford & Volk, 2001).

According to Lex (2005), the Hines et al. model shows some similarities with the K-A-B model in such both of them proposed that knowledge of environment and environmental issues as well as attitude are factors determining responsible environmental behavior; however, the Hines et al. model proposed some other factors related to responsible environmental behavior such as personality factors (i.e., person's locus of control and feelings of personal responsibility), knowledge of and skill in action strategies and situational factors. In related to these factors, Hines et al. (1986-87) proposed that an individual's cognitive knowledge, cognitive skills, and personality factors should combine with his or her intention to take action to show a responsible environmental behavior (as cited in Hungerford & Volk, 2001). Although the Hines et al. model is more complex than the K-A-B model, Kollmuss and Agyeman (2002) criticized it due to the lack of information regarding the relationships between knowledge and attitudes, attitudes and intentions, and intentions and actual responsible behavior.

Building on the Hines at al. model and other studies, Hungerford and Volk (1990) developed a responsible environmental behavior model in which they categorized variables contributing to behavior into three categories, namely entry-level variables, ownership variables, and empowerment variables (Hungerford & Volk, 2001). Although these variable categories probably act in a linear fashion, there can be synergistic relationships among major and minor variables within each category (Hungerford & Volk, 2001). After presenting Hungerford and Volk's environmental behavior model in Figure 2.3, brief information regarding each variable are provided in the following paragraphs.

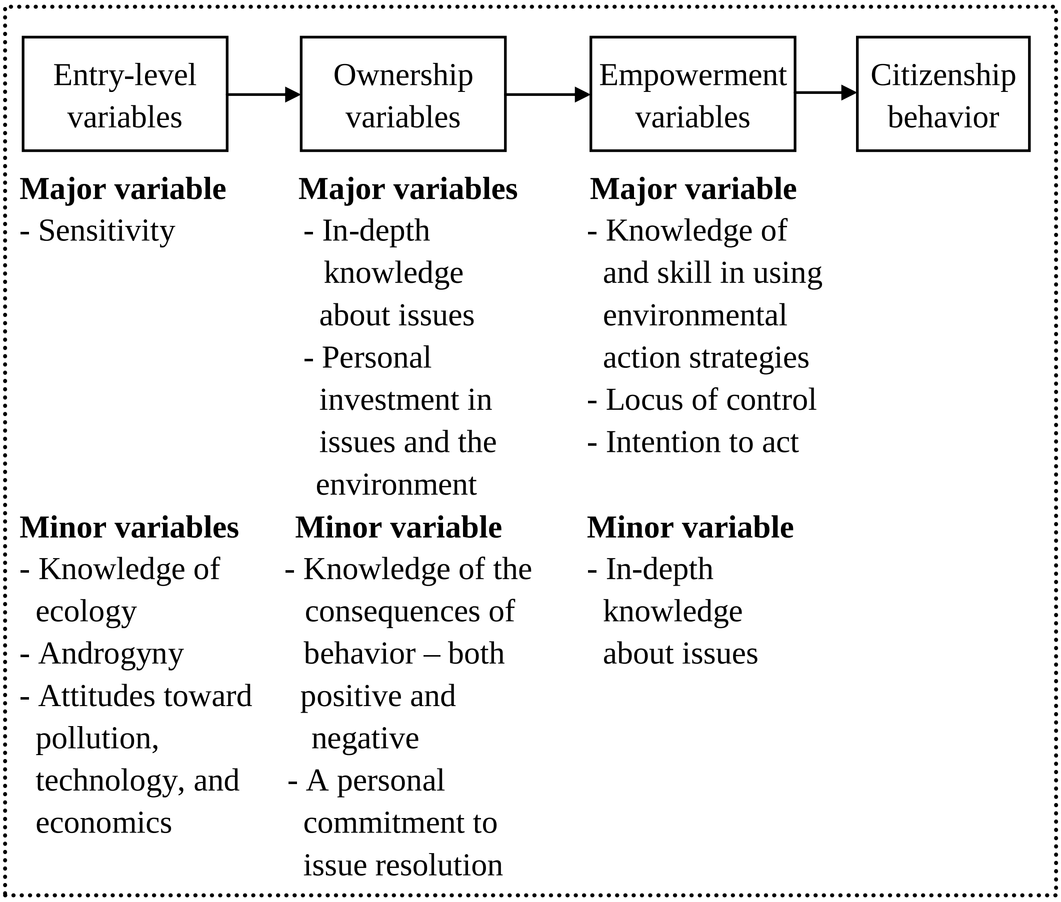

Figure 2.3 Major and minor variables contributing to responsible environmental behavior (Adapted from Hungerford & Volk, 2001).

Hungerford and Volk (2001) described *entry-level variables* as good predictors of responsible environmental behavior or ones that seems to be associated with responsible environmental behavior. Moreover, they stated that entry-level variables would enhance one's decision making once an action is undertaken. *Environmental sensitivity* (one's emphatic perspective toward the environment) was described as the major variable of entry-level variables which is related to responsible environmental behavior while *knowledge of ecology* (ecological conceptual basis for decision-making), *androgyny* (individuals who tend to show nontraditional sex-role characteristics and active in helping resolve environmental issues), and *attitudes toward pollution/technology/economics* were described as significant variables but not as influential as environmental sensitivity variable.

Ownership variables constitute the other variables category that appeared to be important for responsible environmental behavior. These variables make environmental issues very personal. Within this category, there are two major variables, namely *in-depth knowledge (understanding) of issues* and *personal investment*. Although the knowledge of ecology is a minor variable in the entry-level variables, in-depth knowledge about issues is major variable in the ownership variables. Hungerford and Volk (2001) claimed that individuals who deeply understand the nature of issues and its ecological and human implications would show more responsible environmental behavior. Additionally, they see personal investment as ownership itself and they proposed that individuals who feel a substantial personal (economical or ecological) involvement in an environmental issue would probably take responsible environmental behavior (Hungerford & Volk, 2001).

Empowerment variables which were defined as one's feeling regarding his or her ability to make changes and help resolve environmental issues are thought to be crucial in the training of responsible citizens in the environmental dimension (Hungerford & Volk, 2001). According to Hungerford and Volk (2001), *perceived skill in using environmental action strategies* were appeared to be one of the very best predictors of behavior. This major variable of empowerment variables gives individual a sense that they have the power to use citizenship strategies to solve environmental problems. Other major variable of empowerment variables is *knowledge of environmental action strategies* which is listed together with the variable of skill in using environmental action strategies in the model since Hungerford and Volk (2001) claimed that knowledge of environmental action strategies itself is not as powerful predictor as the skill variable. Additionally, they noted that the variables of in-depth knowledge of issues and knowledge of environmental action strategies operate synergistically. In this respect, the Hines et al. model of responsible environmental behavior is different from the Hungerford and Volk model since they represented these two variables separately in their model. Hungerford and Volk (2001) defined *locus of control* as another variable which is important but not as good a predictor as perceived skill in using action strategies. Moreover, they proposed that an individual with an internal locus of control will probably do something to help resolve environmental issues in contrast to other individual with external locus of control. The final variable of empowerment variables is *intention to act*. Hungerford and Volk (2001) proposed that the probability of one's showing responsible environmental behavior increases if s/he intends to take some sort of action. Additionally, they stated that intention to act is closely related with perceived skill in taking action, locus of control, and personal investment.

In summary, three prevalent models of responsible environmental behavior intersect with the variable of knowledge. All of them describe knowledge as one of the important variable that contributes to responsible environmental behavior; however, the Hines et al. model and the Hungerford and Volk model claim that knowledge per se does not determine responsible environmental behavior. Additionally, it is clear that the variable of knowledge was investigated from different perspectives in such the early model of responsible environmental behavior model did not categorized knowledge into different types; however, the Hines et al. model divided knowledge into knowledge of environment issues as well as knowledge of action strategies. Finally, the Hungerford and Volk model considered knowledge as knowledge of issues, knowledge of environmental action strategies as well as knowledge of ecology, and knowledge of the consequences of behavior. These findings suggest that the variable of knowledge is open to further investigation for better understanding of responsible environmental behavior. Thus, the present study investigated the nature of environmental knowledge. To investigate the nature of environmental knowledge individuals should locate environmental knowledge well. That is why knowledge was mainly pictured as knowledge of ecology in all aforementioned models. The present study can provide support for the Hungerford and Volk model since the Hungerford and Volk model highlighted knowledge of the consequences of behavior and knowledge of environmental action strategies except knowledge of ecology. However, the major deficiency of these responsible environmental models is that they did not mention the interdisciplinary nature of environmental knowledge. On the other hand, environmental science is an academic field that focuses on human impacts on natural environment from an interdisciplinary view that encompasses physical sciences and social sciences. All in all, the present study can contribute to these responsible environmental behavior models in two ways. First, it would provide a support to these models by determining what individuals impose the meaning to the nature of environmental knowledge concerning human impact on natural environment. Second, if any it would determine the deficiency in terms of interdisciplinary nature of environmental knowledge and it would give an idea concerning how to reflect this into the existing models. Besides in these models there seems lack of information regarding how that knowledge can be learned and this aspect will also be uncovered by means of the present study.

2.3 The History of Epistemological Beliefs

Epistemology which is the study of the nature of knowledge and knowing has long been investigated by philosophers (Buehl & Alexander, 2001; Hofer, 2001). The term of epistemology stemmed from two Greek words, episteme "knowledge" and logos "explanation" (Buehl & Alexander, 2001). The field of epistemology was particularly structured by the Plato's discussion regarding the nature of knowledge (Buehl, 2003). Around 400 BC, Plato claimed that to call something as knowledge it should consist of three components, namely truth, belief, and justification (Buehl & Alexander, 2001; Muis et al., 2006). Specifically, to call something as knowledge, first you must give a *true* statement. Second, you must *believe* in the truthfulness of that statement. Finally, you must be able to justify the truthfulness of that statement by reason or data (Buehl, 2003; Buehl & Alexander, 2001).

In addition to philosophers, the field of epistemology is also investigated by educational, developmental, and instructional psychologists as well as researchers in counseling, higher education, reading and literacy studies, teacher education, science and mathematics education; however, the focus of their studies was personal epistemology (Hofer, 2002). Although there is not a common definition of personal epistemology (Hofer, 2001; Schommer, 1994a), it is concerned with "how the individual develops conceptions of knowledge and knowing and utilizes them in developing understanding of the world" (Hofer, 2002, p.4). Typically, personal epistemology includes individuals' beliefs regarding what knowledge is, how knowledge is constructed, how knowledge is justified, where knowledge resides, and how knowing occurs (Hofer, 2001, 2002). According to Hofer (2001), there are several approaches that conceptualized personal epistemology in different ways. One of the substantial approaches considered one's beliefs about knowledge and learning as developmental in nature. The second approach defined personal epistemology as a system of more-or-less independent beliefs (Hofer, 2001). Thus, this section first outlines the developmental models of personal epistemology followed by a discussion of the epistemology as a system of independent beliefs.

2.3.1 Developmental Models of Personal Epistemology

A great body of research in the field of personal epistemology points out that one's beliefs regarding knowledge and knowing follows sequential, developmental patterns (Hofer, 2001). There are five main developmental models of personal epistemology which have been empirically identified; the Perry scheme, women's ways of knowing, the Epistemological Reflection Model, reflective judgment, and Kuhn's argumentative reasoning (Hofer, 2001). The descriptions of each developmental model are explained in detail in the next parts.

2.3.1.1 The Perry Scheme

The cornerstone of research in the field of personal epistemology can be traced to the work of William Perry and his research team (Hofer, 2001; Hofer & Pintrich, 1997). In his reissued paperback, *Forms of Intellectual and Ethical Development in the College Years: A Scheme,* Perry (1998) stated that they (Perry and his colleagues of the Bureau of Study Counsel at Harvard College) began their study in 1953 to describe the variety of ways in which Harvard and Radcliffe College students interpret their experiences over their academic years. To understand the reason of such variability they conducted open-ended and relatively unstructured interviews with college students at the end of each of their four years in college. In interviews, students frequently discussed the challenges they experienced in their academic work, social life, extracurricular activities, and jobs. The exhaustive qualitative analyses indicated that the variety of ways which students responded to their experiences in a pluralistic environment are associated with a common directional pattern that characterizes their intellectual and ethical development rather than stable individual differences in personality as they expected to find at the beginning of the study. To describe the sequential, integrated nature of the development they preferred to use the word *position* rather than *stage*. The reason for this was that the word *position* implies "one's stance with respect to knowing, making meaning, and making commitments" (Knefelkamp, 1998, p.xii) and "no assumption is made about duration" (Perry, 1998, p.53). According to their developmental model, students move through sequence of nine positions: Positions 1 through 5 describe the primarily intellectual development while Positions 6 through 9 focus primarily on the ethical development. For their scheme, Perry noted that with respect to different subjects one can be at different positions at the same time.

The nine positions have been grouped into four main, sequential categories (Moore, 1994, 2002): *dualism* (comprising Positions 1 and 2), *multiplism* (comprising Positions 3 and 4), *relativism* (comprising Positions 5 and 6), and *commitment within relativism* (comprising Positions 7 through 9). In their first developmental position, dualism, individuals believe that absolute truths exist for everything (truths are either right or wrong), experts or authority is the ultimate source of truth, and alternative points of view are acknowledged as simply wrong. Next, when individuals begin to view knowledge in a multiple way, they acknowledge the existence of diverse opinion where right answers are not yet known. Such individuals believe that by using right ways or methods authority will find the right answers at some point in the future. At position 4, individuals trust their personal opinions rather than external authority because individuals changed their dualistic view from *not yet known* to *we'll never know for sure*. In the position of relativism, individuals believe that absolute truths could no longer exist for them because truth depends on context and support. Thus, individuals see the necessity of chosing and affirming their own commitments. In the final three positions, individuals make and affirm multiple commitments regarding their careers, partners, values, and personal identity (Moore, 1994, 2002). The similarity of the stages and positions between the Perry Scheme and the remaining four epistemological developmental models were presented in Table 2.1, which was developed by Hofer and Pintrich (1997).

Table 2.1 Models of epistemological development in late adolescence and adulthood

Intellectual and ethical development (Perry)	Women's ways of knowing (Belenky et al.)	Epistemological reflection (Baxter Magolda)	Reflective judgement (King and Kitchener)	Argumentative reasoning (Kuhn)
Positions	*Epistemological perspectives*	*Ways of knowing*	*Reflective judgment stages*	*Epistemological views*
Dualism	Silence Received knowledge	Absolute knowing	Pre-reflective thinking	Absolutists
Multiplicity	Subjective knowledge	Transitional knowing		Multiplists
			Quasi reflective thinking	
Relativism	Procedural knowledge (a) Connected knowing (b) Separate knowing	Independent knowing		Evaluatists
Commitment within relativism	Constructed knowledge	Contextual knowing	Reflective thinking	

Note. Stages and positions are aligned to indicate similarity across the five models. *Note.* Adapted from "The Development of Epistemological Theories: Beliefs about Knowledge and Knowing and Their Relation to Learning" by Hofer & Pintrich, 1997, *Review of Educational Research*, *67*, p.92.

It is important to note that Perry did not explicitly determine college students' beliefs regarding academic knowledge since he also focused on college students' experiences related to their social life, extracurricular activities, and jobs (Buehl & Alexander, 2001). Moreover, there were some limitations in Perry's study such that the sample of his study was predominantly White, elite, male college students and the participants were students from a single college (Hofer & Pintrich, 1997). In spite of these, the Perry' study have substantial contributions to the field of personal epistemology since he was the first to give explanations for how college students made meaning of their educational experiences and his study formed a basis for many other research on personal epistemology in the following years (Hofer & Pintrich, 1997).

2.3.1.2 Women's Ways of Knowing

In her book chapter, *Revisiting Women's Ways of Knowing*, Clinchy (2002) stated that in response to Perry's study with a sample that was predominantly male, Belenky, Goldberger, she and Tarula started a project to investigate the ways that women know information in the world which then culminated in a book on *Women's Ways of Knowing* in 1986. From extensive interviews with a diverse sample of 135 women with respect to age, ethnicity, and social class, they elicited a developmental model consisting of "five different perspectives from which women view the world of truth, knowledge, and authority": *Silence*, *received knowledge*, *subjective knowledge*, *procedural knowledge*, and *constructed knowledge* (Clinchy, 2002, p. 64). She asserted that unlike Perry' positions which are mainly related with the nature of knowledge and truth, their perspectives underline the relationship between women's way of knowing and their self-concept (Clinchy, 2002). Each epistemological perspective of Belenky et al. was lined up to the corresponding position of the Perry scheme in Table 2.1.

One of the ways that women acquire knowledge is *silence*. According to Belenky et al. (as cited in Hofer & Pintrich, 1997) the women in silence have a blind obedience to external authority because they perceive themselves as mindless, voiceless, and powerless with respect to knowledge and truth. When women moved into the perspective of *received knowledge*, they perceive external authority as the only source of the absolute truth. As a result, they can acquire this knowledge by just listening to the external authority. That is, women in received knowledge now have little confidence in their own voice unlike women in silence who believe they cannot understand what authorities say. In the position of *subjective knowledge*, women conceive of truth as personal, private and intuitive. That is, women become their own authorities and they simply accept their inner voices as true rather than what external authority says. In the next way of knowing, *procedural knowledge*, women perceive knowledge as a process that requires work. They now have the voices of reason and test the quality of knowledge by applying objective, systematic procedures. There are two types of procedures that are called "separated knowledge" (a detached, impersonal and critical approach) and "connected knowledge" (an empathic and care approach). *Constructed knowledge* is the last way of knowing wherein women perceive knowledge and truth as contextual. They acknowledge that knowing requires the integration of both subjective and objective strategies and individuals are responsible for the construction of knowledge. In related to the Belenky et al.'s model, Schommer (1994a) claimed that it points out that there is a need for research investigating other epistemological beliefs than beliefs about certainty and source of knowledge.

There are some similarities between the studies of Perry and Belenky et al. First, Belenky et al.'s study did not solely examine epistemological beliefs as in the Perry's study such that the questions asked in the interviews were not necessarily associated with academic knowledge and learning instead they addressed many different aspects of women's lives (Buehl, 2003). Furthermore, the study of Belenky et al. was limited to examination of responses from one gender (Buehl, 2003). Despite of these similarities, the Belenky et al.'s study was differed from the Perry's study such that Perry focused on the nature of knowledge and truth altough Belenk et al. addressed the source of knowledge and truth (Hofer & Pintrich, 1997).

2.3.1.3 The Epistemological Reflection Model

Similarities and differences between the studies of Perry's men (1970) and Belenky et al.'s women (1986) caused Baxter Magolda to investigate the role of gender in college students' epistemic assumptions about the nature, limits, and certainty of knowledge (as cited in Baxter Magolda, 2004). In 1986, Baxter Magolda started her 5-year longitudinal study with 101 randomly selected first year college students (Baxter Magolda, 2002, 2004). She selected such a sample that contains equal number of males and females to make claims about the role of gender (Baxter Magolda, 2004). To reveal students' epistemic assumptions and how their learning experiences affect those assumptions Baxter Magolda conducted annual open-ended interviews in two phases. Phase 1, college phase interviews were related with the roles of students, instructors, and peers in learning, perceptions about evaluation of learning, the nature of knowledge and as well as educational decision making while Phase 2, postcollege phase interviews focused on students' learning experiences and how those experiences affect their thinking (Baxter Magolda, 2002). She also developed and administered the Measure of Epistemological Reflection (MER) to triangulate the interview data (Buehl & Alexander, 2001). Analysis of the interviews yielded the Epistemological Reflection Model (Hofer, 2001). This model consists of a four different ways of knowing characterized by a particular epistemic assumptions: *absolute* (knowledge is certain and authority is the only source of knowledge), *transitional* (knowledge is still certain in some areas while uncertain in other areas where there are different interpretations and authority sometimes is not the source of knowledge), *independent* (knowledge is uncertain and authority is not the source of knowledge), and *contextual* knowing (knowledge is constructed in context by making judgment regarding alternative perspectives on the basis of evidence) (Baxter Magolda, 2002). Each way of knowing of Baxter Magolda was lined up to the corresponding position of the Perry scheme and epistemological perspective of Belenky et al. in Table 2.1.

By using a sample consisting of both males and females, Baxter Magolda was able to build on the single-sex studies of Perry and Belenky et al. (Hofer & Pintrich, 1997). Across the first three ways of knowing she found two distinct gender-related patterns which were not exclusive to one gender. The two patterns within the absolute knowing are receiving (more common among women) and mastery (more common among men). For the transitional knowing, there are patterns of interpersonal (more prevalent among women) and impersonal (more prevalent among men). The patterns for independent knowing are ranged from interindividual (often used by women) to individual (often used by men) (Baxter Magolda, 2002).

Although the study of Baxter Magolda assessed more academically beliefs, similar to Perry she also addressed a number of non-epistemological beliefs such as the beliefs about the role of peers and instructors in learning and students' beliefs about evaluation of learning. That is, Baxter Magolda like Perry primarily focused on the intellectual development of college students (Buehl, 2003).

2.3.1.4 Reflective Judgment Model

Building on Perry's study (1970) and Dewey's (1933, 1938) observation about reflective thinking, King and Kitchener studied how epistemological assumptions affect reasoning (as cited in Hofer & Pintrich, 1997). From both cross-sectional and longitudinal research over 20 years, they elicited and refined Reflective Judgment Model (King and Kitchener, 2002). This model describes how individuals' assumptions regarding the nature, limits, and certainty of knowledge change over time in a developmental fashion and how these epistemic assumptions affect individuals' making judgments about problems with no verified right or wrong answers i.e. ill-structured problems (Mines, King, Hood, & Wood, 1990). The data used to develop Reflective Judgment Model were obtained from interviews with individuals from high school students, college undergraduates, graduate students, and non-student adults (Buehl & Alexander, 2001). In interviews, individuals stated and justified their point of view about four ill-structured problems and responded to six standardized follow-up questions which provided a ground to assess individuals' assumptions regarding the nature of knowledge and the nature or process of justification (Hofer & Pintrich, 1997).

The seven developmental stages of Reflective Judgment Model can be summarized in three major levels: *pre-reflective* (including Stages 1, 2, and 3), *quasi-reflective* (including Stages 4 and 5), and *reflective* (including 6 and 7) (See Table 2.1. Individuals who reason using the assumptions of pre-reflective thinking assume that knowledge is absolute and certain and knowledge is obtained via direct observation or authority figures. On the other hands, individuals who have quasi-reflective reasoning acknowledge uncertainty in knowing and they relate missing information or methods of obtaining the evidence as a reason of this uncertainty. People in reflective thinking are characterized with their assumptions that knowledge is uncertain and actively constructed; knowledge must be evaluated contextually; and the qualities of their judgments are open to reevaluation with respect to available new data or methodologies (King & Kitchener, 2002).

Although King and Kitchener's studies expanded on Perry's views regarding relativism, they have some limitations in such the ill-structured problems used in interview were not related with schooled knowledge (Buehl, 2003; Buehl & Alexander, 2001) instead they were about building of the Egyptian pyramids, the objectivity of news reports, human creation and the safety of chemical additives in food (Buehl & Alexander, 2001). Moreover, the initial purpose of King and Kitchener' study was to understand the processes used in argumentation rather than to develop an epistemological beliefs model (Buehl, 2003).

2.3.1.5 Kuhn's Argumentative Reasoning

Similar to King and Kitchener (1994), Kuhn (1991) also concerned with how epistemological assumptions influence thinking and reasoning (as cited in Hofer, 2001). To investigate this issue, Kuhn selected individuals who were in their teens, 20s, 40s, and 60s (Buehl, 2003; Hofer, 2001; Buehl & Alexander, 2001; Hofer & Pintrich, 1997). The participants of the study were presented three ill-structured problems, namely what causes prisoners to return crime, what causes children to fail in school, and what causes unemployment (Buehl & Alexander, 2001; Hofer & Pintrich, 1997). They were first asked to state and justify their position for each problem and then to generate and rebut an opposing view, offer a solution, and discuss their epistemological reflection on the reasoning presented (Buehl, 2003; Buehl & Alexander, 2001; Hofer & Pintrich, 1997).

The analysis of the participants' responses related to the certainty of expertise elicited three epistemological views: *absolutists*, *multiplists,* and *evaluative* (See Table 2.1). Individuals who hold absolutist view consider knowledge as certain and absolute. Multiplists, on the other hand, question the expert certainty and believed that all views are equally valid. On the contrary, individual who hold evaluative view deny the possibility of certain knowledge and suppose that viewpoints can be compared and evaluated (Buehl, 2003; Buehl & Alexander, 2001; Hofer & Pintrich, 1997).

The Kuhn's classification system is mostly associated with general knowledge beliefs rather than the beliefs about academic knowledge since the participants were chosen from diverse age range and nonacademic problems were used to determine individuals' reasoning and beliefs (Buehl & Alexander, 2001). It is also notable that Hofer and Pintrich (1997) claimed that the findings of Kuhn's study (i.e., only 13 out of 169 subjects were classified in the evaluative category for two or more topics) highlights that the task and domain have an important affect on epistemological beliefs.

In summary, models following a developmental approach assert that an individual's beliefs about knowledge and knowing move through hierarchical stages from naïve to sophisticated epistemological beliefs over time. At each stage, individuals have a particular way of thinking about different epistemological aspects (Kienhues, Bromme, & Stahl, 2008). For example, individuals initially believe that knowledge is simple, certain, and handed down by authority. As individuals experience conflict with their existing epistemological beliefs over time, they reorganize their thinking in such knowledge is complex, tentative, and construed individually. That is, individuals' thinking about different epistemological aspects changes in the same way over time (Kienhues et al., 2008).

2.3.2 Schommer's Epistemological Belief System

Unlike developmental models which have stage-like, unidimensional characteristics (Brownlee, 2003; Kienhues et al., 2008), Schommer considered epistemological perspectives as more than a unidimensional set of beliefs that developed over time (Brownlee, 2003) since Schommer (1994b) argued that considering epistemological beliefs as uni-dimensional may "fail to capture the complexity of epistemological beliefs and may mask the multiple links between personal epistemology and different aspects of learning" (p.300). To investigate these issues, Schommer (1990) developed and validated Epistemological Belief Questionnaire consisting of 63 items which enable college undergraduates to rate their level of agreement on a five-point Likert scale. For the questionnaire, she hypothesized five epistemological belief dimensions which were stated from naïve beliefs:

(a) *Simple knowledge* which ranges from the belief that knowledge is simple to knowledge is complex,
(b) *Omniscient authority* which ranges from the belief that knowledge is handed down by the authority to knowledge is generated from reason,
(c) *Certain knowledge* which ranges from the belief that knowledge is certain to knowledge is tentative,
(d) *Quick learning* which ranges from the belief that learning is quick or not at all to learning is gradual,
(e) *Innate ability* which ranges from the belief that ability to learn is fixed at birth to ability to learn is acquired.

The factor analysis of the questionnaire resulted in four factors, namely innate ability, simple knowledge, quick learning and certain knowledge. Having obtained a set of four factors instead of a single factor, she proposed that epistemological beliefs are a system of beliefs. That is, epistemological beliefs are multidimensional. In addition to this, in her study she found that there is a link between epistemological beliefs and comprehension in such students who consider learning as quick more likely wrote oversimplified conclusions, performed poorly on the mastery test, were overconfidence in test performance while students who conceive of knowledge as certain more likely wrote inappropriate absolute conclusions. These findings provided a ground for further studies regarding the idea of a system of epistemological beliefs (Schommer-Aikins, 2002). In her following studies, she provided additional support for her four-dimensional factor structure of epistemological beliefs (Schommer, 1990) with a sample of high school students (e.g., Schommer, 1993) and other college students (e.g., Schommer, Crouse, & Rhodes, 1992). In the same vein, Schommer's multidimensional conceptualization of epistemological beliefs has been supported by other studies (e.g., Ozturk et al., 2008; Jehng, Johnson, & Anderson, 1993 as cited in Schommer & Walker, 1997; Kardash & Scholes, 1996). Schommer-Aikins (2002) stated that the notion of an epistemological belief system is a product of a synthesis of studies conducted from the late 1960s to the mid 1980s and the desire to capture the complexity of personal epistemology.

More recently, Schommer (1994a) has conceptualized epistemological beliefs within the system as more or less independent. That is, "it cannot be assumed that beliefs will be maturing in synchrony" (Schommer-Aikins, 2002, p.106). This means that an individual may hold different levels of sophistication with respect to different beliefs at the same time. For instance, an individual may strongly believe that learning takes time (a sophisticated belief), yet that individual may concurrently considered that ability to learn is fixed (a less sophisticated belief). In addition to this, Schommer (1994a) claimed that the complexity of epistemological beliefs can be captured better when epistemological beliefs dimensions are pictured as frequency distribution rather than dichotomies or continuums. For instance, a sophisticated learner would probably believe that a large percentage of knowledge is evolving and a small percentage of knowledge is stable.

With Schommer's studies, the epistemological beliefs research has been changed significantly (Buehl, 2003) since she pioneered the approach of multidimensional epistemological beliefs (Kienhues et al., 2008), developed a paper-and-pencil measure of beliefs, and investigated epistemological beliefs within academic context (Buehl, 2003).

As a summary of models concerning epistemological beliefs, the table which was developed by Hofer and Pintrich (1997) was adapted in light of the aims of the present study since this table was a product of comparing and contrasting a number of research that investigated students' thinking and beliefs about the nature of knowledge and knowing. In this table, Hofer and Pintrich categorized different aspects of the various models and theories into two core sets of concerns, namely the nature of knowledge and nature of knowing. As it was seen from the Table 2, Hofer and Pintrich described the nature of learning and instruction and nature of intelligence as peripheral beliefs since they argued that these beliefs are not seen as a part of epistemological beliefs by many researchers except for Schommer. However, according to Schommer-Aikins (2008), studying not only the nature of knowledge beliefs but also learning beliefs would provide deeper understanding of students' epistemological beliefs since both types of beliefs are not independent from each other. Consequently, the Table 2.2 was presented in order to display the dimensions of epistemological beliefs proposed by the theories and models that were discussed up to this point.

Table 2.2 Components from existing models of epistemological beliefs and thinking

	Core dimensions of epistemological theories		Peripheral beliefs about learning, instruction, and intelligence	
Researcher(s)	Nature of knowledge	Nature of knowing	Nature of learning and instruction	Nature of intelligence
Perry	*Certainty of knowledge*: Absolute ↔ Contextual Relativism	*Sources of knowledge*: Authorities ↔ Self		
Belenky et al.		*Sources of knowledge*: Received ↔ Constructed Outside the self ↔ Self as maker of meaning		
Baxter Magolda	*Certainty of knowledge*: Absolute ↔ Contextual	*Sources of knowledge*: Reliance on authority ↔ Self *Justification for knowing*: Received or mastery ↔ Evidence judged in context	Role of learner Evaluation of learning Role of peers Role of instructor	
King &Kitchener	*Certainty of knowledge*: Certain, right/wrong ↔ Uncertain, contextual *Simplicity of knowledge*: Simple ↔ complex	*Justification for knowing*: Knowledge requires no justification ↔ Knowledge is constructed, and judgments are critically reevaluated *Source of knowledge*: Reliance on authority ↔ Knower as constructer of meaning		

Table 2.2 *(continued)*

	Core dimensions of epistemological theories		Peripheral beliefs about learning, instruction, and intelligence	
Researcher(s)	Nature of knowledge	Nature of knowing	Nature of learning and instruction	Nature of intelligence
Kuhn	*Certainty of knowledge*: Absolute, right/wrong answers ↔ Knowledge evaluated on relative merits	*Justification or knowing*: Acceptance of facts, unexamined expertise ↔ Evaluation of expertise *Source of knowledge*: Experts ↔ Experts critically evaluated		
Schommer	*Certainty of knowledge*: Absolute ↔ Tentative and evolving *Simplicity of knowledge*: Isolated, unambiguous bits ↔ Interrelated concepts	*Source of knowledge*: Handed down from authority ↔ Derived from reason	Quick learning: Learning is quick or not at all ↔ Learning is a gradual process	Innate ability Ability to learn is innate ↔ Ability to learn is acquired

Note. Adapted from "The Development of Epistemological Theories: Beliefs about Knowledge and Knowing and Their Relation to Learning" by Hofer & Pintrich, 1997, *Review of Educational Research*, *67*, pp.113-115.

2.4 Domain Generality-Specificity of Epistemological Beliefs

Up to know, it was described the uni-dimensional developmental models and Schommer's multidimensional approach of epistemological beliefs. In addition to dimensionality of epistemological beliefs, there is a frequently discussed question that whether epistemological beliefs are domain-general or domain-specific (Buehl, 2003; Gill, Ashton, & Algina, 2004; Kienhues et al., 2008). According to Muis et al. (2006), both Perry's studies and Schommer's initial studies were conducted with an implicit assumption that epistemological beliefs are domain-general. That is, students hold the same beliefs about mathematical knowledge and knowledge in psychology. However, there is also a view that epistemological beliefs may vary with respect to the domain under investigation (Buehl, 2003; Buehl & Alexander, 2001). More recently, researchers also claimed that epistemological beliefs can be both domain-general and domain-specific concurrently (Buehl, 2003; Kienhues et al., 2008).

According to three recent reviews, to investigate the domain specificity of epistemological beliefs, researchers have been used two designs, namely a between-subjects design and a within-subjects design (Buehl & Alexander, 2001; Muis, 2004; Muis et al., 2006). The between-subjects design has been used to investigate whether students from different domains hold different epistemological beliefs. To do this, the researchers have been selected participants from different disciplines or domain and compared their epistemological beliefs across domains (Buehl & Alexander, 2001). For example, Paulsen and Wells (1998) investigated epistemological beliefs of college students from major fields of humanities and fine arts, social sciences, education, business, engineering, natural sciences and mathematics. They administered Schommer Epistemological Questionnaire to assess 260 college students' beliefs in fixed ability, simple knowledge, quick learning, and certain knowledge. Paulsen and Wells classified the students along two dimensions: hard versus soft (e.g., engineering versus humanities) and pure versus applied (e.g., natural sciences versus education). Based on these classifications, the researchers indicated that students majoring in hard fields hold more naïve beliefs regarding certain knowledge (i.e., viewing knowledge as more certain) than did students majoring in soft fields. Additionally, students majoring in applied fields hold naïve beliefs regarding simple and certain knowledge as well as quick learning (i.e. considering knowledge as more certain and simple as well as learning as quick) than students majoring in pure fields.

Support for domain differences for epistemological beliefs was also found by Lonka and Lindblom-Ylänne (1996). In contrast to Paulsen and Wells (1998), Lonka and Lindblom-Ylänne used different taxonomy to classify the participants. In their study, total of 175 freshmen and fifth year students in psychology and medicine were characterized as dualist or relativist. Lonka and Lindblom-Ylänne indicated that the majority of both psychology and medicine students were relativist; however, dualism was statistically higher among students majoring in medicine while relativism among students majoring in psychology.

Unlike previous studies, King et al. (1990) investigated domain differences using a cross-sectional design. The purpose of their study was to determine whether undergraduate and graduate students' critical thinking scores would show variation with respect to education level, academic discipline, and gender. To investigate this issue, they selected a sample consisting of 40 undergraduate and 40 graduate students. Moreover, there were an equal number of students from each domain. The students' critical thinking was determined by three measures: the Cornell Critical Thinking Test for the ability to solve well-structured problems, the Reflective Judgment Interview for the ability to solve ill structured problems, and the Watson-Glaser Critical Thinking Appraisal for the ability to solve both well-structured and ill-structured problems. They proposed that students in social sciences would perform better on ill-structured problems than those in mathematics since in the social sciences ill-structure problems are more prevalent unlike mathematics where well-structured problems are emphasized. Consistent with their prediction, King et al. found significant main effect for discipline on the Reflective Judgment Interview only. Graduate students majoring in social science scored higher than any other groups. Overall, this investigation along with the previous studies suggests that epistemological beliefs may vary across domains.

Buehl and Alexander (2001) criticized the studies that used between-subject designs i.e., the Lonka and Lindblom-Ylänne study (1996) and Paulsen and Wells study (1998) due to the administration of instrument that were originally developed to determine students' general beliefs about knowledge rather than their beliefs about academic knowledge and domain specific epistemological beliefs. Thus, they argued that the observed differences in epistemological beliefs may be due to the differences in students' general epistemological beliefs rather than different bodies of knowledge. Similarly, Hofer and Pintrich (1997) stated that most of the studies in science and mathematics have not used within-subject designs and so it is not possible to determine whether the observed differences in epistemological beliefs were resulted from general age-developmental differences or domain differences. These highlight that there is a need for research that use within-subjects design to capture students' epistemological beliefs thoroughly across different domains. Consequently, in the present study domain-specific epistemological beliefs were investigated by using within-subjects design.

The within-subjects design has been used to investigate whether students hold different epistemological beliefs across domains. To do this, the researchers require students to "rate their beliefs about different domains and assess whether their epistemic beliefs across domains are similar or different" (Buehl & Alexander, 2001, p.15). For example, Schommer and Walker (1995) aimed to investigate college students' epistemological beliefs regarding mathematics and social studies. To assess students' epistemological beliefs, they used modified version of Schommer Epistemological Belief Questionnaire. In their study, the students completed and instrument by keeping a particular domain in mind (either social science or mathematics). Then they read a passage on social science or mathematics and took a comprehension test on it. The students followed this procedure again but by thinking about the other domain. The results indicated that there are substantial correlations among students' epistemological beliefs across two domains. Moreover, domain-specific epistemological beliefs predicted passage comprehension similarly across two domains. These findings provided a support for a moderate domain-general hypothesis. Concerning Schommer and Walker’s study (1995), Buehl and Alexander (2001) raised several methodological concerns. First of all, they claimed that the domains of mathematics and social sciences do not seem parallel. Second, the Schommer Epistemological Belief Questionnaire was not developed to assess domain-specific epistemological beliefs and it includes items that are not directly related to academic knowledge beliefs. Consequently, the apparent similarities in epistemological beliefs may be attributed to the lack of specificity in the measure.

Similar programs of research on domain-specificity of epistemological beliefs have been conducted in science. For instance, in her work of epistemological beliefs, Hofer (2000) questioned whether first-year college students hold different epistemological beliefs across science and psychology. To test this issue, unlike the Schommer and Walker (1995) study, Hofer developed a questionnaire that measures domain specific epistemological beliefs. For this study, 326 first-year students from an introductory psychology class completed the domain-specific questionnaire for both science and psychology. The results indicated that students hold different epistemological beliefs regarding science and psychology in that knowledge in science is more certain and unchanging than knowledge in psychology; personal knowledge and firsthand experience are sources of justification in psychology rather than science; authority and expertise are the source of knowledge more in science than in psychology; and truth is attainable by experts in science more than in psychology. Although Hofer (2000) used a measure that explicitly assesses domain specific epistemological beliefs, his study was also criticized by Buehl and Alexander (2001). They claimed that Hofer can select chemistry and biology as a target field instead of psychology and science since the term science includes a variety of fields and psychology and science are not parallel in terms of their breath.

Unlike Hofer (2000), Tsai (2006) selected two fields of science, namely biology and physics to investigate domain-specificity of epistemological beliefs. In order to determine Taiwan high school students' views concerning the tentative and creativeness nature of the biology and physics, Tsai developed a domain-specific questionnaire which consists of four scales (i.e., the tentative nature of the biology, the creative future of the biology, the tentative nature of the physics, and the creative nature of physics). The analyses indicated that although the students considered biology and physics as tentative and creative, they strongly believe in the tentativeness of biology more than that of physics. Although Tsai used a domain-specific measure of epistemological beliefs and selected parallel domains, his study was limited in terms of investigating different dimensions of epistemological beliefs.

In summary, both between-subjects and within-subjects design highlighted that epistemological beliefs may depend on the domain under investigation. However, most of the studies regarding domain-specificity of epistemological beliefs focused on mathematics. Consequently, there is a need for research that investigates epistemological beliefs in different domains. Moreover, there are some evidences supporting that epistemological beliefs may be both domain-general and domain-specific which points out that much more research is needed that examine dimensions of epistemological beliefs. Because of the above-mentioned reasons, in the present study epistemological beliefs regarding the source, justification, certainty, and structure of knowledge as well as the control and speed of learning were examined in the domain of environment through comparing with other domains that were previously investigated in other studies.

CHAPTER 3

METHOD

In this section, method of inquiry for the present study is explained in detail. In the first part the design of the study is described. Then, the participants and instrument of the study are presented. These parts are followed by the procedures of data collection and data analysis. Finally, the issues related to the trustworthiness of the study are provided followed by assumptions and limitations of the study.

3.1. Design of the Study

There are different types of qualitative study methodologies used in education. The basic or generic qualitative study, ethnography, phenomenology, grounded theory, and case study are the five most commonly used types of qualitative studies in education (Merriam, 1998). Among them the design of the present study was based on the basic or generic qualitative approach due to the following reasons:

First, according to Merriam (1998, p.11), one of the basic characteristics of basic or generic qualitative approach is that it simply seeks to "discover and understand a phenomenon, a process, or the perspectives and worldviews of the people involved" rather than focusing on culture, building a grounded theory or focusing on intensive case studies and for the present study the researcher investigated the PSTs' understandings regarding the nature of knowledge and learning in the domain of environment through comparing with that of in the domains of biology, physics, chemistry, and mathematics. To do this, as Merriam (1998) stated the researcher identified recurrent patterns in the PSTs' explanations regarding epistemological beliefs across domains. Second reason to use the basic or generic qualitative approach in the present study was that Merriam (1998, p.11) pointed out that “concepts, models, and theories in educational psychology, developmental psychology, cognitive psychology, and sociology” are generally used in the basic or generic qualitative study and for present study the PSTs’ understandings regarding domain-specific epistemological beliefs were drawn from the literature on personal epistemology and environmental education.

3.2. Participants

For the present study, the research questions were addressed by using data obtained from the PSTs who will teach elementary school science for 6th through 8th grade students after graduation. Since teachers play central role in attaining the goals of the EE (WCED, 1987) and since teachers’ epistemological beliefs affect their teaching practices (Pajares, 1992), understanding the PSTs’ environmental epistemological beliefs would be crucial. All PSTs were senior in Elementary Science Education program of Education Faculty at Middle East Technical University (METU). Thus, they would have some beliefs regarding nature of knowledge and nature of learning in the domains of environment, biology, physics, chemistry, and mathematics since they had completed a variety of courses related to environment, biology, physics, chemistry, and mathematics as prerequisite courses in the ESE program. Because of having similar age, they would not have so much difference in their epistemological beliefs caused by their development. If there are any differences in the PSTs’ epistemological beliefs they would probably be related to the characteristics of domains under investigation. In addition to these, the participants of this present study were also registered for an elective course of Laboratory Applications in Science and Environmental Education in the fall semester of 2008-2009 at Middle East Technical University. This course was described as an environmental laboratory course which provides opportunities for students to be equipped with necessary skills and knowledge to access and evaluate scientific and environmental issues. Thus, the participants were expected to be motivated to provide detailed information regarding their epistemological beliefs in the domain of environment. Considering those reasons, purposive sampling method was used. In addition to these, convenience sampling method was also used since the participants of the present study were from the university where the researcher is working as a research and teaching assistant. Totally, 12 PSTs participated in the present study. All participants were female. All participants' major was elementary science education and their minor was elementary mathematics education. They had an age range from 21 to 23 with an average of 22 years (*SD*=0.85). Their cGPA scores varied between 2.35 and 3.41 out of 4 with an average 2.79 (*SD*=0.35). Of participants, 10 PSTs lived in city while 2 PSTs in town before entering METU. The educational levels of participants' mothers were primary (33.3%), secondary (25.0%), high school (33.3%), and university (8.3%) while educational levels of their fathers were primary (33.3%), secondary (8.3%), high school (25.0%), and university (33.3%). In addition to these background characteristics, the participants' characteristics related to environment were also obtained. The vast majority of the participants thought that their parents have adequate environmental concerns (58.3 %). All participants had taken at least one course related to environment. The participants liked most of the taken environmental courses (86.4%). The vast majority of the participants believed that they have adequate level of environmental knowledge (58.3%). Of the participants, 91.7% were not a member of a non-governmental organization (NGO). The participants generally considered newspaper (100.0%) and TV (91.7%) as the sources of their environmental knowledge rather than magazines (41.7%) and internet (41.7%). The Table 3.1 gives more detailed information regarding the participants' characteristics related to environment.

Table 3.1 The participants' characteristics related to environment

	Frequency	Percent (%)
Parents' Environmental Concern		
Inadequate	1	8.3
Poor	4	33.3
Adequate	7	58.3
Good	0	0
The Number of Taken Environmental Courses		
1	4	33.3
2	6	50.0
3	2	16.7
Degree of Enjoyment of Taken Environmental Courses		
Dislike	3	13.6
Like	19	86.4
Environmental Knowledge Level		
Inadequate	1	8.3
Poor	4	33.3
Adequate	7	58.3
Good	0	0.0
Membership of a NGO		
No	11	91.7
Yes	1	8.3
TV (Environmental knowledge source)		
No	1	8.3
Yes	11	91.7
Frequency of TV		
Never	1	8.3
Sometimes	8	66.7
Often	3	25.0
Always	0	0.0

Table 3.1 *(continued)*

Newspaper (Environmental knowledge source)		
No	0	0.0
Yes	12	100.0

Frequency of Newspaper		
Never	0	0.0
Sometimes	9	75.0
Often	3	25.0
Always	0	0.0
Magazine or Journal (Environmental knowledge source)		
No	7	58.3
Yes	5	41.7
Frequency of Magazine or Journal		
Never	7	58.3
Sometimes	4	33.3
Often	0	0.0
Always	1	8.3
Internet (Environmental knowledge source)		
No	7	58.3
Yes	5	41.7
Frequency of Internet		
Never	7	58.3
Sometimes	5	41.7
Often	0	0.0
Always	0	0.0

3.3. Instrument

In this study, Personal Information Sheet and Interview Protocol developed by Schommer-Aikins (2008) were utilized to collect data from the PSTs.

3.3.1. Participant Personal Information Sheet

As indicated at Appendix A, there were 14 questions that provided personal information regarding background and environmental characteristics of the PSTs:

- Background characteristics of the PSTs: gender, age, academic major, grade level, cGPA, educational levels of parents.

- Environmental characteristics of the PSTs: thought of their parents' environmental concerns, taken environmental courses in the university, the degree of enjoyment of taken environmental courses, the thought of their environmental knowledge level, membership of a NGO, and the ways of development of their environmental knowledge with their frequencies.

3.3.2 Interview Protocol

The major data source of the present study was a semi-structured interview which was developed by Schommer-Aikins (2008). For the present study, some changes in Schommer-Aikins's interview protocol were conducted by the researcher. One of the changes done was related to domain characteristics of the interview protocol. The original version of the interview protocol was developed to assess individuals' beliefs regarding epistemological beliefs in the domain of mathematics; however, the aim of the present study was to investigate the PSTs' epistemological beliefs in the domain of environment through comparing with the domains of biology, physics, chemistry, and mathematics. Thus, for the present study the questions related to epistemological beliefs were asked not only for mathematics but also environment, biology, physics, chemistry. Second change in Schommer-Aikins's interview protocol was that the questions related to study habits and the numbers of solutions to most problems found in the textbooks were taken out by the researcher since these questions were not appropriate for the purposes of the present study. Thus, the interview protocol that was conducted for the present study includes 11 questions (See Appendix B). Examples of the interview questions were given below:

- Where do you think (environmental/ biological/ physical/ chemical/ mathematical) knowledge comes from?
  [Source of knowledge in the domains question]

- Some people think that the ability to learn in (environment/ physics/ chemistry/ biology/ mathematics) concepts is mostly inborn, that is, some people are born good learners, others are not. On the other hand, some people think that we actually learn how to learn. We can literally improve our ability to learn. What do you believe about the ability to learn?

  Assign percentages to the following two categories. You are free to assign 0% or 100% or anything in between.

  ____Percent of ability to learn in (environment/ physics/ chemistry/ biology/ mathematics) due to genetical predisposition.

  ____Percent of ability to learn in (environment/ physics/ chemistry/ biology/ mathematics) due to learning how to learn.

  [Control of learning in the domains question]

3.4. Data Collection Procedure

After literature review and preparation of the interview protocol, the researcher took the required permission for conducting research involving human subjects from Ethical Committee of METU (See Appendix C). Then data collection of the present study was conducted in October 2008. Before conducting interviews, the purpose of the present study was explained to the participants in the first meeting of their elective course as to learn what they believe about the nature of knowledge and nature of learning. After that, consent form and personal information sheet were distributed to the participants. All participants accepted to participate voluntarily in the present study and they were interviewed individually during their free days by the same researcher in order to ensure consistency of data collection procedure and to obtain maximum reliability on the data. The interviews took approximately an hour. Interview data were tape recorded and transcribed in verbatim. This provided researcher to preserve everything the participants said for analysis.

During each interview, the participants were told that information they provided in the personal information sheet will be used in order to investigate the responses given to interview questions in detail. Then the researcher started to conduct interview after the repetition of the purpose of the study. After having told that participants' answers, personal identification information and the audio-records will be kept strictly confidential, it was clearly expressed that the interview questions do not have any right or wrong answers and the PSTs will not being assessed on the nature of their beliefs. In this way, it was assumed that the PSTs would not give answers that do not reflect their own beliefs in order to get higher grades from the course. After the purpose of the study and confidentiality of the data were provided to the participants, it was added that during the interviews the participants are allowed to speak in their native language in order to express their thoughts clearly and thoroughly; however, the interview questions will be given in English. The reason of this was explained to the participants as to reduce the change or loss of meaning in translation. This procedure was followed since the language of instruction at the university was English and so the participants were expected to have a certain level of English proficiency. However, it was also highlighted to the participants that if they still need help for further clarification, the researcher will provide necessary clarification. Then each interview question was asked for each domain and answers related to the particular domain were noted under the corresponding column on a piece of paper. For instance, one of the interview questions was "how do you know when information is true or not?" After asking this question for the domain of environment as "how do you know when information in environment is true or not?", the researcher wrote what the participant said under the column of environment on a piece of paper then the question was asked for the domain of physics by just putting physics instead of the word of environment such as "how do you know when information in physics is true or not?" Similarly, the researcher wrote what the participants said regarding physics under the column of physics on the paper. This procedure was followed for each domain. It was felt that participants' responses in this way were appropriate for eliciting differences in epistemological beliefs with respect to domains. When the researcher did not understand some parts of participants' responses, she asked non-leading follow-up probes such as, “Could you tell me more” and “What do you mean by that”. Probes were generally asked to elaborate the PSTs’ initial responses or researcher’s interpretation of a response in order to get more clear and detailed information regarding their epistemological beliefs.

3.5 Data Analysis Procedure

The data of the present study were analyzed through descriptive statistics and Miles and Huberman approach (1994):

3.5.1 Descriptive Statistics for Data Analysis

The descriptive statistics were used to describe the basic characteristics of the participants as well as to indicate the number of occurrence of codes or categories. However, descriptive statistics were also used in the analyses of some interview questions since the PSTs assigned percentages for some of the questions, namely the questions of trust in authority, stability of knowledge, control of learning, and speed of learning. To exemplify, for the trust in authority question the PSTs assigned percentage of time they believe in experts in the domains. In this question, the researcher aimed to assess whether the trust in experts in the domain of environment was higher or lower than that in other domains. To explore this, the frequencies regarding percentage of time were compared across domains in such the more the PSTs trust in experts in the domain of environment than other domains the more frequency would be obtained in the higher percentage of time in the domain of environment. In addition to frequencies, the researcher sometimes used means and standard deviations to analyze the data of the present study. For instance, for the control of learning question the PSTs assigned percentages to two categories which were “percentage of ability due to genetical predisposition” and “percentage of ability due to learning how to learn”. In this question, the researcher aimed to investigate the PSTs’ thoughts whether they believe that learning in the domain of environment is more innate or improvable than that in other domains. To investigate this, the means and standard deviations of two categories were compared across domains in such the more the PSTs believe that learning in the domain of environment is innate the more mean score for the category of "percentage of ability due to genetical predisposition" would be obtained in the domain of environment rather than other domains. These analyses were presented under the related topics in results section.

3.5.2 The Miles and Huberman Approach for Data Analysis

In this present study, the Miles and Huberman approach (1994) was used to analyze the PSTs' explanations given for the questions regarding source of knowledge, justification of knowledge, stability of knowledge, control of learning and speed of learning. In this approach, analysis of qualitative data involves three components; data reduction, data display, and conclusion drawing and verification.

According to Miles and Huberman (1994), one part of data analysis is to reduce the data analytically through the production of session summary sheet, document sheet, and development of coding categories, writing memos, and the interim summary to make decisions regarding how to display them. This data analysis process is conducted during and after data collection. In this study, during each interview session the researcher formed a table whose columns were the names of the domains while rows were the interview questions. In these tables, the researcher took notes summarizing what the participant said related to the particular interview question and the particular domain. Thus, when an interview session finished the researcher got an idea regarding what issues were covered related to each epistemological beliefs dimension by just looking these notes and the table. That is to say, the researcher formed a session summary sheet for each participant to reduce the data of the present study. In addition to this, in this study the researcher also used interim summary for the deduction of the data in such during coding the researcher formed another table for each interview question covering the names of the codes, the participants who stated the each code, and descriptions of the codes for each domain. While forming these interim summaries, the researcher also obtain information regarding differences between codes or differences in the description of the particular code across domains. That is, the researcher sometimes used her memos to reduce the interview data.

Data display is the second component of the Miles and Huberman approach (1994). There are many ways of displaying data, of which the matrix is one of the main types and a table with rows and columns is an example of a matrix (Miles & Huberman, 1994). In this study, with the help of summary sheets the researcher formed checklist matrices to describe the PSTs' epistemological beliefs across domains. These checklist matrices included descriptions and representative quotations of each code across domains. See Appendix D for translated interview quotations presented at these checklist matrices.

According to the Miles and Huberman approach (1994), the third component of data analysis is drawing conclusion from the data and verification. In this study, to understand whether there is a difference across domains in terms of epistemological beliefs the researcher read many times all interview documents and summary sheets to make sense of the PSTs' explanations given for each interview question, counted the occurrence of codes across domains for each epistemological beliefs question; and contrast and compared each code across domains. That is to say, the researcher used the PSTs' epistemological beliefs in the domains of biology, physics, chemistry, and mathematics as a standard to determine the level of sophistication in the domain of environment. The verification of data analysis is related to "whether the meanings you find in the qualitative data are valid, repeatable, and right" (Miles & Huberman, p.245). That is, the verification of the data analysis is related to validity and reliability of the study which will be explained in detail under the heading of trustworthiness of the study.

3.6 Trustworthiness of the Study

Any research no matter it is quantitative or qualitative is trustable if it provides reliable and valid knowledge in an ethical manner (Merriam, 1998). To ensure the trustworthiness of this qualitative study, issues related to validity, reliability, and ethics were taken into account throughout the study and they were presented in the following part.

3.6.1 Validity

There are eight strategies that are frequently used in qualitative research and at least two of them are recommend to be considered in any study (Creswell, 2007). To ensure the validity of this qualitative study, three of validation strategies were used: (1) peer review or debriefing; (2) clarifying researcher bias; and (3) rich, thick description.

3.6.1.1 Peer Review or Debriefing

Lilcoln and Guba (1999) define peer review or debriefing as an external check of the inquiry process. This reviewer is the inquirer's peer who knows a great deal about the area of the inquiry and the methodological issues and s/he has an important role to keep the inquirer honest; ask challenging questions regarding methods, meaning, and interpretations; and by listening the inquirer sympathetically help the inquirer to clear the mind from emotions or feelings that may affect the quality of the inquiry (Lilcoln & Guba, 1999). In this study, it was asked a peer who is a well-known researcher in the field of personal epistemology to comment on the methodology of the study. Moreover, after the researcher analyzed each dimension of epistemological beliefs the findings were also peer reviewed by the thesis supervisor. Consequently, this study ensured the peer review for the validity.

3.6.1.2 Clarifying Researcher Bias

A researcher can ensure the internal validity of the study by clarifying their "assumptions, worldview, and theoretical orientation at the outset of the study" (Merriam, 1998, 205). In this clarification, the researcher gives information regarding his or her position, biases, assumptions, past experiences that may affect the study (Creswell, 2007). The findings of the present study may be biased due to the thought that the participants of this study do not have beliefs regarding the nature of environmental knowledge and learning. Thus, while coding the researcher might not code some parts of the participants' explanations which can actually represent the nature of environmental knowledge and learning.

3.6.1.3 Rich, Thick Description

Lilcoln and Guba (1999) stated that although the question of what constitutes thick description is still under question, the researcher can establish transferability by describing in detail the participants or setting under study. Rich, thick description provides the reader to decide whether it is possible to transfer the findings of the study to other settings (Merriam, 1998; Lilcoln & Guba, 1999). In this study, to display the data checklist matrices were constructed which was crucial to establishing the trustworthiness of my procedure. Moreover, the characteristics of each participant were given in detail in the "participants" part of the methodology section and in the result section the quotations of a particular code were presented at the matrices with the participants' numbers so that the reader can establish relationships between the data and characteristics of the participants. Thus, it was assumed that widest range of information regarding the participants and setting of this study were presented in this study.

3.6.2 Reliability

The reliability in the qualitative research is different from whether the findings of the study can be replicated (Merriam, 1998). Instead, it refers to "the stability of responses to multiple coders of data sets" (Creswell, 2007, p.210). That is, reliability in the qualitative research is related to dependability of the results obtained from the data (Lilcoln & Guba, 1999).

To indicate that the findings of the research are reliable (dependable) it is enough to show that they are valid since validity cannot be obtained without reliability (dependability) (Lilcoln & Guba, 1999). In this respect, it can be said that the findings of this study are reliable since the validity of the findings of this study was obtained through debriefing, clarifying researcher bias, and rich, thick description.

The researchers use different ways to show that the results of the research are dependable (Merriam, 1998). One of the ways to ensure the dependability of the qualitative research is intercoder agreement (Creswell, 2007). Thus, intercoder agreement was used to enhance the reliability of the findings in this qualitative study.

3.6.2.1 Intercoder Agreement

In intercoder agreement process of this study, the researcher first developed a code sheet that includes tentative names of the codes and a tentative definition of each code. Then the researcher met with the thesis supervisor to explain the code sheet. In this step, the names of some codes were sometimes revised or some codes fell within a more general code through discussions. After deciding the codes, thesis supervisor look at the passages that the researcher coded and assigned a code word to the passages, based on the definitions in the code sheet. Then we calculated percentage of agreement on these passages that both of us coded. This process was conducted for each interview questions regarding epistemological beliefs. We established 87% agreement for the source of knowledge question, 82% agreement for the justification of knowledge question, 84% agreement for the stability of knowledge question, 90% agreement for structure of knowledge question, 88% for the control of learning question, and

84% agreement for the speed of learning question. Miles and Huberman (1994) recommended an 80% agreement for having reliable data. Thus, the reliability of the data as intercoder agreement was ensured in the present study since the researcher obtained more than 80% agreement for each interview questions regarding epistemological beliefs.

3.6.3 Ethics

Every researcher should consider three important issues to ensure that their research are ethical; protecting participants from harm, ensuring confidentiality of research, and deception of participants (Fraenkel & Wallen, 2006). The participants were not harmed physically or psychologically during this study since consent forms were given to the participants. In this consent forms, it was said that the interview does not contain questions that may cause discomfort in the participants followed by if they feel uncomfortable they are free to quit from the study at any time. The confidentiality of this study was also guaranteed since the participants' answers to interview questions, personal identification information and the transcripts of the audio-records were kept strictly confidential in every step of this study by assigning numbers to the participants rather than using their names; their answers and the transcripts of the audio-records were evaluated only by the researchers; and the obtained data were used for scientific purposes. Finally, the participants in this study were not deceived since in the consent forms the participants were provided enough information regarding the aim of the study and the researchers' contact information including their phone numbers and e-mail addresses were given in order to answer their questions related to this study after all interviews were conducted.

3.7 Assumptions of the Study

The following assumptions were made for this study:

1. To discover, understand, and gain insight into epistemological beliefs in the domain of environment the participants of this study were selected based on purposeful sampling by deciding their grades and ages. Thus, it was assumed that the participants of this study constituted a sample that the most can be learned regarding epistemological beliefs in the domain of environment.

2. The major data source of the present study was interviews and each participant was interviewed face to face during their free times. Thus, it was assumed that interviews were conducted under standard conditions.

3. The major data of the present study was tape recorded. Thus, it was assumed that the participants' responses were not so much affected being recorded. The reason for this was that most researchers indicated that participants of any study forget being taped after answering some initial questions in the interview (Merriam, 1998).

4. To investigate epistemological beliefs in the domain of environment the researcher analyzed responses given to interview questions by the PSTs who registered for "Laboratory Applications in Science and Environmental Education" elective course. Thus, it was assumed that the PSTs participated in the study responded interview questions sincerely. To ensure this, during the interview it was many times said that the interview questions do not have any right or wrong answers and the participants will not being assessed on the nature of their beliefs during the course.

3.8 Limitations of the Study

The major limitations of this study were:

1. The participants of this study were 12 volunteer female PSTs who had been enrolled in the course of "Laboratory Applications in Environmental

Education" in the fall semester of 2008-2009 academic year. Consequently, the results of this study may only be generalized to individuals whose credentials and academic experiences are similar to those studied.

2. Since the present study was a qualitative research, data collection and data analysis procedure may be limited by the researcher's background.

3. Completion time of interviews took about one hour and this might cause boredom and tiredness for some participants.

CHAPTER 4

RESULTS

In this chapter, the results of the study were presented in five sections consisting of five dimensions of epistemological beliefs: omniscient authority, stability of knowledge, structure of knowledge, control of learning, and speed of learning. The first three sections revealed the PSTs' epistemological beliefs regarding knowledge and the remaining ones indicated their epistemological beliefs regarding learning in the domains of environment, biology, physics, chemistry, and mathematics.

4.1 Omniscient Authority

Examining first three questions about the degree of trust in experts, source of knowledge, and the justification of knowledge in the domains of environment, biology, physics, chemistry, and mathematics elicited the PSTs' domain-specific epistemological beliefs in the dimension of omniscient authority.

4.1.1 Trust in Experts

The degree of trust in experts is about to what degree the PSTs believe experts in any domain. The one's beliefs regarding degree of trust in experts can be placed on a continuum that ranges from objectively tied to experts' perspective (naive epistemological belief) to the subjectively tied to experts' perspective (sophisticated epistemological belief). In the following part of the result section, the analysis of the PSTs' responses regarding the degree of trust in experts was presented in the domains of environment, biology, physics, chemistry, and mathematics.

To elicit the PSTs' beliefs regarding the degree of trust in experts, they were asked to assign percentage of time that they believe experts in the domains of environment, biology, physics, chemistry, and mathematics. The analysis of the PSTs' responses was presented in Table 4.1.

Table 4.1 The degree of trust in experts across domains

Trust in Experts	**Domain**				
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**
45-64% of the time	2	1	0	0	3
65-79% of the time	1	3	1	2	0
80-100% of the time	8	8	11	10	9

From the frequencies indicated in Table 4.1, it was observed that no matter what the domains are the vast majority of PSTs believed in experts 80% or more of the time. This indicated that there is little disagreement among the PSTs with respect to trusting experts. That is to say the PSTs had a high degree of faith in an expert's words in all domains. In this respect, the PSTs assigning high percentages for their degree of trust in experts hold naïve epistemological beliefs. When the PSTs' responses were taken into account across domains, it was seen that the PSTs have less confidence in experts' opinions in the domain of environment over the other domains.

4.1.2 Source of Knowledge

The source of knowledge question is related to the one's beliefs regarding the generation of knowledge and this dimension is placed on a continuum that ranges from the belief that knowledge originates outside the self and resides in external authority (naive epistemological belief) to the belief that knowledge is actively constructed by the person in interaction with others (sophisticated epistemological belief). In the following part of the result section, the analysis of the PSTs' beliefs regarding the source of knowledge was presented in the domains of environment, biology, physics, chemistry, and mathematics.

The analysis of the PSTs' responses for the source of the domain knowledge resulted in seven main codes which were named as "formal education", "experiences/observations", "experts' scientific investigations", "informal education", "curiosity", "logic/ reasoning", and "imagination". The source of knowledge codes and their frequencies were presented in Table 4.2.

Table 4.2 The source of knowledge codes with their frequencies across domains

Source of Knowledge Code	**Domain**					**Total Frequency**
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**	
Formal education	5	6	6	6	6	29
Experiences/ observations	5	8	6	4	3	26
Experts' scientific investigations	4	2	5	6	1	18
Informal education	5	2	2	1	1	11
Curiosity	1	3	2	1	1	8
Logic/ reasoning	0	0	0	0	3	3
Imagination	0	0	0	0	2	2

From the total frequency of each source of knowledge code, it was seen that the most frequent code was "formal education". This code includes the statement that knowledge comes from general education at schools, courses at school or from the teacher. From the frequencies tabulated in Table 4.2, it was seen that there was a little variances in responses for the source of knowledge as the code of "formal education" in that the PSTs believed that no matter what the domains are their knowledge comes from formal education. For example, the below quote was observed in the domain of chemistry:

> PST 9: In chemistry…Indeed, all of them [environmental, biological, physical, chemical, and mathematical knowledge] occur at first through somebody's triggering. Again, the knowledge I gained in the courses maybe after, this also necessitates an interest. For example, I cannot learn any chemistry. That is, since I do not like chemistry, if I have an interest I read carefully and the details remain in my mind. However, in chemistry according to me a teacher is needed. I cannot learn chemistry by myself. Since I am not interested in chemistry teaching of a course is required for me.

In here it was observed that the PST did not perceive himself or herself as a source of chemical knowledge instead the PST had excessive dependence on external authority such as a teacher to acquire chemical knowledge. In this respect, the beliefs supporting "formal education" code were considered as naïve epistemological beliefs in terms of source of knowledge. The detailed descriptions and representative quotations of "formal education" code across domains were presented in Table 4.3.

Table 4.3 "Formal education" code across domains with representative quotes

Source of Knowledge Code	Domain (Frequency)	Description	Representative Quote
Formal education	Environment (5)	Knowledge comes from school, teacher, or courses that are taken at schools.	PST 5: There are many accumulated knowledge. We learn from books. From teachers, from the university, the courses that we took, from TV. We learn from many sources.
	Biology (6)		PST 1: Again, in the first place, school. Well, since we saw like that. To my mind, it comes school, teacher.
	Physics (6)		PST 3: Physical knowledge is directly from school R: Does it directly come from school? Why? PST 3: Because, well, you learn reasons at school. Well, you learn it is like that at school. Since your family does not explain that look this is buoyancy force or this is the case.
	Chemistry (6)		PST 2: Well, we learn from our environment but we do not name it. Well, if the meal stays outside in the summer, it spoils. However, we cannot explain the reason of it. It was caused by bacteria. We cannot do this but we reach this knowledge: if the meal stays for a long time in the summer then it spoils. I see this from my experiences but I learn at the courses that this is related to this topic or the reason of this event is directly this.
	Mathematics (6)		PST 1: Definitely from the school R: School? PST 1: From primary school. It starts from the first class to forever.

As it was shown in Table 4.2, the second most frequent source of knowledge code referred to "experiences/ observations". This code encompassed *experts' shared experiences/ observations* and *personal experiences/ observations*. In *experts' shared experiences*, the PSTs highlighted that what they know comes from what experts observed/experienced over years. That is, they generally mentioned *experts' shared experiences/ observations* as an accumulation of knowledge. From the frequency of "experts' shared experiences/ observations" it was seen that it was mostly observed in the domains of physics (4 PSTs) with the below representative quote:

> PST 12: It seems that in all positive sciences, there should be a problem so that a solution would be proposed. Well if there was not a problem, it would not be solved. If we look at everything as a problem then it seems that all positive sciences originate from a problem. Well, the existence of the world was a problem. How did it exist? Big Bang happened. This is a solution. The solution of it becomes a theorem.

In this particular answer, the PST focused on a problem that previous people were experienced because the PST thinks that what we know today was originated while experts were solving such kinds of problems. In here, the PST gives importance to agreements on experts' opinions rather than directly depends on experts; however, s/he does not view himself/ herself as a source of knowledge. In this respect, the beliefs supporting "experts' experiences/ observations" were judged as moderate epistemological beliefs regarding source of knowledge.

In the code of personal experiences/ observations the PSTs, however, emphasized their own experiences/observations instead of experts' experiences/observations. When the frequency of personal experiences/observations was taken into account across the domains, it was seen that personal experiences/observations was mostly observed in the domain of biology (5 PSTs) with the below representative quote:

> PST 6: As I said since biology is more related to the human beings maybe it is easier to see. Indeed, in my opinion we can think environment as if it is a sub-branch of biology. That is why in biology some things maybe the simplicity in the biology is that we can do

> more personal observations or it is originated from knowing the things in our body. It is strange that I have never understood biology but I think that it does not also change in it. In biology, it depends on observations and further interpretations.

In here, it was observed that although the PST considers himself/ herself as a source of biological knowledge and not have blind obedience on any external authority, s/he views observations just as *seeing*. As a result, the beliefs supporting "personal experiences/ observations" were considered as moderate epistemological beliefs regarding source of knowledge.

The detailed descriptions and representative quotations of "experiences/observations" code across domains were presented in Table 4.4.

When descriptions of "experiences/ observations" code were considered across domains, it was observed that *personal experiences/ observations* were present in all domains except mathematics. This indicated that the PST believed that they cannot generate knowledge by themselves in the domain of mathematics. In this respect, the PSTs hold less sophisticated epistemological beliefs regarding source of knowledge in the domain of mathematics than other domains.

Table 4.4 “Experiences/ observations” code across domains with representative quotes

Source of Knowledge Code	**Domain (Frequency)**	**Description**	**Representative Quote**
Experiences/ observations	Environment (5)	Knowledge comes from previous experts’ experiences/ observations or personal experiences/ observations.	PST 7: Well, there is environmental knowledge in elementary level. Again, you know, this knowledge emerges from daily life experiences. You know, even a person who not deal with any science can reach that knowledge just by observing it. That is, I think that environmental knowledge is emerged from people’s direct observations or from academic studies.
	Biology (8)	Knowledge comes from previous experts’ experiences/ observations or personal experiences/ observations.	PST 6: As I said since biology is more related to the human beings maybe it is easier to see. Indeed, in my opinion we can think environment as if it is a sub-branch of biology. That is why in biology some things may be the simplicity in the biology is that we can do more personal observations or it is originated from knowing the things in our body. It is strange that I have never understood biology but I think that it does not also change in it. In biology, it depends on observations and further interpretations.
	Physics (6)	Knowledge comes from previous experts’ experiences/ observations or personal experiences/ observations.	PST 12: It seems that in all positive sciences, there should be a problem so that a solution would be proposed. Well if there was not a problem, it would not be solved. If we look at everything as a problem then it seems that all positive sciences originate from a problem. Well, the existence of the world was a problem. How did it exist? Big Bang happened. This is a solution. The solution of it becomes a theorem.
	Chemistry (4)	Knowledge comes from previous experts’ experiences/ observations or personal experiences/ observations.	PST 4: Well, in general chemistry is in daily life. I do not know! Such as it snowed; snow will melt; it rained. I do not know! We see water droplets on the window of the room. Why did this happen? This was caused by evaporation or tea kettle boils. It [chemistry] comes first from the daily life but we learn it without knowing.
	Mathematics (3)	Knowledge comes from previous experts’ experiences/ observations.	PST 5: Again, I think that it was emerged from the need. As I just mentioned, I should determine the area of my field so that I would plant a tree or I should build a barrier so that the man near me would not enter my garden. Therefore, I have this much square meter garden. I need to explain this to him. I have to tell. Or I should plant the seeds with a distance of 10cm or 1 hand span so that their roots would not intermingle. If we look at the first needs. Therefore, even if it is a hand span there is a measurement there and math starts there, anyway.

The third frequently stated code was "experts' scientific investigations" as presented in Table 4.2. In this code like the code of "formal education" the PSTs indicated obedience on experts for evidence of the truth. However, the experts' scientific investigations code differed from the formal education code in terms of the emphasis on experts' active involvement in knowledge generation. That is, in both codes the experts were vital to acquire knowledge; however, in the experts' scientific investigations code the PSTs stated that experts reach that knowledge through processes requiring very active participation. In this respect, the beliefs supporting to the experts' scientific investigations code were considered as more sophisticated than the beliefs supporting the code of formal education in terms of source of knowledge. However, when the code of experts' scientific investigations was compared with the code of experiences/ observations in terms of sophistication the belief supporting to the code of experiences/ observations was considered as more sophisticated since personal experiences/ observations in the code of experiences/ observations included the belief that the PSTs can also be source of knowledge. That is, the PSTs can also actively participate in knowledge generation. When the frequency of experts' scientific investigations was considered, it was seen that the code was mostly observed in the domain of chemistry (6 PSTs) with the below representative quote:

> PST 7: Chemical knowledge depends more on experiments, of course… This is also hmm… chemical knowledge is, you know, somethings such as the properties of the substances. Their, well, knowing the properties of each substance, knowing the atomic structures, these are not observable things. That is to say, by mean of observation, I mean they are not one to one observable. You know, it [knowledge] is got through some things like experiment and inferences. I again want to say that it [knowledge] is something that experts reach.

In this particular answer, the PST believed that knowledge is acquired through processes such as experiments, inferences, and so on that experts have done. The detailed descriptions and representative quotations of the code across domains were presented in Table 4.5.

Table 4.5 “Experts’ scientific investigations” code across domains with representative quotes

Source of Knowledge Code	**Domain (Frequency)**	**Description**	**Representative Quote**
Experts’ scientific investigations	Environment (4)	Knowledge comes from scientific investigations that experts have actively conducted.	PST 7: These are, well environmental knowledge, I think something that can arise more by one to one field research that researchers did. That is, collection of data, analyzing these data. Mostly these make up environmental knowledge. Well, mostly in academic level.
	Biology (2)		PST 11: Environmental things are the things that are already around us. It is more like only scientists and we come out and by observing we decided as this is this, that is that and this knowledge is like that. You know maybe there is a basic knowledge but we were in fact able to investigate this in more depth by the development of technology. R: what about biological knowledge? PST 11: Biological knowledge is like environment.
	Physics (5)		PST 10: Hmm…Again comes from the actual events that occur in nature. The scientists come to my mind directly. Hypotheses are formulated…That is to say, any event in the nature, by formulating hypotheses, by doing various observations and if it is possible by doing experiments by testing we can reach that knowledge.
	Chemistry (6)		PST 7: Chemical knowledge depends more on experiments, of course… This is also hmm… chemical knowledge is, you know, somethings such as the properties of the substances. Their, well, knowing the properties of each substance, knowing the atomic structures, these are not observable things. That is to say, by mean of observation, I mean they are not one to one observable. You know, it [knowledge] is got through some things like experiment and inferences. I again want to say that it [knowledge] is something that experts reach.
	Mathematics (1)		PST 8: Mathematics, you know mathematics comes to me so abstract, to tell the truth. R: Where does this knowledge come from? PST 8: Well, I will say from the theories… R: What do you mean by the theories? PST 8: You know, theories, for example, there are derivations, integral, and so on in mathematics. For instance, these come to me so abstract. These come to me as theories. That is to say, there is no logic.

From the total frequency of each source of knowledge code, it was seen that the next frequent code was "informal education" as shown in Table 4.2. In this code, the PSTs believed that the generation of knowledge relied on interaction with the mass media, their families, or/and friends around them that act as a teacher. That is to say, the PSTs naming informal education as the source of one's ideas were dependent on external sources to receive ideas without much work. In this respect, the beliefs supporting the informal education code were judged as naïve epistemological beliefs in terms of source of knowledge. When the code of informal education was compared with the code of formal education, they were similar in terms of sophistication. However, the code of formal education differed from the code of informal education since in the code of formal education the PSTs mentioned about the program of instruction rather than an unstructured knowledge acquisition taking place outside of the formally organized schools. When the frequency of the informal education code was considered across the domains, it was seen that the code was mostly observed in the domain of environment (5 PSTs) with the below representative quote:

> PST 4: In the first place, I think that it [environmental knowledge] comes from the family. If the family inspires in the child environmental knowledge, a love of nature it seems to me that by being based on this the child would construct knowledge in the future and this knowledge, at the same time, primary school teachers you know especially in kindergarten and first, second, and third grade, teachers are the models. The children behave as how their teachers behave. For example, classroom arrangement, classroom cleaning if the teacher at least as a model inspires this in the child then this becomes the children's character. This knowledge, at first, comes from the family then primary school and from the child's circle of friends. Well, even if the family has given a good education if there are other children around the child who hit and break trees, the child may think that what would happen even if I do.

In this particular answer, it was observed that the PST highlighted the knowledge acquisition that takes place unintentionally in an unstructured environment by means of interaction with family, friends, and the teacher. The detailed descriptions and representative quotations of the code across domains were presented in Table 4.6.

Table 4.6 “Informal education” code across domains with representative quotes

Source of Knowledge Code	Domain (Frequency)	Description	Representative Quote
Informal education	**Environment (5)**	Knowledge comes from family, friends, books, TV.	PST 4: In the first place, I think that it [environmental knowledge] comes from the family. If the family inspires in the child environmental knowledge, a love of nature it seems to me that by being based on this the child would construct knowledge in the future and this knowledge, at the same time, primary school teachers you know especially in kindergarten and first, second, and third grade, teachers are the models. The children behave as how their teachers behave. For example, classroom arrangement, classroom cleaning if the teacher at least as a model inspires this in the child then this becomes the children’s character. This knowledge, at first, comes from the family then primary school and from the child’s circle of friends. Well, even if the family has given a good education if there are other children around the child who hit and break trees, the child may think that what would happen even if I do.
	Biology (2)	Knowledge comes from family	PST 2: Well, it [biological knowledge] seems to me as the same [with chemical and physical knowledge]. Again, we observe. In fact, we learn it [biological knowledge] in a way -mouth, nose, eyes- but with an informed family perhaps s/he learns more professionally. However, if the family is not conscious s/he does not learn the detailed knowledge such as it goes through throat and digested in there. But in general I think that s/he still learns.
	Physics (1)	Knowledge comes from books	PST 1: I think that in physics I have to learn from the teachers or by reading books. Although we are not aware of we have intimate relationships with it. But there must be compulsorily an instructor.
	Chemistry (1)	Knowledge comes from books	PST 1: Chemistry is same with Physics. I think that it is again teacher as well as book, supplementary books.
	Mathematics (1)	Knowledge comes from family, friends, books	PST 1: Maybe by means of some people, such as friends, mother, father. That is to say, since it is mathematics it seems to me that it is more difficult to learn by your own without [help from] people.

The “curiosity” was the next frequently stated code for the source of knowledge as shown in Table 4.2. This code included the statement that knowledge can be generated by one’s curiosity since curiosity has a potential for inducing one to investigate something. When the frequency of curiosity code was taken into account across the domains, it was seen that the code was mostly observed in the domain of biology (3 PSTs) with the below representative quote:

> PST 12: …from curiosity, from the need, from being necessary. I think it is a requirement. It should be. There is no reason. You have to learn biology. Well, because, if people want to know themselves, people first need to recognize their own body; where can you learn that body? I think that it seems you can recognize it only from biology.

In this particular answer, the PST believed that people have curiosity about knowing their own bodies and because of this curiosity they are seeking answers about their bodies. In here, it was observed that the PST did not have a dependence on external source to acquire biological knowledge and the PST acquire biological knowledge in an active way while trying to know his or her body. In this respect, the beliefs supporting to curiosity were considered as sophisticated epistemological beliefs in terms of source of knowledge. The detailed descriptions and representative quotations of the curiosity across domains were presented in Table 4.7.

Table 4.7 “Curiosity” code across domains with representative quotes

Source of Knowledge Code	Domain (Frequency)	Description	Representative Quote
Curiosity	Environment (1)	Knowledge comes from people’s being curious about something.	PST 10: Well, these phenomena are, in fact, present in the nature. People’s curiosities, because of their curiosities people investigate and reach that knowledge.
	Biology (3)		PST 12: …from curiosity, from the need, from being necessary. I think it is a requirement. It should be. There is no reason. You have to learn biology. Well, because, if people want to know themselves, people first need to recognize their own body; where can you learn that body? I think that it seems you can recognize it only from biology.
	Physics (2)		PST 11: There are definitely observations. All in all, you observe something. You are curious about it and you do in-depth investigations in that how it happened or how it can happen.
	Chemistry (1)		PST 6: It also does not change. Maybe the observation part can be narrowed a bit. Since it is composed of very small particles and very small things, it is difficult to observe. But, for instance in a chemical reaction since we observe color change, we wonder what is going on here. We apply the same process and we make an inference by saying that this happened because of these. That is why, it does not change.
	Mathematics (1)		PST 11: The curiosity looks strange in that a couple of people wondered and then others wondered about these previous people’s curiosity. R: What do you mean by curiosity? Can you explain how it can come from curiosity? PST 11: For example, the numbers came out. Well, you have many numbers in your hand. Well, what can these be? What would happen if I add this? For example, if we think the easiest, in four operations we can say that how can I make a connection between this and that? What can be between these numbers? By thinking like that, for instance, human can find addition. After discovering addition, well I can think that I can find another number by adding these numbers. Another number may come out. Then by saying that whether I can play this in a different way I can discover division, subtraction. At the same time, since physics was developed the ones in physics use it. This might have gone on like that. These [ones in mathematics] look at physics and said that something else may happen if these [ones in physics] did like that.

The final two codes regarding source of knowledge were “logic/ reasoning” and “imagination”. Both codes were derived from a few PSTs’ responses and observed only in the domain of mathematics. The code of logic/ reasoning included statements that mathematical knowledge comes from seeking out patterns. The representative quotation of the code was given below:

> PST 10: Again, studying on it. Well, it is not curiosity but how do I say? Can it be with trial and error method?
> R: What do you mean by trial and error method? Can you explain it?
> PST 10: That is, well, when we want to reach a formula it is not like that its formula is this. Well, how do I say? Well, without knowing whether it is true they [experts] had done operations; however, the same result had always been obtained. Well, it had followed the same logic and well, s/he had obtained that knowledge. Through trial and error; however, I could not explain it.
> R: Do you mean with many trials and repetition?
> PST 10: Yes, many trials and repetition. Little logic is included in it.

In this particular answer, the PST emphasized that experts do many operations to find relationships among numbers or variables. In here, it was observed that mathematical knowledge is actively constructed by the person using reasoning and logic. In this respect, the beliefs supporting the code of logic/ reasoning were considered as sophisticated epistemological beliefs in terms of the source of knowledge.

In addition to logic/ reasoning code, the PST believed that mathematical knowledge can also be originated from people’s imagination. In this code, the PST highlighted the process of forming ideas in the mind that is unlike things one has seen. The representative quotation of the code was given below:

> PST 7: I see mathematics as an element that is used for formulating model to understand physics, chemistry, and biology that are in general called as earth science. I mean mathematics alone does not express anything. I think that mathematics is functional only when I create mathematical modeling of topics related to physics or again related to chemistry. I mean, mathematics, in fact, is something created by humans. That is, it doesn’t have a nature. You cannot observe mathematics outside. I mean, you can express what you have observed outside as mathematics but it is not mathematics that does it.

> That is why they see mathematics as an abstract thing. In mathematics, well, I will come to the question that where does mathematical knowledge come from, right? I think that mathematical knowledge also comes from people's imagination and such as comparisons they made based on their imaginations and constructing such relationships.

In this particular answer, it was observed that people can generate mathematical knowledge by using their creativity and resourcefulness. That is, the PST thought that people can be independent source of mathematical knowledge rather than having blind obedience on external sources. In this respect, the beliefs supporting the code of imagination were judged as sophisticated epistemological in terms of the source of knowledge.

In accordance with what has been told and illustrated up to this point, one can conclude the followings regarding source of knowledge across domains:

1. There was a little variance in responses in that for all domains, environment, biology, physics, chemistry, and mathematics the vast majority of the PSTs had dependence on external sources such as formal education, informal education, experts' scientific investigations, experts' shared experiences/observations. In this respect, the vast majority of PSTs hold naïve epistemological beliefs in terms of the source of knowledge in all domains.

2. Although the majority of the PSTs had dependence on external sources of knowledge not only for the domain of environment but also for the domains of biology, physics, chemistry, and mathematics, the comparison of epistemological beliefs across domains revealed an important finding regarding nature of environmental knowledge in that informal education as an external source of knowledge was emphasized especially for the domains of environment.

4.1.3 Justification of Knowledge

The justification of knowledge question is related to how PSTs understand whether knowledge is true or not. PSTs' epistemological beliefs regarding the justification of knowledge can be placed on a continuum that ranges from the belief that knowledge claims are justified through direct observations and authority or on the basis of what feels right (naïve epistemological beliefs) to the belief that knowledge claims are justified through the process of critical inquiry and the evaluation and integration of different sources (sophisticated epistemological belief). In the following part, the analysis of PSTs' beliefs regarding the justification of knowledge was presented in the domains of environment, biology, physics, chemistry, and mathematics.

As shown in Table 4.8, the analysis of PSTs' depictions of justification of the domain knowledge resulted in six main codes which were named as "we never really know for sure", "accept the truth from the authority", "direct observations", "personal check", "experiment", and "proofing".

Table 4.8 Frequencies of justification of knowledge codes across domains

Justification of Knowledge Code	**Domain**					**Total Frequency**
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**	
We never really know for sure	4	4	6	6	5	25
Accept it from the authority	5	4	4	4	6	23
Direct observations	9	6	1	1	0	17
Personal check	4	4	3	3	3	17
Experiment	3	2	4	6	0	15
Proofing	0	0	0	0	6	6

From the total frequency of each justification of knowledge code, it was seen that the most frequent code was "we never really know for sure". This code includes the statement that knowledge is justified on the basis of probability since there is always some ambiguity in knowledge. For example, the below quote was observed very frequently for the chemical, physical and mathematical knowledge:

> PST 3: I do not believe the truth of their [physical, chemical, and mathematical] knowledge, anyway. Well, it seems to me that all of them are assumptions. One emanated and said that this is like that. May be after 5, 10 years or 50, 100 years it will change. I think like that for mathematics and also for chemistry. There is present-day knowledge. You know there are accepted things; however, there is no truth or wrong.

In here it is observed that the PST believed that the existing body of domain knowledge is always open to be changed in the future. As a result, there is no absolute truth. In this respect, the beliefs supporting the code of "we never really know for sure" were considered as sophisticated epistemological beliefs in terms of justification of knowledge. From the frequencies tabulated in Table 4.8 and Table 4.9, it was observed that the code of "we never really know for sure" was mostly seen in the domain of biology and environment. In light of this finding, it was concluded that the PSTs' epistemological beliefs regarding the justification of environmental and biological knowledge were less sophisticated when it was compared with the domains of physics, chemistry, and mathematics. The detailed descriptions and representative quotations of the code across domains were presented in Table 4.9.

Table 4.9 “We never really know for sure” code across domains with representative quotes

Justification of Knowledge Code	**Domain (Frequency)**	**Description**	**Representative Quote**
We never really know for sure	Environment (4)	There is an inherent uncertainty in knowledge so the justification of knowledge is not certain instead it is always open to change in the future.	PST 6: I think that it cannot be known. I mean, if it fits only your ideas, it may come to you as true; however, something related to environment is true or not? As I said before, it remains as something that depends on our own inferences. You and I can make the same inference; however, someone else might think differently. As a result, we cannot know whether it is true or not. There can be doubt within us at every time.
	Biology (4)		PST 10: I mean that any new information that may come can also change it [the existing knowledge in Biology] because perhaps I say this by thinking only one topic in my mind but this can be for every topic. Well, a new knowledge can change.
	Physics (6)		PST 2: Nowadays, I start to think that we know a lot of information but in practice while we are doing in laboratories we make a lot of mistakes. Perhaps, we cannot see exactly…it seems to me that as if we try to make that knowledge true…At this point, I fall into doubt. I wonder how many experiments were done or from which of them we obtain the truth so that there is such an acceptance or such something is taught as certain … it seems to me that we may not be doing somethings because of not knowing or because of our inexperience.
	Chemistry (6)		PST 10: Again, the same thing is valid for me. Both of them [physics and chemistry]...are in the field of science. That is, a field that experiments can be done. I mean that the absoluteness of any knowledge, that is, this is definitely that, the truth is this. We cannot ever say this. With observations or experiments, it was tried to be proven in some ways.
	Mathematics (5)		PST 6: In mathematics, a lot of different that is there can be different theories that come up with the same result or there can be different results but the starting point is the same. That is why, it can always change. We cannot know.

As shown in Table 4.8, the second frequently used code regarding justification of knowledge was “accept the truth from authority”. A PST who hold a sophisticated epistemological belief regarding justification of knowledge would state that generation of knowledge through scientific investigation or acceptance of the knowledge by majority does not show that whether knowledge is true or not. In this respect, the beliefs supporting the code of “accept the truth from authority” were considered as naïve epistemological beliefs in terms of justification of knowledge. Unlike the code of “we never really know for sure” where the truth is not attainable, in the code of “accept the truth from authority” the PSTs think that the truth can be obtained and transmitted to them by the authority. That is, knowledge is justified by authority. For example, the below quote was observed very frequently in this code across each domain:

> PST 10: All in all, since scientists did we accept. In physics, in chemistry, up to now, we accepted… Like questioning, trying or doing what they found is not possible, anyway. Well, when their findings say that these are true, their true is also mine. I accept them only by reading their studies, well, what they did, and their interpretations. Well, it is important that there is more than one scientist. Well, according to this I accept.

In here it was observed that the PST believed that what the scientists say can be accepted as true because they find that knowledge through conducting research and that knowledge is approved by many other scientists. See Table 4.10 for the detailed descriptions and representative quotations of the code across domains.

From the frequencies tabulated in Table 4.8 and Table 4.10, it was observed that the justification of knowledge as the code of “accept the truth from authority” was mostly seen in the domains of mathematics and environment. In light of this finding, it was concluded that the PSTs’ epistemological beliefs regarding justification of mathematical and environmental knowledge were less sophisticated when it was compared with the domains of biology, physics, and chemistry.

Table 4.10 “Accept the truth from the authority” code across domains with representative quotes

Justification of Knowledge Code	Domain (Frequency)	Description	Representative Quote
Accept the truth from the authority	Environment (5)	Authorities know the truth through conducting research and so we accept what authorities say as if it is true.	PST 3: I investigate a little bit. I read on such as generally from the Internet, articles or when I followed the news although I cannot do self observations through the long term research it is emerging that this is like that. Well, we can benefit from it saying whether it is true or not by following the latest things.
	Biology (4)		PST 12: Again, we can find it [the truth] from the evidences. If it was proven and the people of higher authorities said that yes this is true, I may believe its truthfulness.
	Physics (4)		PST 10: So far, for example, we learned the information in the courses by saying that this is that without ever questioning or by saying that this is that we learn formulas, solve questions based on these. However, we have never accepted the other point of view by saying whether it could be true or by thinking the exact opposite. In Turkey, it is like that. Well, it is accepted. But, I think that we accept it like that maybe due to the fact that scientists approved it. All in all, they do experiments.
	Chemistry (4)		PST 10: All in all, since scientists did we accept. In physics, in chemistry, up to now, we accepted… Like questioning, trying or doing what they found is not possible, anyway. Well, when their findings say that these are true, their true is also mine. I accept them only by reading their studies, well, what they did, and their interpretations. Well, it is important that there is more than one scientist. Well, according to this I accept.
	Mathematics (6)		PST 8: All in all, the men had built the theory. Well, related to derivatives, integrals, related to many things there are lots of theories that we need to know. Through these theories we can say whether it is true or wrong. However, how are these theories formulated? Who found the theories? Or are the theories correct? We do not know this or we do not have the capacity to question this.

From the total frequency of each justification of knowledge code, it was seen that "direct observation" and "personal check" were the third frequently stated codes as shown in Table 4.8. In the "direct observations" code, justification of knowledge was explained with the statement that by observing the phenomena of the domain knowledge, they can understand the truthfulness of the knowledge with their naked eyes. That is, knowledge claim can be justified through people's direct observations, observing the things through by just looking. For example, the below quote was observed very frequently in the domain of environment:

> PST 11: I say that it can be understood via observations at first… well, all in all, the things happen in environment are related to something else rather than theories. The other things [other domains] are linked to theories much more. Generally, these [things happen in environment] are as law. For example, you say that this is green and you put the dot there.

From this quote, it was observed that although the PST does not believe that the truth is handed down by authorities, her or his belief is still reflection of a naïve epistemological belief regarding the justification for knowledge. The reason of this is that instead of a sophisticated belief that there is no absolute truth the PST thinks that absolute truth can be obtained via direct observations; in fact, the PST conceives of observations in very primitive level in such seeing without including other senses is enough to say that knowledge is true. This naïve epistemological belief as a code of "direct observations" was observed especially in the domains of environment and the detailed descriptions and representative quotations of the code across domains were shown in Table 4.11.

From the frequencies tabulated in Table 4.8 and Table 4.11, it was observed that the justification of knowledge as the code of "direct observations" was mostly seen in the domain of environment with the highest frequency. In light of this finding, it was concluded that the PSTs' epistemological beliefs regarding the justification of environmental knowledge were less sophisticated when it was compared with the domains of biology, physics, and chemistry. This finding was parallel with the finding of the "accept the truth from the authority" code which indicated a naïve epistemological beliefs regarding justification of knowledge and was found mostly in the domain of environment rather than the domains of biology, physics, and chemistry.

Table 4.11 “Direct observations” code across domains with representative quotes

Justification of Knowledge Code	Domain (Frequency)	Description	Representative Quote
Direct observations	Environment (9)	The truth can be attainable through direct observations.	PST 11: I say that it can be understood via observations at first… well, all in all, the things happen in environment are related to something else rather than theories. The other things [other domains] are linked to theories much more. Generally, these [things happen in environment] are as law. For example, you say that this is green and you put the dot there.
	Biology (6)		PST 8: Anyway, since biology investigates the living things it [truth of biological knowledge] is by direct observation. Well, in biology, all in all we can observe whether it is true or not.
	Physics (1)		PST 10: In others [environment, biology, physics, chemistry] it can be through our observations. Everything does not depend on experiments. All in all, there are topics in which experiments cannot be done.
	Chemistry (1)		PST 10: In others [environment, biology, physics, chemistry] it can be through our observations. Everything does not depend on experiments. All in all, there are topics in which experiments cannot be done.

In the “personal check” code, the PSTs emphasized that although knowledge is generated by the authority, they want to evaluate the accuracy of that knowledge. This code was observed for all domains; however, the ways of checking the accuracy of the knowledge showed some variations with respect to the domains. For instance, in the domains of environment and biology the PSTs generally stressed the necessity of crosschecking with multiple sources while in the domains of physics, chemistry, and mathematics the PSTs generally highlighted the finding the same result with the authority after applying what they said. The below quote was observed very frequently in the domain of environment:

> PST 1: Well, it seems like that mathematics and physics are a bit certain. Well, if one person says in these or if one expert says then it is true. However, when it is environment I think that it seems like more relative. That is why one source may not be enough. Well, I think that I may need more research.
> R: Why may you need more research?
> PST 1: Well, since it is environment everyone can observe differently. That is why, observations can be different.

From this quote, it was observed that the PSTs believed that there is a need to check knowledge claims with more than one sources even if that knowledge was generated by the authority due to the subjective nature of observations. In here the PST thinks that what the authority says may not be true and so the evaluation and integration of different sources are needed to justify knowledge claims. In this respect, the belief supporting the code of “personal check” was thought as more sophisticated epistemological belief in terms of justification of knowledge than the belief supporting the codes of “accept the truth from authority” and “direct observations”. The detailed descriptions and representative quotations of the code across domains were shown in Table 4.12.

Table 4.12 “Personal check” code across domains with representative quotes

Justification of Knowledge Code	Domain (Frequency)	Description	Representative Quote
Personal check	Environment (4)	The authority knows the truth but the truthfulness of the knowledge should be checked with multiple sources or self observations.	PST 1: Well, it seems like that mathematics and physics are a bit certain. Well, if one person says in these or if one expert says then it is true. However, when it is environment I think that it seems like more relative. That is why one source may not be enough. Well, I think that I may need more research. R: Why may you need more research? PST 1: Well, since it is environment everyone can observe differently. That is why, observations can be different.
	Biology (4)	The authority knows the truth but the truthfulness of the knowledge should be checked with multiple sources or self observations or person’s prior knowledge.	PST 12: We hear so many things around. This is not just for the environment but for all positive sciences. Well, something that is good for today may not be good for the next day to the environment or body, or against anything. That is why it seems to me that it is needed to get the more present day knowledge. Let’s say not [knowledge of] 10 years ago but today’s [knowledge] and it is needed to be researched from too many resources.
	Physics (3)	The authority knows the truth but the truthfulness of the knowledge should be checked with multiple sources or applying what the authority says	PST 4: When I apply now if I obtain a correct result then I understand that it is true. For instance, balance. For example, in physics let’s a person says to me that here there is 5m mass, here there is m mass and these remain in balance. When I apply this and when I do not see that it is true then I say wrong to that knowledge. However, when I can prove that it is true, I say that yes that knowledge is true.
	Chemistry (3)	The authority knows the truth but the truthfulness of the knowledge should be checked with multiple sources or applying what the authority says	PST 11: I mean through the things you do, I do not know, with atomic number you can also see it [truth of knowledge] on paper by saying if this combines with that, this emerges; if that combines with this, this emerges.
	Mathematics (3)	The authority knows the truth but the truthfulness of the knowledge should be checked with multiple sources or applying what the authority says	PST 4: By putting in the formula. By proving one to one. However, for environment this proof at least for me is not under consideration. I cannot do.

The next code regarding justification of knowledge was “experiment” which included explanations that knowledge claims can be justified via doing experiment. This code was observed in the domains of environment, biology, physics, and chemistry. However, the nature of experiment showed some variations with respect to domains. For instance, in the domains of chemistry the half of the PSTs focused on the necessity of repetition to reduce uncertainty and increase accuracy in knowledge claims. However, in the domains of environment and biology none of the PSTs stated such repetitions to justify knowledge claims. The below quote was observed very frequently in the domain of chemistry:

> PST 8: Since chemistry also includes the information which can be observed in the laboratory environment if the information coming from the environment is chemical knowledge or related to chemistry we can observe whether that information is true or wrong if there are proper materials, if there is a proper laboratory environment and if there are available technological materials.
> R: We observe via doing experiment?
> PST 8: Yes, via doing experiment.
> R: Well, if I can observe, it is true; if I cannot, it is wrong?
> PST 8: If we observe yes it is true; however, if we cannot observe this does not mean that it is wrong. Maybe we made a mistake in the experiment. There is an experimental error. That is why; we control our data with the experiment. We do it again.

From this quote, it was observed that the PST had blind dependence on and trusts in experiments for justification. The PST believed that the knowledge acquired through experiments is true knowledge since the truth of that knowledge is observable with naked eyes. In this respect, the belief supporting the code of “experiment” was considered as naïve epistemological beliefs in terms of justification of knowledge. The detailed descriptions and representative quotations of the code across domains were shown in Table 4.13.

Table 4.13 “Experiment” and “proofing” codes across domains with representative quotas

Justification of Knowledge Code	Domain	Description	Representative Quote
Experiment	Environment (3)	The truth can be attainable via doing experiment	PST 8: By doing experiment we can observe whether it [environmental knowledge] is true or wrong. If this knowledge comes from the environment and that knowledge is true, if the results of the experiment and the data support this, that knowledge is true.
	Biology (2)	The truth can be attainable via doing experiment	PST 5: In biology, there are experiments, there are many observations. When we look, there are inferences. There is a data collection. All are available in biology.
	Physics (4)	The truth can be attainable via doing experiment or repeated experiments	PST 5: How do we examine whether it is true or wrong? In physics, there are many variables. We ignore some things such as the friction of air while we are solving problems. However, except small experimental error we can again do experiment. Via experiment. Via repeatedly doing experiments.
	Chemistry (6)	The truth can be attainable via doing experiment or repeated experiments	PST 12: Chemistry…In chemistry, there are things which are concrete and observable. More concrete things. How is it [truth] obtained in Chemistry? In chemistry, it seems to me that it is needed to do more experiments. You try more. You will look at the result. It either happens or not. Of course, those experiments are not one-time experiment. All in all, one experiment can sometimes give different results. It seems to me that it depends more on experiments. It seems coming from the experiment.
Proofing	Mathematics (6)	The truth can be attainable via proofing.	PST 5: Mathematics is abstract. How do we know in mathematics? Mathematics has testing methods in itself. There are proofing methods. You introduce a problem. You approach it from the right and you find a result. Then you said that let’s look at whether it is true and you also approach the problem from the left. You find a result for it. It likes walking in the dark. There is an object in the middle of a dark room. It is a testing method whether you will be able to find the same thing by applying the same method when you enter the room from this door as well as from the other door. If we find it with two methods or several testing methods we accept it as true.

As indicated in Table 4.13, the code of “proofing” was the final code related to the justification of knowledge. This code was observed only in the domain of mathematics and included the explanations that mathematical knowledge is justified through proofing. From the representative quotation given Table 4.13, it was clear that the PST believed that the PST has blind dependence on and trusts in proofing for justification. In this respect, the belief supporting the code of “proofing” was considered as naïve epistemological beliefs in terms of justification of knowledge

In accordance with what has been told and illustrated up to this point, one can conclude the following regarding justification of knowledge across domains:

The PSTs’ responses to the justification of knowledge suggested that the nature of justification of knowledge in the domain of environment is different from the other domains in such the vast majority of the PSTs use their direct observations to propose whether environmental knowledge is true or not and yet others were content to simply accept what the authority says as evidence of the truth in environmental knowledge. However, in the domains of physics and chemistry, the half of the PSTs believed that justification of knowledge is inherently subjective and yet others again considered the authority as the source of the truth. From the nature of justification of knowledge, it was seen that the vast majority of the PSTs hold naïve epistemological beliefs in the domain of environment when it was compared with other domains.

4.2 Stability of Knowledge

One of the dimensions of personal epistemology is the stability of knowledge. This dimension can be placed on a continuum that ranges from the belief that knowledge is discovered and unchanging (naïve epistemological belief) to the belief that knowledge is always changing and evolving (sophisticated epistemological belief). In this part of the result section, PSTs’ epistemological beliefs related to the stability of knowledge in the domains of environment, biology, physics, chemistry, and mathematics were presented.

To elicit PSTs' domain specific epistemological beliefs regarding the stability of knowledge dimension, PSTs were first asked to assign percentages to three categories of the stability of knowledge which are "never changes", "yet to be discovered", and "always changing or evolving" knowledge for each domain. Then they were asked to explain why they conceive of the domain knowledge as certain or uncertain. As a result, PSTs' epistemological beliefs related to the stability of knowledge were presented in two parts: The stability of knowledge in terms of percentages and the underlying reasons for why the domain knowledge is certain or uncertain.

4.2.1 Stability of Knowledge in terms of Percentages

As indicated in Table 4.14, the percentages emphasizing stability of knowledge in the domain were observed in a decreasing order of mathematics, chemistry, physics, biology, and environment.

Table 4.14 The mean percentages of the stability of knowledge across domains

Stability of Knowledge Category	**Domain**				
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**
Never changes	33.75 (23.07)*	38.92 (25.42)	41.67 (25.53)	49.58 (27.26)	61.67 (35.70)
Yet to be discovered	35.42 (15.73)	33.33 (13.54)	30.83 (17.30)	27.92 (15.44)	19.17 (17.94)
Always changes	30.83 (16.49)	27.75 (15.78)	27.92 (15.15)	22.50 (16.58)	19.17 (23.44)

*standard deviations shown in parentheses

To understand the PSTs' epistemological beliefs regarding the stability knowledge thoroughly in the domains, the number of frequencies for each individual percentage was also presented for the most naïve category of the stability of knowledge which is “never changes” as shown in Table 4.15.

Table 4.15 Frequencies of individual percentages for “never changes” code across domains

Percentages (%)	**Domain**				
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**
0	1	0	0	0	1
2	0	1	0	0	0
5	0	1	1	1	0
10	1	0	0	0	0
15	1	0	0	0	0
20	2	1	2	1	1
25	0	1	2	1	1
30	3	3	1	1	1
35	0	0	1	0	0
40	0	0	0	1	1
50	0	1	1	3	0
60	3	1	1	0	0
70	1	2	1	1	0
75	0	1	0	0	0
80	0	0	1	1	2
85	0	0	0	1	0
90	0	0	0	1	3
95	0	0	0	0	1
100	0	0	0	0	1

The PSTs believed that knowledge is the most certain in the domain of mathematics with the mean (percentage) of 61.67 as shown in Table 4.14. One of the reasons for this was when three categories - Never changes, Yet to be discovered, Always changes- of the stability question were taken into account, it was observed that the PSTs gave disproportionately large percentage in the “never changes” category. Moreover, when the frequencies of individual percentages for “never changes” category in the domain of mathematics were concerned, it was seen that the vast majority of the PSTs believed that 80% or more of mathematical knowledge is unchanging (See Table 4.15). In this domain, the least percentage was given to “yet to be discovered” category. The PSTs believed that most of the knowledge in mathematics has been already discovered.

The PSTs put chemistry in the second order to indicate the stability of knowledge in this domain. However, they did not seem to have clear opinion about stability of knowledge in chemistry because about half of the PSTs viewed chemistry as somewhat stable with the mean (percentage) of 49.58 yet the remaining PSTs considered chemical knowledge as being open to discoveries or change.

Physics was ordered as the third most certain knowledge. Unlike chemistry and mathematics, the total mean percentage of physical knowledge that is open to being discovered and changed was much greater than the percentage of physical knowledge that will never change.

Next certain domain knowledge was seen as biology because the mean (percentage) in the “never changes” category of biological knowledge was less than that of physical knowledge. Uncertainty of biological knowledge can also be seen when the frequencies of individual percentages given for the “never changes” category were taken into account (See Table 4.15). The PSTs believed that at most 70% of biological knowledge can be unchanging unlike mathematics where 100% of knowledge can be unchanging.

The lowest mean percentage in the category of “never changes” (33.75) was obtained in the domain of environment. That is, the least certain knowledge was considered in the domain of environment. The uncertainty of environmental knowledge can be also observed from the highest mean percentages given for the category of “always changes” (30.83). When the mean percentages of “yet to be discovered” category was considered one can see that knowledge in the domain of environment was viewed as knowledge that is waiting to be discovered rather than unchanging or changing. On the contrary to environment, mathematics with the most certain knowledge interestingly has the least percentage in the “yet to be discovered” category.

According to the Table 4.15, the least certain knowledge was in the domain of environment since a few PSTs’ responses were observed in higher percentages for the “never changes” category while the vast majority of PSTs’ responses were gathered in lower percentages especially between 0% and 30%. On the contrary to environmental knowledge, mathematical knowledge was accepted as the most certain one since most of the PSTs responded on the higher percentages ranging from 80% to 100% for the “never changes” category.

The overall analyses revealed that PSTs’ epistemological beliefs related to the stability of knowledge can show differences across the domains in such the PSTs conceived of knowledge as more certain in mathematics and chemistry (naïve epistemological beliefs) while more uncertain in environment, biology, and physics (sophisticated epistemological beliefs). The PSTs’ explanations of why the particular domain knowledge is certain or uncertain were also analyzed to provide more detailed information about their epistemological beliefs related to the stability of knowledge. These findings were presented in the next section.

4.2.2 Reasons for Why Knowledge is Certain and Uncertain in the Domains

For each domain, the PSTs’ were asked to explain why they assigned higher or lower percentages in any one of the three categories of stability of knowledge. The PSTs who hold naïve epistemological beliefs would give responses that indicate knowledge is certain. On the contrary, the PSTs who hold sophisticated epistemological beliefs would state that uncertainty in knowledge is fundamental property of knowledge. Analysis of the PSTs’ explanations revealed five distinct codes for uncertainty and five distinct codes for certainty of knowledge in the domains. In the following part, first the codes for uncertainty of knowledge then the codes for the certainty of knowledge in the domains were presented thoroughly in light of the specific codes emerged during analysis.

4.2.2.1 Codes for Uncertainty of Knowledge in the Domains

As shown in Table 4.16, the analysis of PSTs' explanations regarding why knowledge in a particular domain is uncertain resulted in four main uncertainty codes, named as "discovery as enhancement", "discovery as inventions", "uncertainty in measurement", and "uncertainty in complex knowledge".

Table 4.16 Frequencies of all uncertainty codes across domains

Uncertainty Code	**Domain**					**Total Frequency**
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**	
Discovery as enhancement	1	3	6	2	2	14
Discovery as inventions	6	2	1	1	3	13
Uncertainty in measurement	6	2	3	1	0	12
Uncertainty in complexity of knowledge	0	1	0	0	0	1
Total frequency	13	8	10	4	5	40

As indicated in Table 4.16, when the total frequency of four uncertainty codes was compared across domains it was seen that uncertainty codes were mostly observed in the domains of environment (13), physics (10), and biology (8). Thus, these codes and associated frequencies showed some parallel results with the findings of stability of knowledge in terms of percentages given above.

When we consider the total frequency of each uncertainty category, it was seen that the "discovery as enhancement" and "discovery as inventions" codes together accounted for 67.5 % of all reasons given for knowledge's being uncertain in the domains and observed in all domains. The detailed descriptions and representative quotes of the "discovery as enhancement" and "discovery as inventions" codes were presented in Table 4.17.

Table 4.17 “Discovery as enhancement” and “discovery as inventions” codes across domains with representative quotes

Uncertainty Code	Domain (Frequency)	Description	Representative Quote
Discovery as enhancement	Environment (1)	Uncertain since discoveries will probably change the existing knowledge	PST 2: Well, I think that basic knowledge can be certain but they are also open to be changed… Well, probably newly discovered things will change that knowledge.
	Biology (3)	Uncertain since discoveries/ new evidences/ technology will probably change the existing knowledge	PST 4: Now it is said that the cell consists of this and this but it can be missing. In the past, there was no electron microscope. We could not observe that much detail but now we have and observe. Maybe with a better microscope we will observe in more details.
	Physics (4)	Uncertain since discoveries/ inventions/ technology/ personal perspectives will probably change the existing knowledge	PST 11: …well we can change previously existing knowledge by means of continuously developing technology or newly invented tools or different perspective of someone else. As a result, I think that it is in a situation that there are still many ongoing changes.
	Chemistry (2)	Uncertain since discoveries will probably change the existing knowledge	PST4: Mathematics seems to me something that develops continually. There are thing not certain yet. It is also similar in physics, chemistry, and mathematics…There are theories not proven yet. For instance, there is not absolute certainty in atom theory. I think that these show that it can develop.
	Mathematics (2)	Uncertain since discoveries/ proofs will probably change the existing knowledge	PST4: Mathematics seems to me something that develops continually. There are thing not certain yet. It is also similar in physics, chemistry, and mathematics…There are theories not proven yet. For instance, there is not absolute certainty in atom theory. I think that these show that it can develop.
Discovery as inventions	Environment (5)	Uncertain since there are many things waiting to be discovered in **nature**	PST 12: Environmental knowledge is not stable, definitely not… I mean there are many places, animals, plants, etc. that are not discovered yet.
	Biology (1)	Uncertain since there are many things waiting to be discovered in biology	PST 12: In biology, of course there seems to be many things that will be discovered.
	Physics (1)	Uncertain since there are many things waiting to be discovered in physics	PST 3: I mean that there are many undiscovered things in physics… Still we are in the Earth or busy to pollute the Earth’s atmosphere but the beyond is absent.
	Chemistry (1)	Uncertain since there are many things waiting to be discovered in chemistry	PST 7: I mean that now it is said that there are that number of elements in the periodic table but you know the presence of other elements can emerge. I think in chemistry there can be much more discoveries in the future.
	Mathematics (3)	Uncertain since there are many things waiting to be discovered in mathematics	PST 11: It seems that there are many undiscovered things… Well, tomorrow something will emerge, the day after tomorrow again something will emerge since it is not depended on anything definite it seems that anything can occur anytime even more could happen.

As shown in Table 4.16 and Table 4.17, discovery was seen as the most important reason for the uncertainty of knowledge in the domains. However, the ways PSTs interpret the discovery were different. The PSTs' understanding regarding discovery was gathered under two codes as "discovery as enhancement" and "discovery as invention".

The code of "discovery as enhancement" included the statement that some things that might be found in the future have potential to change existing body of knowledge. However, the nature of those things showed some variations across domains in such the things that might be found in the future are stated as proofs and discoveries for the domain of mathematics; and inventions, technologies, personal perspectives, and discoveries for the domain of physics while for the domain of environment they are only discoveries. For instance, the below quote was observed very frequently in the domain of physics:

> PST 11: For physics, hmm, discovered but I mean it changes such as development of technology…well, these changes are as if there was knowledge in the past and we change it know…That is why, I want to give much more to this. It is 50%.
> R: Which one?
> PST 11: Changing or evolving. I want to say 30% to yet discovered and 20 remains for unchanging. Why did I do this like that? As I said that well we can change previously existing knowledge by means of continuously developing technology or newly invented tools or different perspective of someone else. As a result, I think that it is in a situation that there are still many ongoing changes.

From this particular response, it was observed that the PST believed that developing technology and inventions that might be found in the future will probably change the nature of the existing knowledge. That is to say, there is always a probability of change in knowledge. Thus, the uncertainty reason as "discovery as enhancement" was a reflection of sophisticated epistemological beliefs in terms of stability of knowledge.

On the contrary to "discovery as enhancement", in "discovery as invention" code the PSTs believed that discoveries would add new information to already existing body of knowledge, no changing at all in the nature of existing knowledge. Generally this belief was observed in the domain of environment. Below is a representative quote for this belief:

> PST 12: Percent of environmental knowledge that is unchanging… it is not stable, definitely not.
> R: We will give percentages to all of them [three categories of stability of knowledge].
> PST 12: knowledge yet to be discovered… open being discovered… I absolutely give 100% to this. Always changing or evolving… well, we do not say to this always… I mean there are many places, animals, plants, etc. that are not discovered yet.

In this understanding it was observed that the PST believed that the number of species' names will increase in light of discoveries. That is to say, the PST conceived of knowledge as uncertain since there are things not yet discovered and it can be said that when they are discovered they probably would be certain. In this respect, the uncertainty reason as the code of "discovery as inventions" was judged as more naive epistemological beliefs than the uncertainty reason as the code of "discovery as enhancement".

When the frequencies of "discovery as enhancement" code were compared across domains, the highest frequency (4) was observed in the domain of physics and the lowest frequency (1) was seen in the domain of environment. On the contrary, for "discovery as invention" code the highest frequency (5) was observed in the domain of environment while the lowest frequency (1) was obtained in other domains. That is, the domain of environment had high frequency for more naïve code and low frequency for more sophisticated code. In light of this finding, it was concluded that the PSTs' epistemological beliefs regarding uncertainty of environmental knowledge were less sophisticated when it was compared with the other domains.

The remaining two codes of "uncertainty in measurement" and "uncertainty in complex knowledge" accounted for 32.5 % of all reasons given for uncertainty of knowledge and were not observed for all domains in contrast to the codes of “discovery as enhancement” and “discovery as inventions” (See Table 4.16). The detailed descriptions and representative quotations of the codes of “uncertainty in measurement” and “uncertainty in complex knowledge” across domains were presented in Table 4.18.

Table 4.18 “Uncertainty in measurement” and “uncertainty in complex knowledge” codes across domains with representative quotes

Uncertainty Code	Domain	Description	Representative Quote
Uncertainty in measurement	Environment (6)	Uncertain since it is difficult to measure nature well due to its inherent complexity and continuously changing structure	PST 4: There are always living things ultimately movement and change. I mean that chemical structure always changes such as rain and snow. In addition, characteristics of living things change. Human beings also interfere. For example, we are also changing environment by moving some things from somewhere to another place. Therefore, there do not remain so many stable things.
	Biology (2)	Uncertain since it is difficult to measure the phenomena of biology well due to its complexity	PST 9: In biology, it seems to me that it cannot be gone too deep. For example, in the cell, I think that there are more unknown than known things since the interactions among proteins and enzymes cannot be known for certain. When one factor is known the other cannot be known seperately due to continuous interactions among each other. That is, we cannot do something about that topic separately. Therefore, it is not understood fully. Each of them is too related to each other.
	Physics (3)	Uncertain since it is difficult to measure the phenomena of physics well since it depends on inferences rather than	PST 6: Because in physics, it cannot be said imagination, since we are dealing such things that we cannot observe and are small, I suppose that something which can escape notice or we ignored for today, for example, can in fact be very important for tomorrow. For that reason, I think that physics is more open to change.
	Chemistry (1)	Uncertain since it is difficult to measure the phenomena of chemistry well since it depends on inferences rather than observations.	PST 6: In environment, if one stores a bottle 10 days or 10 years and looks at it, s/he can see that it will not disappear. That is, since these are more observable things it is easier to understand. For that reason I think it is easier to explore. That is why I think that the error rate is a bit lower but I think that it will not be like that in chemistry and physics.
Uncertainty in complex knowledge	Biology (1)	Uncertain since there are complex relationships among ideas	PST 3: In biology, we do not add up knowledge on the previous one. We are moving on by relating to it [knowledge] rather than directly adding up. For instance, [in physics] we state that the gravity is this and we directly construct our aircraft or other things according to that, directly taking gravity as a reference. I mean that in biology we associate more rather than add up directly.

The code of “uncertainty in measurement” included explanations that knowledge is uncertain since concise measurements of the phenomena in the domain are not possible. When the code of “uncertainty in measurement” was compared across domains, it was seen that the nature of uncertainty caused by measurement in the domain of environment is different from that in the domains of biology, physics, and chemistry. In the domain of environment, the PST emphasized that nature is inherently complex since the phenomena in the nature are affected by many variables (1 PST), the consequences of the natural events are seen in a very long time period (2 PSTs), and nature itself always changes (4 PSTs). Thus, it is difficult to investigate phenomena of *nature* which brings about uncertainty in the domain of environment. Ironically even though the PSTs were asked to indicate their understanding about stability of environmental knowledge they generally talked about nature as being changed as in the below representative quote:

> PST 4: There are always living things ultimately movement and change. I mean that chemical structure always changes such as rain and snow. In addition, characteristics of living things change. Human beings also interfere. For example, we are also changing environment by moving some things from somewhere to another place. Therefore, there do not remain so many stable things.

From this particular response it was observed that the PST believed that environmental knowledge is uncertain since things in nature such as living things, chemical structure of rain, etc are subject to change. We expected from this PST to indicate that our knowledge about living things is being changed or our understanding about chemical composition of rain and snow is being changed in light of new measurements. Thus, we are getting better in understanding of how human behavior influences the dynamic structure of the nature. That is, the PST does not point out the complexity of the environmental knowledge, which compromises interpretation of human impact of environment in light of knowledge in both the physical sciences (physics, chemistry, biology, geology, geography, resource technology, and engineering) and the social sciences (resource management and conservation, demography, economics, politics and ethics) rather the PST highlighted nature as being changed. In this respect, the beliefs supporting the code of “uncertainty in measurement” were judged as naïve in the domain of environment. However, the beliefs supporting the code of “uncertainty in measurement” were sophisticated in other domains. The reason for this was in other domains the PSTs defined knowledge and pointed out the difficulty in investigating that knowledge unlike the domain of environment where the PSTs described nature and emphasized the difficulty in investigating nature:

> PST 9: In biology, it seems to me that it cannot be gone too deep. For example, in the cell, I think that there are more unknown than known things since the interactions among proteins and enzymes cannot be known for certain. When one factor is known the other cannot be known seperately due to continuous interactions among each other. That is, we cannot do something about that topic separately. Therefore, it is not understood fully. Each of them is too related to each other.

In here, it was observed that the PST believed that our knowledge regarding the concepts of protein and enzyme can be changed in the future since concise measurement of the relationships among protein and enzymes is not possible due to their inherent complexity.

The final code regarding the uncertainty of knowledge was “uncertainty in complex knowledge”. As shown in Table 4.16 and Table 4.18, this code was given only by one PST for the domain of biology with the below representative quote:

> PST 3: In biology, we do not add up knowledge on the previous one. We are moving on by relating to it [knowledge] rather than directly adding up. For instance, [in physics] we state that the gravity is this and we directly construct our aircraft or other things according to that, directly taking gravity as a reference. I mean that in biology we associate more rather than add up directly.

From this particular answer, it was observed that the PST believed that knowledge in the domain of biology is uncertain since biological knowledge does not build up accepted knowledge. That is, the PST believed that the uncertainty of biological knowledge was related to the complex structure of biological knowledge. In the structure of knowledge dimension, if one conceives of the relationships among knowledge as complex, that person has more sophisticated epistemological beliefs than the person who considers relationships among knowledge as simple. In this respect, beliefs supporting the code of “uncertainty in complex knowledge” represented more sophisticated epistemological beliefs in terms of uncertainty of knowledge.

In accordance with what has been told and illustrated up to this point, one can conclude the following regarding uncertainty of knowledge across domains:

1. The PSTs’ responses to why they think that knowledge is uncertain suggested that the nature of uncertainty in the domain of environment was different from other domains in such the PSTs conceived of environmental knowledge as uncertain due to the codes of “discovery as inventions” and “uncertainty in measurement” while in the domain of biology as “discovery as enhancement” and “uncertainty in measurement”, in the domain of physics as “discovery as enhancement”, in the domain of chemistry as “discovery as enhancement” and in the domain of mathematics as “discovery as inventions”.

2. Although uncertainty codes were mostly seen in the domain of environment, the explanations regarding why environmental knowledge is uncertain were less sophisticated when compared with other domains. The PSTs hold more sophisticated beliefs regarding the uncertainty of knowledge in the domains of physics and biology rather than environment.

3. The investigation of uncertainty of knowledge in the domain of environment through comparing with other domains indicated an important finding regarding the nature of environmental knowledge in such in their explanations of why environmental knowledge is uncertain the PSTs located nature instead of knowledge while in the other domains

they could locate knowledge. In light of this finding, it can be concluded that the PSTs' points of view regarding environmental knowledge are limited with what they see in nature.

4.2.2.2 Codes for Certainty of Knowledge in the Domains

As indicated in Table 4.19, the analysis of PSTs' explanations regarding the reasons of domain knowledge's being certain resulted in three distinct certainty codes which were "discovered certainty", "concrete certainty", and "abstract certainty".

Table 4.19 Frequencies of all certainty codes across domains

Certainty code	**Domain**					**Total frequency**
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**	
Discovered certainty	4	5	6	7	7	29
Concrete certainty	2	2	2	4	0	10
Abstract certainty	0	0	0	0	5	5
Total frequency	6	7	8	11	12	44

From the total frequencies of three certainty codes across domains, it was concluded that PSTs used the certainty codes mostly for the domains of mathematics (12) and chemistry (11). This finding was parallel with the analyses of stability of knowledge in terms of percentages since PSTs hold naïve epistemological beliefs regarding stability of knowledge by assigning the highest percentages to the category of "never changes" for the domains of mathematics and chemistry as it was shown in part 2.1.

When we consider the total frequency of each certainty category, it was seen that the mostly observed certainty code was "discovered certainty" with the frequency of 29. This code accounted for 66% of all reasons given for why the domain knowledge is certain and was predominantly observed in all domains. The second mostly obtained certainty code was “concrete certainty” which was observed in all domains except mathematics. The code of “abstract certainty” was the final code regarding why knowledge is certain and this code was observed only in the domain of mathematics. The detailed descriptions and representative quotes of the “discovered certainty”, “concrete certainty”, and “abstract certainty” codes were presented in Table 4.20.

Table 4.20 “Discovered certainty”, “concrete certainty” and “abstract certainty” codes across domains with representative quotes

Certainty Code	Domain (Frequency)	Description	Representative Quote
Discovered certainty	Environment (4)	Certain since many things already discovered and formed the basic knowledge.	PST 5: When I think the World, many places have been investigated now. I mean that status of lakes, living things such as unicellulars, even the ones whom we do not see, or climate change. Now, we know the status of the pole. We can calculate at which Celsius degrees icebergs start to melt or we can go and observe directly.
	Biology (5)		PST 11: I look at the existing knowledge. Well, I do not think that there are more things that can be investigated related to our body. When I look the things around us; for example, I think that we already reached many things about fungi.
	Physics (6)		PST 5: You say optic and the points where it [physics] can come had been figured out years ago actually. I think that the things or topics which would be investigated are a bit limited in there [in physics].
	Chemistry (7)		PST 9: It seems that chemistry is more stable than environment. Well, through experiments, many things, many developments had been already made and many things had been already discovered. So, it seems that the percentage of knowledge that yet to be discovered is less.
	Mathematics (7)		PST 5: I mean when you think too in-depth calculations are done. Especially, after the usage of computer we could reach the numbers including many zeros. As I know, calculations of higher exponents, integrals, differentiations are able to be made. As a result, I thought that we probably reached the point where mathematics can come.
Concrete certainty	Environment (2)	Certain since knowledge is obtained through certain observations or experiments	PST 6: In environment, if one stores a bottle 10 days or 10 years and looks at it, s/he can see that it will not disappear. That is, since these are more observable things it is easier to understand. For that reason I think it is easier to explore. That is why I think that the error rate is a bit lower.
	Biology (2)		PST 8: Biology, in fact, in biology I say 70% for stable knowledge; 10% for yet to be discovered. There is more stable knowledge in biology since we can observe.
	Physics (2)		PST 6: I think that since other fields [physics and chemistry] are obtained in laboratory environment, they can be measured more accurately. That is why I think that the known is more close to the truth.
	Chemistry (4)		PST 5: Well, chemistry seems to me a more stable field. A reaction…you put something, there occurs an interaction and the result is definite since it was observed. For instance, when I combine hydrochloric acid with another component, it gives only one result or when you change it you calculate and see the ones that can change.
Abstract certainty	Mathematics (5)	Certain due to being abstract, proven, or logical	PST 8: Well, in mathematics since we cannot do observations or we cannot do experiments related to this field it is more stable. So, let’s give 90% to the stable part. R: We cannot do observations in mathematics. If we cannot do, PST 8: It is certain. I directly accept as if it is true.

As shown in Table 4.20, in the code of "discovered certainty" the PSTs believed that knowledge in a particular domain is certain since we have already discovered many things which then formed the basic knowledge in the corresponding domain. For example, the below quote was observed in the domain of mathematics:

> PST 5: I mean when you think too in-depth calculations are done. Especially, after the usage of computer we could reach the numbers including many zeros. As I know, calculations of higher exponents, integrals, differentiations are able to be made. As a result, I thought that we probably reached the point where mathematics can come.

In here, it was observed that the PST conceived mathematical knowledge as certain since the number of mathematical knowledge that is yet to be discovered is less. This mostly expressed certainty code together with the uncertainty codes of "discovery as inventions" and "discovery as enhancement" revealed that the stability of any domain knowledge is related to what extent we have reached the body of knowledge in particular domain yet. If PSTs believed that we had reached almost all knowledge in a particular domain, corresponding domain is viewed as certain. On the contrary, if PSTs thought that there is so much knowledge waiting to be discovered in a particular domain, corresponding domain is considered as uncertain.

The second most frequent reason given for domain knowledge being certain was related to the measurement of phenomena in a particular domain as shown in Table 4.19 and Table 4.20. PSTs' explanations regarding the measurement were categorized under two codes which were "concrete certainty" and "abstract certainty". In the code of "concrete certainty", the PSTs believed that measurements through observations or experiments provide us certain knowledge since they can observe the phenomena or observe the results of the experiments with their naked eyes. That is, they concerned the concreteness, tangibility or observability of the phenomena in the domain as a reason of being certain knowledge. When the frequencies of "concrete certainty" across domains were taken into account, it was seen that this code was mostly observed in the domain of chemistry with below representative quote:

> PST 5: Well, chemistry seems to me a more stable field. A reaction…you put something, there occurs an interaction and the result is definite since it was observed. For instance, when I combine hydrochloric acid with another component, it gives only one result or when you change it you calculate and see the ones that can change.

From this particular answer, it was observed that the PST believed that chemical knowledge is certain since one can easily observe its certainty through experiments. This naïve epistemological beliefs regarding stability of chemical knowledge was parallel to the finding obtained by the analysis of reasons given for knowledge' s being uncertain in such the code of "uncertainty in measurement" was observed the least in the domain of chemistry.

On the contrary to the "concrete certainty" code, in the "abstract certainty" the PSTs believed that the measurements obtained through proofs or logic generate certain knowledge since the measurements does not depend on observation or experiments or there cannot be any error in the proofs because of being numerical or the things obtained through a logical way cannot be wrong. The code of "abstract certainty" was observed only in the domain of mathematics with below representative quote:

> PST 8: Well, in mathematics since we cannot do observations or we cannot do experiments related to this field it is more stable. So, let's give 90% to the stable part.
> R: We cannot do observations in mathematics. If we cannot do,
> PST 8: It is certain. I directly accept as if it is true.

From this particular answer, it was observed that the PST believed that mathematical knowledge is certain since mathematical knowledge is abstract and so s/he cannot observe the truthfulness of mathematical knowledge.

In accordance with what has been told and illustrated up to this point, one can conclude the following regarding certainty of knowledge across domains:

The PSTs' responses to why they think that knowledge is certain suggested that the certainty in the domains of environment, biology and physics was different from the certainty in the domains of chemistry and mathematics in such the PSTs associated certainty in the domains of environment, biology, and physics mostly with "discovered certainty" code while in the domain of chemistry with "discovered certainty" and "concrete certainty" and in the domain of mathematics with "discovered certainty" and "abstract certainty".

4.3 Structure of Knowledge

The other dimension of personal epistemology is related to the structure of knowledge. This dimension is placed on a continuum that ranges from the belief that knowledge is simple and isolated (naïve epistemological belief) to complex and highly integrated (sophisticated epistemological belief). In this part of the result section, PSTs' epistemological beliefs within the structure of knowledge dimension were presented for the domains of environment, biology, physics, chemistry, and mathematics.

To identify PSTs' domain specific epistemological beliefs regarding the structure of knowledge dimension, PSTs were asked first to generate or select analogy indicating the organization of environmental knowledge in the mind of a good learner and then to explain why they chose the particular analogy. After PSTs' depictions of the structure of environmental knowledge for a good learner, PSTs also wanted to do the same for a poor learner. The same procedure was followed for the other domain knowledge (physical, chemical, biological, and mathematical) in turn.

Analogies given for the structure of domain knowledge dimension were theoretically considered as reflection of a sophisticated epistemological belief when they indicated that knowledge has many complex and integrated links and when they suggested flexible links. On the contrary, analogies were concerned as reflection of a naïve epistemological belief when they pointed out isolated bits or a linear links and when they revealed rigid links.

The most informative part of the question regarding the structure of knowledge was PSTs' explanations given for why they chose a particular analogy rather than their analogies. As a result, in the following part of the result section analogies and their explanations as a reason of having been chosen were presented together first for the good learner and then for the poor learner.

4.3.1 Structure of Knowledge in the Mind of a Good Learner across Domains

For the question of the structure of knowledge in the mind of a good learner across domains, the PSTs were given the analogies of "puzzle", "legos", and "sorting program"; however, it was said that the PSTs are free to generate another analogy. When the frequencies of analogies given for a good learner were taken into account, it was seen that "legos" and "puzzle" were the most frequently used analogies (See Table 4.21). These analogies were the ones that we already gave them. That is, the PSTs had a difficulty in generating new analogies describing the organization of knowledge in the mind of a good learner across domains.

Table 4.21 The analogies given for a good learner in the domains

Analogy	**Domain**					**Total frequency**
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**	
Legos	6	4	4	5	5	24
Puzzle	2	5	5	5	5	22
Domino	1	1	0	0	0	2
Sorting	1	0	0	0	0	1
Road map	1	0	0	0	0	1
Tree	0	0	1	0	0	1
Tool box	0	0	0	0	1	1
Neural network	1	0	0	0	0	1
Web	1	0	0	0	0	1
Snail Shell	0	0	0	1	0	1
Internet web	0	0	1	0	0	1
Tambourine	0	1	0	0	0	1

The mostly used analogy, *legos* generally were chosen to indicate flexible links among ideas because one can connect sticks with many places and reconnect when the need arises. However, the analogy of *legos* was sometimes used to show linear links among ideas because in order to build legos one should place the new lego on the previous lego. In contrast to *legos*, the second mostly used analogy, *puzzle* was selected generally to indicate fixed links among the ideas because the pieces of a puzzle only fit in one place. However, there were some PSTs who chose the puzzle to indicate the complex links among ideas. From the puzzle and legos examples, it can be understood that the analogy itself sometimes was not enough to determine PSTs' beliefs related to the structure of knowledge. As a result, PSTs' explanations as to why they chose a particular analogy gave the most information regarding their beliefs related to the structure of knowledge and these explanations were presented in the following paragraphs.

The analyses of PSTs' explanations regarding the organization of domain knowledge in the mind of a good learner indicated that connections among knowledge were considered as important but the nature of these connections showed differences. PSTs' understandings regarding the nature of connections were categorized under four codes which were "complex links", "linear links", "flexible links", and "fixed links" as tabulated in Table 4.22.

Table 4.22 Frequencies of codes given for a good learner for the structure of domain knowledge

Structure of knowledge code	**Domain**					**Total frequency**
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**	
Flexible links	7	5	4	5	4	23
Linear links	2	4	5	5	4	18
Fixed links	2	4	3	2	6	16
Complex links	7	1	1	1	1	11

The PSTs' understanding regarding changeability of links among ideas was categorized under two codes as "flexible links" and "fixed links". In "flexible links" code the PSTs believed that organization of existing knowledge in the mind of a good learner can vary with many connections or new information can change the organization of existing knowledge in the mind of a good learner. This code was observed very frequently in the domain of environment with below representative quote:

> PST 4: I can emulate my environmental knowledge to the legos because I can disconnect and then reconnect them. I can change legos' places since I think that the environmental knowledge is not fixed in this manner.

From this particular answer, it was observed that the PST selected the analogy of *legos* to indicate that the links among environmental concepts open to be changed in the mind of good learner.

In contrast to the code of "flexible links", in "fixed links" code the PSTs thought that links among ideas do not change and knowledge in the mind of a good learner fits in only one place. In this respect, the beliefs supporting to the code of “fixed links” were judged as naive epistemological beliefs in terms of structure of knowledge than the code of “flexible links”. The “fixed links” code was observed very frequently in the domain of mathematics with below representative quote:

> PST 10: It seems to be that mathematical knowledge is not always changing. How should I tell? I thought that s/he [good learner] considers each new incoming as the one piece of the puzzle and by adding these pieces together s/he can reach the whole.

In here, it was observed that the PST selected the analogy of *puzzle* to indicate that links among mathematical concepts are fixed and to be a good learner you should place every piece of knowledge to its correct place.

The detailed descriptions and representative quotations of the codes of “flexible links” and “fixed links” were presented together in Table 4.23.

Table 4.23 “Flexible links” and “fixed links” codes across domains with representative quotes

Structure of Knowledge Code	**Domain (Frequency)**	**Description**	**Representative Quote**
Flexible links	Environment (7)	Organization of existing knowledge can vary with many connections or new information can change the organization of existing domain knowledge	PST 4: I can emulate my environmental knowledge to the legos because I can disconnect and then reconnect them. I can change legos’ places since I think that the environmental knowledge is not fixed in this manner.
	Biology (5)		PST 10: A good learner connects the third lego after analyzing previously placed two legos. However, once s/he learns something new, this organization can change. Well, the new knowledge can comes into different categories.
	Physics (4)		PST 4: It seems to me that physics is open to being changed. So, I choose the legos. I can disconnect and reconnect legos but in the puzzle every piece has a definite place and if I put the pieces to wrong places I can observe the wrongfulness. However, in the legos there is no wrongfulness.
	Chemistry (5)		PST 2: The change in organic chemistry; in other topics, again change in the knowledge regarding atoms can affect it [matter topic]. That is, there is an event of being affected in legos. When I take one of them [a lego], it can change the knowledge in the other. However, here [at puzzle] it may not be a change rather remains as missing.
	Mathematics (4)		PST 4: My every knowledge, the new knowledge I have learned can be applied onto other knowledge as in the legos. The puzzle seemed to me as more strict. So, mathematical knowledge is not like puzzle. I think that mathematical knowledge changes continually as in the legos.
Fixed links	Environment (2)	Knowledge fits in one way or new information goes into the existing body of knowledge, no changing at all in the nature of existing knowledge	PST 8: The student does not understand a piece without completion of another piece. That is why the student should use this piece in its most proper place. Otherwise, since the knowledge will not fit there, s/he will not make its explanation. If this knowledge is used for only here and the student tries to benefit from this knowledge in different topic it will not explain, support that. I say puzzle.
	Biology (4)		PST 12: In biology, it is like a puzzle. Well, knowledge is related to each other as in the puzzle but the links in biology are not as in the legos. Legos are different since in legos the connection of a lego with the other legos gives a different result. However, in biology there is not such a thing.
	Physics (3)		PST 8: To me physical topics are in integrity. So, a good student should do a puzzle. That is, if the student use a formula or a theory in a different place instead of its particular place, the result of this question will be wrong.
	Chemistry (2)		PST 8: I can say a puzzle for chemistry since we cannot use a particular topic in a different topic in chemistry. For example, we cannot use Boyle Mariotte in volume or I do not know in the other things related to another theory.
	Mathematics (6)		PST 10: It seems to be that mathematical knowledge is not always changing. How should I tell? I thought that s/he [good learner] considers each new incoming as the one piece of the puzzle and by adding these pieces together s/he can reach the whole.

The PSTs' understanding regarding to what extent knowledge is related was categorized under two codes as "complex links" and "linear links". In "complex links" code the PSTs believed that all knowledge within the domain is highly integrated and complex. This code was observed very frequently in the domain of environment with below representative quote:

> PST 3: Environmental knowledge, I think something which is interwoven but I could not find an analogy now.
> R: How interwoven?
> PST 3: Like a water cycle. In a tick, water cycle came to my mind. It can be a chain but in chain all follow each other. However, in environment it can be daisies consisting of many chains. I mean one does not depend only on the other instead all factors are interdependent.
> R: What can it be?
> PST 3: May be something like a road map. I mean on it [road map] there is an environment where everything is always connected to each other. For instance, any disturbance in one road always affects others.

In here it was observed that the PST believed that the relationships among environmental ideas are not linear instead all of them are interrelated with each other. That is, environmental knowledge is not so simple.

In contrast to the code of "complex links", in "linear links" code the PSTs emphasized that all knowledge is not related to each other instead they thought that some links among ideas were more important than the others. In this respect, beliefs supporting to the code of "linear links" were seen as more naïve epistemological beliefs than beliefs supporting the code of "complex links". The code of "linear links" was generally observed in the domain of physics with below representative quote:

> PST 11: I think that in the beginning s/he [good learner] has a core of knowledge. As information comes on that knowledge, I think that his or her that knowledge further enlarges. I can emulate this to a snail shell. All in all, in some way they are also attached to each other. The rings in the shell grow up the end of the previous one. We can say in the structure of a snail or in the structure of a spiral shape.

From this particular answer it was observed that the PSTs believed that new knowledge builds up prerequisite knowledge and to be good learner you should first know this prerequisite knowledge.

The detailed descriptions and representative quotations of the codes of “complex links” and “linear links” were presented together in Table 4.24.

Table 4.24 "Complex links" and "linear links" codes across domains with representative quotes

Structure of Knowledge Code	Domain (Frequency)	Description	Representative Quote
Complex links	Environment (7)	The phenomena in environment are affected by many factors or Interdisciplinary nature of environmental knowledge	PST 3: Environmental knowledge, I think something which is interwoven but I could not find an analogy now. R: How interwoven? PST 3: Like a water cycle. In a tick, water cycle came to my mind. It can be a chain but in chain all follow each other. However, in environment it can be daisies consisting of many chains. I mean one does not depend only on the other instead all factors are interdependent. R: What can it be? PST 3: May be something like a road map. I mean on it [road map] there is an environment where everything is always connected to each other. For instance, any disturbance in one road always affects others.
	Biology (1) Physics (1) Chemistry (1) Mathematics (1)	Interdisciplinary nature of domain knowledge	PST 6: My analogies for biology, physics, chemistry, and mathematics do not change. I think that it is required to relate all of them to each other all the way since none of them are indeed separated things from each other. All of them support each other…. Also within physics, there is chemistry. Also within chemistry, there is physics. Mathematics is already in each of them.
Linear links	Environment (2)	New knowledge build up prerequisite knowledge	PST 4: For example, I had built but when I take a look I might have built it poorly so it collapses. Why? That is to say I have forgotten to put something in the base of it. I mean that below that basic knowledge my main piece is missing. Therefore, I suppose, I emulate my environmental knowledge to a lego.
	Biology (4)		PST 4: I think that for a good learner there is a much development. That is to say that the good learner uses the legos to build a ladder.
	Physics (5)		PST 2: There is some basic knowledge and new information comes onto this basic knowledge. In this way, it expands and grows. It seems more explanatory. Well, it is like that. Maybe when I remove one [lego], it will fall down. That is why I can say the legos for physical knowledge.
	Chemistry (5)		PST 11: I think that in the beginning s/he [good learner] has a core of knowledge which new knowledge is built up. I can emulate this to a snail shell. In some way, the snail shell is also attached to each other. The rings in the shell grow up the end of the previous one. We can say in the structure of a snail or in the structure of a spiral shape.
	Mathematics (4)		PST 2: My analogy is the same for mathematics. As in the legos, there is also basic knowledge in mathematics and new information builds upon this basic knowledge.

As indicated in Table 4.24, the PSTs' descriptions of the complexity of knowledge in the domains were different. In the domain of environment, the PSTs believed that links among ideas were complex since first environmental problems have more than one solution each of which does not have only one right answer:

> PST 12: Why lego? Since in lego the pieces are related to each other and we can make new pieces. Also in environment, it is like that. I mean all things are related to each other but as I said I am saying this by thinking new solution or different solutions can be generated. As I said before, while solving an environmental problem there is not only one solution. If I want, let's say, I can find six solutions. In fact, by placing different pieces to different places I can generate different things related to environmental knowledge.
> R: Why is it not a puzzle?
> PST 12: In puzzle there are also relationships but you cannot put this piece to another place. It has a fixed place.

Second, only one PST stated that links among environmental knowledge is complex since we need other domains for a better understanding of the environmental knowledge i.e., interdisciplinary nature of environmental knowledge. However, in other domains one PST explained the complexity of links as only interdisciplinary nature of knowledge. This indicated that the PSTs' epistemological beliefs regarding complexity of knowledge were more sophisticated than other domains but not sophisticated since interdisciplinary nature of environmental knowledge was not highlighted so much.

In accordance with what has been told and illustrated up to this point, one can conclude the following regarding structure of knowledge across domains:

The analysis of the PSTs' explanations regarding structure of knowledge in the minds of good learner indicated that many PSTs hold more sophisticated epistemological beliefs in the domain of environment than other domains in such in the domain of environment the vast majority of PSTs depicted a good learner's knowledge as either complex or flexible in its connections (both of which are sophisticated epistemological beliefs) while in the domain of biology, physics, and chemistry majority of PSTs thought that a good learner in these domains view knowledge either linear in its connections (naïve epistemological belief) or flexible in its connections (sophisticated epistemological belief) and in the domain of mathematics many PSTs considered a good mathematical learner's knowledge as either linear or rigid in its connections (both of which are naïve epistemological beliefs).

4.3.2 Structure of Knowledge in the Mind of a Poor Learner across Domains

As shown in Table 4.25, for the question of structure of knowledge in the mind of a poor learner across domains, PSTs did not give a variety of analogies instead they concentrated on the analogy of *sorting program* which was already given to them.

Table 4.25 The Analogies given for a Poor Learner

Analogy	**Domain**					**Total Frequency**
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**	
Sorting	10	10	10	10	9	49
Puzzle	1	1	0	1	0	3
Road map	1	0	0	0	0	1
Legos	0	0	1	0	0	1
Gas molecules	0	0	0	0	1	1
Tool box	0	0	0	0	1	1

The mostly used analogy of *sorting program* can give some ideas regarding what the vast majority of PSTs think about the organization of domain knowledge in the mind of a poor learner. The sorting program was defined as a computer program placing information into separate files. That is, the poor learner's knowledge is separated from each other. However, there were some cases that *sorting program* was used to explain different structure of domain knowledge such as the certainty of links among ideas. As the example of different usages of *sorting program* analogy indicated, the most informative data were obtained when the PSTs were explaining their analogies given for the structure of domain knowledge in the mind of a poor learner and this was presented in the following paragraphs. The PSTs' explanations regarding the organization of domain knowledge in the mind of a poor learner were categorized under three codes which were "isolated bits of knowledge", "fixed connection among ideas", and "missing information" as tabulated in Table 4.26.

Table 4.26 Frequencies of all structure of domain knowledge codes for a poor learner

Structure of Knowledge Code	**Domain**					**Total Frequency**
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**	
Isolated bits of knowledge	9	8	9	8	9	43
Fixed connections among ideas	3	2	2	2	1	10
Missing information	1	1	0	1	1	4

When total frequencies of all structure of domain knowledge codes for a poor learner were considered, it was observed that the most frequently used explanation (isolated bits of knowledge and fixed connections among ideas) revealed that the PSTs considers connections among ideas as important again. The detailed descriptions and representative quotations of the codes of "isolated bits of knowledge" and "fixed connections among ideas" were presented together in Table 4.27.

Table 4.27 “Isolated bits of knowledge” and “fixed connections among ideas” codes across domains with representative quotes

Structure of Knowledge Code	Domain (Frequency)	Description	Representative Quote
Isolated bits of knowledge	Environment (9)	There are not at all or enough connections among knowledge.	PST 2: Sorting program since in sorting program there are not so much connections with one another. I understood sorting program as always placing information into one file. Well, a poor student will not see the connections among each other.
	Biology (8)		PST 3: I can say sorting program because a poor student will think separately. Well, s/he cannot relate much.
	Physics (9)		PST 5: I can say scattered files in a computer which are indeed connected. That is, I can say not being able to relate files which are in the same category.
	Chemistry (8)		PST 2: I select the sorting program because in sorting program the student thinks each topic separately and does not establish so many connections.
	Mathematics (9)		PST 7: For a poor student, well, this [knowledge] is separated as in the filing… Yes, [poor student’s knowledge] it is at different places. If s/he concentrated on this knowledge s/he forgets that other knowledge can help although s/he knows this other knowledge. This is something that is somewhat related to memorizing. Although it [knowledge] is in memory, s/he forgot that it is there and it can be helpful. That is to say s/he memorized without realizing it. Not establishing connections among knowledge indicates that s/he is a poor student and as I said it is like filing…
Fixed connections among ideas	Environment (3)	New information does not change the organization of the existing knowledge	PST 11: For example, a good student may think that living things can live in different environments and this can change; however, a poor student does not think that his or her knowledge can change or evolve instead s/he says that this is this, that is that. For example, s/he thinks a tree in the garden as only one piece of it.
	Biology (2)		PST 10: For a good learner, I think the legos because the organization of the existing knowledge changes in light of new information but for a poor student I can say the sorting program since it does not have a possibility of reconnection as in the legos.
	Physics (2)		PST 12: In the mind of a poor learner, an apple goes into the apple file and a pear goes into the pear file. That is, knowledge in the mind of a poor student can be shown as completely certain knowledge.
	Chemistry (2)		PST 10: I say sorting program again since the organization of the existing knowledge does not change in light of new information as in the legos.
	Mathematics (1)		PST 12: I consider a poor student as a student who is not open to development. An apple goes into the apple file and a pear goes into the pear file. That is, the poor student prefers certainty whatever the domain.

As shown in Table 4.26 and Table 4.27, for the structure of knowledge in the mind of a poor student the vast majority of the PSTs generally mentioned the code of "isolated bits of knowledge" which included the statement that there were either no or enough connections among ideas. When the frequencies of the code of "isolated bits of knowledge" were considered across domains, it was observed that there were not so much differences in the frequencies. That is to say the vast majority of the PSTs believed that no matter what the domain are the knowledge is separated from each other in the mind of a poor learner:

> R: For a poor student?
> PST 7: For a poor student, this [knowledge] is separated, well, like the filing.
> R: Do you say like the sorting program?
> PST 7: Yes, [poor student's knowledge] it is at different places. If s/he concentrated on this knowledge s/he forgets that other knowledge can help although s/he knows this other knowledge. This is something that is somewhat related to memorizing. Although it [knowledge] is in memory, s/he forgot that it is there and it can be helpful. That is to say s/he memorized without realizing it. Not establishing connections among knowledge indicates that s/he is a poor student and as I said it is like filing. When I think a while this does not show differences with respect to fields… I thought and it really does not differ. We mention study habits here. I mean this is being a good student and poor student.

In here, it was observed that the PST believed that a poor student does not establish connections among knowledge in all domains. That is, knowledge in the mind of a poor student consists of isolated bits.

The next frequently used explanation given for the structure of knowledge in the mind of a poor learner was related to the code of "fixed connections among ideas" as shown in Table 4.26. In this code, PSTs believed that knowledge in the mind of a poor learner can have some links in contrary to the code of "isolated bits of knowledge". However, in the code of "fixed connections among ideas" the nature of these links was highlighted. The PSTs believed that poor learners do not change the organization of their existing knowledge in light of new information as shown in Table 4.27. The code of “fixed connections among ideas” was generally observed in the domain of environment with below representative quote:

> R: Ok. What about your analogy for a poor learner?
> PST 11: I do not believe that a poor student can think so complex. I do not also think that it is separated like sorting program. So, I think it [the structure of environmental knowledge] can be like a puzzle.
> R: Why puzzle?
> PST 11: Why I selected the puzzle. For example, a good student may think that living things can live in different environments and this can change; however, a poor student does not think that his or her knowledge can change or evolve instead s/he says that this is this, that is that. For example, s/he thinks a tree in the garden as only one piece of it.

From this particular answer, it was observed that the PST believed that a poor learner may have establish some connections among environmental knowledge but these connections are not complex instead they fit only in its particular place and do not change in light of new knowledge. When the frequencies of the “complex links” code given for a good learner were considered across domains, it was observed that the “complex links” code like “fixed connections among ideas” code was obtained mostly in the domain of environment. In light of these findings, it can be concluded that when connections among ideas are complex you become a good learner in the domain of environment; however, if the connections among ideas are fixed you are a poor learner in the domain of environment.

The final code was “missing information” whose detailed description and representative quotations across domains were presented in Table 4.28.

Table 4.28 “Missing information” code across domains with representative quotes

Structure of Knowledge Code	Domain (Frequency)	Description	Representative Quote
Missing information	Environment (1)	The amount of knowledge is not so much. All pieces of knowledge are not present.	PST 3: I can emulate to a road map. For a poor learner, the road map may consist of only the main roads and not have any freeway or pathway. This is due to not having so much information.
	Biology (1)		PST 11: For a poor learner, it is something that remained missing. I cannot say sorting program. I think that there are much more missing things. A poor student can see knowledge in his or her mind as complete. I thought that this puzzle is in fact missing when we look at it; however, when s/he looks s/he sees it as complete.
	Chemistry (1)		PST 3: For a poor learner in chemistry, there are some missing pieces in the puzzle. When s/he completes those missing pieces, s/he will also be a good student.
	Mathematics (1)		PST 3: If we say that knowledge in the mind of a good learner is the number of keys in the toolbox, everything in the toolbox is ordered and s/he has many tools to use. However, for a poor learner the toolbox is small and not ordered instead it can be mixed.

Unlike the codes of "isolated bits of knowledge" and "fixed connections among ideas" where connections among ideas were emphasized for the structure of knowledge in the mind of a poor learner, the code of "missing information" included the statements regarding the amount of knowledge in the mind of a poor learner as indicated in Table 4.28. From the frequencies of the "missing information" code across domains, it was seen that there is not so much difference in terms of the code across domains. That is to say, the PSTs had a belief that no matter what the domain are a poor learner has limited amount of knowledge:

> PST 3: For a poor learner in chemistry, there are some missing pieces in the puzzle. When s/he completes those missing pieces, s/he will also be a good student.

From this particular answer, it was observed that the PST selected the missing puzzle to indicate that the difference between a poor and good student is that a poor learner has missing information in his or her mind.

In accordance with what has been told and illustrated up to this point, one can conclude the following regarding structure of knowledge in the mind of a poor learner across domains:

There was a little variance in responses regarding the structure of knowledge in the mind of a poor learner in that the vast majority of the PSTs believed that a poor learner has knowledge that is isolated from each other in all domains. However, in the domain of environment a poor student can also view connections among knowledge as fixed. That is to say, analyzing the structure of poor learner's knowledge in the domain of environment through comparing with other domains indicated an importing finding that environmental knowledge in the mind of a good learner should be highly related to each other and connections among knowledge should be flexible. This finding was parallel to the finding obtained by analysis of the structure of environmental knowledge in the mind of a good learner.

4.4 Control of Learning

In personal epistemology literature, one's epistemological beliefs regarding learning has been investigated under two dimensions which are "control of learning" and "speed of learning". The dimension of the control of learning is related to the beliefs about one's ability to learn and this dimension is placed on a continuum that ranges from the belief that ability to learn is genetically predetermined (naive epistemological belief) to the belief that ability to learn is acquired (sophisticated epistemological belief). In the following part of the result section, the analyses of PSTs' epistemological beliefs regarding the control of learning were presented in the domains of environment, biology, physics, chemistry, and mathematics.

To elicit PSTs' domain-specific epistemological beliefs in control of learning dimension for each domain the PSTs were first asked to assign percentages to two categories of control of knowledge dimension which are "the ability to learn due to genetical predisposition" and "the ability to learn due to learning how to learn". Then they were asked to explain why they think that ability to learn can be innate or acquired after the birth. As a result of this data collection process, the analysis of the PSTs' epistemological beliefs regarding control of learning dimension across domains was presented in two parts: The ability to learn in terms of percentages across domains and the underlying reasons for why innate ability to learn and acquired ability to learn across domains.

4.4.1 Ability to Learn in terms of Percentages across Domains

The mean percentages of two categories of control of learning dimension were presented for the domains of environment, biology, physics, chemistry, and mathematics in Table 4.29.

Table 4.29 The mean percentages of the control of learning categories across domains

Control of learning Category	**Domain**				
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**
Learning due to genetic predisposition	21.67 (14.67)*	27.08 (21.37)	26.25 (22.27)	26.67 (21.78)	30.42 (19.71)
Learning due to how to learn	78.33 (14.67)	72.92 (21.37)	73.75 (22.27)	73.33 (21.78)	69.58 (19.71)

*standard deviations shown in parentheses

When the mean percentages of the categories of "learning due to genetic predisposition" and "learning due to how to learn" were compared for each domain, it was observed that the mean percentage of "learning due to genetical predisposition" category was much more greater than the mean percentage of "learning due to how to learn" category for all domains as tabulated in Table 4.29. This revealed that the vast majority of the PSTs believed that no matter what the domain are much of learning is due to abilities that are acquired rather than fixed at birth. In this respect, the PSTs hold sophisticated epistemological beliefs regarding the dimension of control of learning for all domains.

To elicit PSTs' sophisticated epistemological beliefs regarding control of learning thoroughly, the number of frequencies for each individual percentage was also presented for the most naïve category of control of learning which is "learning due to genetical predisposition" as shown in Table 4.30.

Table 4.30 Frequencies of individual percentages for “learning due to genetic predisposition” category across domains

Percentages (%)	Domain				
	Environment	Biology	Physics	Chemistry	Mathematics
0	2	2	2	2	0
5	0	0	0	1	1
10	2	2	2	1	2
20	2	2	3	2	3
30	5	2	2	2	1
40	0	1	0	1	1
45	0	1	1	1	2
50	1	1	0	1	1
60	0	0	1	0	0
70	0	1	1	1	1

As it was seen in the Table 4.30, almost all PSTs hold sophisticated epistemological beliefs regarding the control of learning in all domains since there were at most two PSTs who believed that learning in the domains is mostly related to genetical predisposition rather than how to learn. For instance, in the domain of environment only one PST assigned the percent of ability due to genetical disposition as 50% while in the domains of biology, physics, chemistry, and mathematics only two PSTs believed that 50% or more of ability to learn is due to genetical disposition.

The overall analysis revealed that the PSTs hold different degree of sophistication in terms of control of learning in the domains in such the mean percentages given for the category of “learning due to genetical predisposition” were observed in a decreasing order of mathematics, biology, chemistry, physics, and environment (See Table 4.29). Similarly, for the category of “learning due to genetical predisposition” the PSTs generally assigned the lowest percentages (the percentages between 0% and 30%) to the domain of environment while the highest percentages (the percentages between 40% and 70%) to the domain of mathematics (See Table 4.30). In light of these findings, it was concluded that learning in the domain of environment is the least genetically predetermined one while learning in the domain of mathematics is the most genetically determined one among the learning in other domains. In this respect, the vast majority of the PSTs hold more sophisticated epistemological beliefs regarding the control of learning in the domain of environment than other domains.

4.4.2 Underlying Reasons for Why Innate Ability to Learn and Acquired Ability to Learn across Domains

For each domain, the PSTs' were asked to explain their percentages given to two categories of control of learning dimension. Analysis of the PSTs' explanations revealed two distinct codes for the percentage of "innate ability to learn" category and three distinct codes for the percentage of "acquired ability to learn". In the following part, for the domains of environment, biology, physics, chemistry, and mathematics first why the ability to learn can be innate then why the ability to learn can be acquired after the birth was presented thoroughly in light of the specific codes emerged during analysis.

4.4.2.1 Underlying Reasons for why Innate Ability to Learn across Domains

Although almost all PSTs believed that in the domains of environment, biology, physics, chemistry, and mathematics the large percentage of the ability to learn acquired after the birth, they gave few percentages to the ability to learn that comes from genetical predisposition in these domains. The analysis of why the PSTs gave percentages to the category of "ability to learn due to genetical predisposition" in the domains of environment, biology, physics, chemistry, and mathematics resulted in two codes named as "innate interest" and "intelligence" (See Table 4.31).

Table 4.31 Codes of the category of "innate ability to learn" across domains

Innate Ability to Learn Code	**Domain**				
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**
Innate interest	6	4	3	4	3
Intelligence	0	1	5	3	5
Total Frequency	6	5	8	7	8

When total frequencies given for the "innate interest" and "intelligence" codes of innate ability to learn were taken into account for each domain, it was observed that the PSTs had difficulty in explaining why the ability to learn can come from at the birth in the domains of environment and biology when compared with other domains. In light of this finding, it was concluded that the PSTs believed that the ability to learn in the domains of environment and biology is not as innate as other domains. This was parallel to the finding obtained by the analysis of the ability to learn in terms of percentages in such almost all PSTs hold the most sophisticated epistemological beliefs regarding control of learning in the domains of environment with the least mean percentages in the category of "ability to learn due to genetical predisposition".

As indicated in Table 4.31, the most frequently used reason regarding why the ability to learn can be innate was "innate interest". The half of the PSTs believed that some percentages of the ability to learn can be innate since some people are born with interest in learning, others are not. This code was frequently observed in the domain of environment with below representative quote:

> PST 6: Ability to learn environmental science…hmm I think that 20% is genetical predisposition and the remaining is related to learning how to learn. I actually think that there is a genetical percentage because as I said in some way it is related to interest and this is something that comes from genetic.

In addition to “innate interest”, some PSTs believed that innate percentage of the ability to learn can be “intelligence”. The code of “intelligence” was frequently observed in the domains of mathematics and physics. For instance, the PST 5 believed that innate percentage of ability to learn is the most in the domain of mathematics since mathematics is more related to intelligence than other domains:

> R: What do you think about the percentage of ability to learn is innate in mathematics?
> PST 5: 40% is innate.
> R: What about physics?
> PST 5: 0%. It [ability to learn in physics] is not innate like biology, chemistry, and environment since to me mathematics is a bit related to intelligence; however, the others [physics, chemistry, biology, and environment] are more related to observation.

The detailed descriptions and representative quotes of the codes of “innate interest” and “intelligence” were presented in Table 4.32.

Table 4.32 “Innate interest” and “intelligence” codes across domains with representative quotes

Innate Ability to Learn Code	**Domain (Frequency)**	**Description**	**Representative Quote**
Innate Interest	Environment (6)	Some percentage of the ability to learn can be innate since the ability to learn is related to interest and interest is innate.	PST 6: Ability to learn environmental science…hmm I think that 20% is genetical predisposition and the remaining is related to learning how to learn. I actually think that there is a genetical percentage because as I said in some way it is related to interest and this is something that comes from genetic.
	Biology (4)		PST 6: Biology is same with environment since as I said it [ability to learn due to genetical predisposition] is something related to people’s interest.
	Physics (3)		PST 3: 30% may come from innate. I mean the thing coming from innate is, in fact, field of interest. For instance, for some people dealing with numbers comes more instructive; for some people reading comes more instructive.
	Chemistry (4)		PST 12: Genetic is 40%. It is related to motivation. I mean some students already have internal motivation. They do not need a teacher; however, other students need to be motivated externally. I think that internal motivation is related to genetic.
	Mathematics (3)		PST 9: 20% is genetic effect. Actually, it is general since we mention about learning for all. So, percentages of learning are the same for all. However, for a person more interest may come from innate.
Intelligence	Biology (1)	Some percentage of the ability to learn can be innate since the ability to learn is related to intelligence and intelligence is innate.	PST 7: When you say physics, chemistry, mathematics even biology I will give the same [percentage] since they require a higher IQ. This depends more on mother and father. I will say this 70%.
	Physics (4)		PST 8: May be %10 is innate since physics is a bit abstract. No, it is not abstractness instead since physics requires more of an ability to think, intelligence.
	Chemistry (2)		PST 2: In chemistry like physics and mathematics, 40% [ability to learn due to genetical predisposition] to 60% [ability to learn due to learning how to learn] since it is more quantitative. Just now we say that we should use multiple intelligence… It seems to me that being good at in quantitative is genetical.
	Mathematics (5)		PST 5: 0%. It [ability to learn in physics] is not innate like biology, chemistry, and environment since to me mathematics is a bit related to intelligence; however, the others [physics, chemistry, biology, and environment] are more related to observation.

From the Table 4.31 and Table 4.32, it was observed that the reasons for the percentages of the ability to learn coming from at the birth are different in the domains in such in the domain of environment, biology, and chemistry the PSTs generally associated innate percentages of the ability to learn with innate interest rather than intelligence while in the domains of mathematics and physics with intelligence.

4.4.2.2 Underlying Reasons for why Acquired Ability to Learn across Domains

As shown in Table 4.33, the analysis of why the PSTs thought that the ability to learn in the domains of environment, biology, physics, chemistry, and mathematics can be acquired after the birth resulted in three codes named as "experiences/ observations", "learning how to learn" and "effort".

Table 4.33 Codes of the category of "acquired ability to learn" across domains

Acquired Ability to Learn Code	**Domain**				
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**
Learning how to learn	3	3	3	3	3
Experiences/ observations	5	2	0	2	0
Effort	1	2	2	2	2
Total Frequency	9	7	5	7	5

When the total frequency of "experiences/ observations", "learning how to learn", and "effort" codes were compared across domains, the highest frequency of 9 was observed in the domain of environment. In light of this finding, it was concluded that the PSTs believed that among domains environment is the one in which the ability to learn can be acquired mostly after the birth. This finding was parallel to the finding regarding the ability to learn in terms of percentages in such the highest mean percentage in the category of “ability to learn due to learning how to learn” was obtained in the domain of environment.

The most frequent code regarding acquired ability to learn category was “learning how to learn” whose definition and representative quotes were given in Table 4.34.

Table 4.34 “Learning how to learn” code across domains with representative quotes

Innate Ability to Learn Code	Domain (Frequency)	Description	Representative Quote
Learning how to learn	Environment (3) Biology (3) Physics (3) Chemistry (3) Mathematics (3)	Some percentage of the ability to learn can be acquired after the birth through learning how to learn.	PST 3: I believe that there is an innate percentage; however, I do not believe that it [the ability to learn] is completely innate. For example, if a student is bad at Turkish in primary school or bad at in environment related issues I do not believe that there is such a thing that the whole life of that student will pass like that or the student will be strained so much in learning environmental science. However, after a while, for example, everyone has their own method to learn some things. I think that if s/he discovers how to learn by the help of teachers or self-questioning s/he can increase his or her ability to learn and I think that more of it is from the improvable one. PST 6: I think that 20% is genetical predisposition; the remaining is related to learning how to learn. For example, I can learn biology easier when I relate it to chemistry or when I relate it to physics. In that case, it is actually needed to learn how we learn. PST 9: I think that a large percentage is learning how to learn afterwards, 80% and 20% is genetic effect. Actually, it is general since we mention about learning for all. So, percentages of learning are the same for all [environment, physics, chemistry, biology, and mathematics]… Innate intelligence affect a little bit… No matter how much somebody works s/he actually learns how to learn.

As indicated in Table 4.33 and Table 4.34, the most frequent code regarding reasons for why the ability to learn can be acquired was "learning how to learn". In this code, three PSTs believed that large percentage of the ability to learn not only in the domain of environment but also in other domains is improvable through "learning how to learn" with below representative quote:

> PST 3: I believe that there is an innate percentage; however, I do not believe that it [the ability to learn] is completely innate. For example, if a student is bad at Turkish in primary school or bad at in environment related issues I do not believe that there is such a thing that the whole life of that student will pass like that or the student will be strained so much in learning environmental science. However, after a while, for example, everyone has their own method to learn some things. I think that if s/he discovers how to learn by the help of teachers or self-questioning s/he can increase his or her ability to learn and I think that more of it is from the improvable one.

From this particular answer, it was observed that the PST believed that a person can develop the ability to learn through being aware of the strategy s/he can use. That is, the PST highlighted the importance of process of discovery about learning to acquire ability to learn after the birth.

Some PSTs also believed that one's ability to learn can be improvable after the birth through experiences or observations. The "experiences/ observations" code was mostly observed in the domain environment with below representative quote:

> PST 11: 90% can be learned after the birth, 10% is innate since people all in all do not remember anything until 5 years old. Well, no matter how much s/he learned the things that other people said may come to her or him as a story until that age. That is why I think that it [ability to learn] does not depend more on genetic. Besides I see that although environment related knowledge at elementary school is very small piece, now it can be enormous range. Well, that is why I think that as I see my environment, listen from the others, and do observations I can learn it more and I can understand it more.

From this particular answer, it was observed that the PST believed that large percentage of the ability to learn can be acquired since we learn the nature more as we observe it or as we listen from other people's experiences. In here, s/he only mentioned about knowledge acquisition in the domain of environment through observations or experiences without any integration of how these experiences or observations result in the development of the ability to learn. In this respect, the code of “experiences/ observation” was not sophisticated as it was expected.

In addition to “learning how to learn” and “experiences/ observations”, few PST believed that some percentage of the ability to learn can be acquired through showing *effort*. The code of “effort” was mostly observed in the domains of mathematics, physics, chemistry, and biology with below representative quote:

> PST 7: When you say physics, chemistry, mathematics even biology I will give the same [percentage] since they require a higher IQ. This depends more on mother and father. I will say this 70%. 30% is remaining for working, working hard.

In here, it was observed that the PST hold naïve epistemological beliefs in terms of control of learning, viewing much of the ability to learn as genetically predetermined; however, s/he thought that ability to learn in the domains of physics, chemistry, mathematics, and biology can be a little improvable after the birth through hard work. The detailed descriptions and representative quotes of the codes of “experiences/ observations” and “effort” were presented in Table 4.35.

Table 4.35 "Experiences/ observations" and "effort" codes across domains with representative quotes

Innate Ability to Learn Code	Domain (Frequency)	Description	Representative Quote
Experiences/ Observations	Environment (5)	Some percentage of the ability to learn can be acquired through experiencing or observing phenomena in nature.	PST 11: 90% can be learned after the birth, 10% is innate since people all in all do not remember anything until 5 years old. Well, no matter how much s/he learned the things that other people said may come to her or him as a story until that age. That is why I think that it [ability to learn] does not depend more on genetic. Besides I see that although environment related knowledge at elementary school is very small piece, now it can be enormous range. Well, that is why I think that as I see my environment, listen from the others, and do observations I can learn it more and I can understand it more.
	Biology (2)	Some percentage of the ability to learn can be acquired through observing phenomena in biology.	PST 11: Again, I want to say 90% [ability to learn due to learning how to learn] to 10% [ability to learn due to genetical predisposition]… All in all, since biology is also in environment, even if nothing happens human can do observation his or her own body. Well, even going to kindergarden girls realize their being a female; boys realize their being a male. That is, because of something based on observation I said 90%. I do not think that doing observation is something that is acquired.
	Chemistry (2)	Some percentage of the ability to learn can be acquired through experiencing or observing phenomena in chemistry.	PST 4: Chemistry, I say this, 30% [ability to learn due to genetical predisposition] and 70% [ability to learn due to learning how to learn]. It is same with environment since it is also a bit related to daily life.
Effort	Environment (1)	Some percentage of the ability to learn can be acquired through effort.	PST 3: I think this [ability to learn] in general. I mean that for instance, in fine arts it is also said that drawing is ability. Although little is innate if a person study s/he can draw after a while even s/he had bad drawing before.
	Biology (2) Physics (2) Chemistry (2) Mathematics (2)	Some percentage of the ability to learn can be acquired improvable through hard work or effort.	PST 7: When you say physics, chemistry, mathematics even biology I will give the same [percentage] since they require a higher IQ. This depends more on mother and father. I will say this 70%. 30% is remaining for working, working hard.

In accordance with what has been told and illustrated up to this point, one can conclude the followings regarding control of learning across domains:

1. Although the vast majority of the PSTs believed that large percentage of the ability to learn can be acquired after the birth not only in the domain of environment but also in other domains, the PSTs had difficulty in explaining their sophisticated epistemological beliefs regarding control of learning.

2. Although few explanations were given regarding why some percentage of the ability to learn are not fixed at birth, the analysis of them indicated that some PSTs believed that one's ability to learn can develop after the birth through learning how to learn, experiences or observations, and effort.

3. Investigating the PSTs' understanding regarding acquired ability to learn in the domain of environment through comparing with other domains provided an important finding that some PSTs believed that acquired percentage of the ability to learn was mostly related to people's experiences or observations in the domain of environment unlike other domains.

4.5 Speed of Learning

In addition to "control of learning", "speed of learning" is also an epistemological beliefs dimension regarding learning. The dimension of "speed of learning" is placed on a continuum that ranges from the belief that learning is quick or not at all (naive epistemological belief) to the belief that learning is slow gradual process (sophisticated epistemological belief). In the following part of the result section, the analyses of PSTs' epistemological beliefs regarding the speed of learning were presented in the domains of environment, biology, physics, chemistry, and mathematics.

To elicit PSTs' domain-specific epistemological beliefs in the dimension of speed of learning, for each domain the PSTs were first asked to assign percentages to three categories of the speed of knowledge dimension -slow learning, moderately slow learning, and fast learning- by considering the average student. Then they were asked to explain why they gave lower or higher percentage to the category of "slow learning" or "fast learning". Moreover, the same procedure was conducted for the smart student. As a result of this data collection process, the analysis of PSTs' epistemological beliefs regarding the speed of learning dimension across domains was presented in two parts: The speed of learning in terms of percentages across domains and the underlying reasons for why fast learning and slow learning across domains.

4.5.1 Speed of Learning in terms of Percentages across Domains

The PSTs who hold sophisticated epistemological beliefs in "speed of learning" dimension would assign more percentages to "slow learning" category rather than "fast learning" category for the average student. Moreover, they would not assign more than 50% to "fast learning" category for the smart student. That is, they would think that even smart students need to take their time.

The mean percentages of three categories of speed of learning dimension for the average and smart student were presented for the domains of environment, biology, physics, chemistry, and mathematics in Table 4.36.

Table 4.36 The mean percentages of the speed of learning categories across domains

Speed of Learning Category	Percentages in the Domains Given for the Average Learner				
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**
Slow learning	29.17 (15.50)*	29.73 (17.63)	46.82 (16.17)	32.73 (14.03)	41.53 (17.69)
Moderately slow learning	38.75 (10.47)	40.73 (16.55)	36.36 (12.86)	42.27 (14.73)	39.03 (10.70)
Fast learning	32.08 (15.59)	29.55 (19.81)	16.82 (10.07)	25.00 (13.23)	19.86 (13.49)
Speed of Learning Category	**Percentages in the Domains Given for the Smart Learner**				
	Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**
Slow learning	16.33 (12.34)	22.09 (15.53)	26.36 (14.85)	19.82 (13.65)	24.67 (15.45)
Moderately slow learning	32.42 (14.02)	32.73 (15.06)	37.73 (16.94)	36.09 (13.61)	32.83 (12.97)
Fast learning	51.25 (19.90)	45.18 (18.07)	35.91 (11.36)	44.09 (16.86)	42.50 (23.01)

*standard deviations shown in parentheses

When the mean percentages of the most sophisticated speed of learning category (slow learning) were compared with the mean percentages of the most naïve speed of learning category (fast learning) for the average learner, it was observed that the mean percentage of the "slow learning" category was higher than the mean percentages of the "fast learning" category across domains except environment as tabulated in Table 4.36. This revealed that the vast majority of the PSTs believed that for the average learner learning in the domain of environment does not need as much time as other domains. Similarly, when the mean percentages of "slow learning" and "fast learning" categories were taken into account for the smart learner, it was observed that less than 50% of knowledge was attributed to fast learning in the domains of biology, physics, chemistry, and mathematics except the domain of environment. This pointed out that many PSTs believed that smart students need more time in their studies in all domains except environment. In this respect, the vast majority of PSTs hold more naive epistemological beliefs regarding speed of learning in the domain of environment when compared with other domains.

When the mean percentages of the categories of "slow learning" and "fast learning" were compared across domains for both the average learner and smart learner, it was observed that the domain of environment was more similar to the domain of biology. After the domain of biology, the speed of learning was ordered as chemistry, mathematics, and physics. In light of this finding, it was concluded that the PSTs have the most sophisticated epistemological beliefs regarding speed of learning in the domain of physics among other domains in such the PSTs believed that learning in physics takes more time than that in other domains.

4.5.2 Underlying Reasons for Why Fast Learning and Slow Learning across Domains

For the domains of environment, biology, physics, chemistry, and mathematics, the PSTs' were asked to explain why they assigned higher or lower percentages to the categories of speed of learning dimension. Analysis of the PSTs' explanations revealed three codes, one of which was related to the category of "fast learning" (concrete knowledge) and two of them were attributed to the category of "slow learning" (abstract knowledge and interrelated knowledge) as tabulated in Table 4.37.

Table 4.37 Codes of speed of learning dimension across domains

Speed of Learning Category	**Speed of Learning Code**	**Domain**				
		Environment	**Biology**	**Physics**	**Chemistry**	**Mathematics**
Fast Learning	Concrete knowledge	8	4	1	2	0
Slow Learning	Abstract knowledge	0	2	6	3	9
	Interrelated knowledge	5	3	4	1	2

From the Table 4.37, it was observed that the frequency of “slow learning” category was more than that of “fast learning” category in all domains except environment. This indicated that the PSTs had strong beliefs that among domains environment is the one in that learning does not take so much time. This finding was parallel to the finding obtained by analysis of speed of learning in terms of percentages for both average and smart learner in such the PSTs assigned more percentages to “fast learning” rather than “slow learning” in the domain of environment among domains.

When total frequencies of speed of learning codes were taken into account, it was observed that “concrete knowledge” and “abstract knowledge” were the most frequently used codes. In both codes, the PSTs concerned with the observability, tangibility, and concreteness of knowledge in the domains; however, the difference was that in “concrete knowledge” code the PSTs believed that the speed of learning is fast when they can observe knowledge in a particular domain while the speed of learning is slow in “abstract knowledge” code since they cannot observe knowledge in that domain. The detailed descriptions and representative quotes of “concrete knowledge” and “abstract knowledge” codes across domains were given in Table 4.38 and Table 4.39.

Table 4.38 “Concrete knowledge” code across domains with representative quotes

Speed of Learning Code	Domain (Frequency)	Description	Representative Quote
Concrete knowledge	Environment (8)	Knowledge that depends on observations is learned fast.	PST 6: Moderate is 50%; fast is 30%; and gradually is 20%. R: Why do you think that 50 percentage of environmental knowledge is learned moderately? PST 6: Since environmental knowledge is something that we can completely see and understand. It is something that the average student himself or herself can observe. That is why I do not think that it is something too difficult to be understood or too incomprehensible. As I said, for instance, when a dam is constructed in a place it is not difficult to predict that living thing in there will die. I think that it is not difficult to accept this when you see this or in some ways read something related to this or watch. That is why I think that everyone can easily understand moderately.
	Biology (4)		PST 3: I think that biology is again like environment. I think that it is easier to learn things coming from after terms. I mean that s/he [average student] learns faster the things that s/he can observe. S/he is strained for other things like terms or concepts.
	Physics (1)		PST 4: If I were a very smart student, I would do more observations in daily life. That is why fast percentage would increase for all… Since chemistry like physics can be turned into concrete fast part will be again high. For instance, if fast learning is 40%, moderate learning is 40% and slow part becomes 20%.
	Chemistry (2)		PST 8: For chemistry, fast learning is 50%; 30% [moderate learning I]; and 20% [slow learning]. As I said before, you say physical changes, evaporation of water, water boils at 100°C. All in all for instance we enter kitchen and all in all we cook. We are very involved with a chemical matter everywhere in our daily life. That is why for instance I think that even our mothers also have chemical knowledge… I mean we use and we observe. For that reason, we learn faster.

Table 4.39 “Abstract knowledge” code across domains with representative quotes

Speed of Learning Code	Domain (Frequency)	Description	Representative Quote
Abstract Knowledge	Biology (2)	Knowledge that does not depend on observations is learned slowly.	PST 4: Biology is also abstract. We are able to make experiments; however, we are able to do experiments for only a few parts. Hmm, probably slow learning part is 50%.
	Physics (6)		PST 8: Physics. 40% [fast learning], 20% [moderate learning], 40% [slow learning]. Even you are smart you learn physics more slowly. R: why do you think so? PST 8: Due to its being abstract. It [learning physics] requires more time since they are abstract concepts. R: what do you mean by abstract concepts? PST 8: I mean observing or not observing in daily life as well as seeing with naked eyes. I do not know, when I think the things related to universe, in my opinion physics becomes abstract.
	Chemistry (3)		PST 2: I can say the same thing [thing I said for physics] for chemistry. 40% [slow learning], 50% [moderate learning], 10% [fast learning]. The average student learns basic knowledge that s/he can observe from environment fast. As s/he goes into less observable s/he will learn more slowly since it will be more abstract and more theoretical.
	Mathematics (9)		PST 5: I think that gradual learning is 80%; 20% is moderate learning; and 0% is fast learning. R: Is fast learning 0%? PST 5: I think there is no since we learn by studying even abacus such that homework is given. It is not easy to digest mathematics instantly even for a smart student since in my opinion mathematics is abstract.

From frequencies indicated in Table 4.37 and Table 4.38, it was observed that "concrete knowledge" code was mostly stated in the domain of environment with below representative quote:

> PST 6: Moderate is 50%; fast is 30%; and gradually is 20%.
> R: Why do you think that 50 percentage of environmental knowledge is learned moderately?
> PST 6: Since environmental knowledge is something that we can completely see and understand. It is something that the average student himself or herself can observe. That is why I do not think that it is something too difficult to be understood or too incomprehensible. As I said, for instance, when a dam is constructed in a place it is not difficult to predict that living thing in there will die. I think that it is not difficult to accept this when you see this or in some ways read something related to this or watch. That is why I think that everyone can easily understand moderately.

From this particular, it was observed that the PST believed that learning in the domain of environment is not a slow process since s/he can easily observe environmental knowledge with his or her naked eyes. In this respect, the beliefs supporting the code of "concrete knowledge" were judged as naive epistemological beliefs regarding speed of learning. The PSTs who hold sophisticated epistemological beliefs would state that no matter what domains are learning requires active participation of the learner and connections among ideas which take time and effort.

From frequencies shown in Table 4.33 and Table 4.39, it was observed that in contrast to "concrete knowledge", "abstract knowledge" code was mostly observed in the domain of mathematics with below representative quotation:

> PST 5: I think that gradual learning is 80%; 20% is moderate learning; and 0% is fast learning.
> R: Is fast learning 0%?
> PST 5: I think there is no since we learn by studying even abacus such that homework is given. It is not easy to digest mathematics instantly even for a smart student since in my opinion mathematics is abstract.

In here, it was observed that the PST believed that learning in the domain of mathematics takes time and effort. In this respect, the PST holds sophisticated epistemological beliefs regarding speed of learning dimension. However, the underlying reason for slow learning in mathematics was not so sophisticated when "interrelated knowledge" code was considered. The reason for this was that in "interrelated knowledge" code the PSTs emphasized that learning takes time and effort since it requires connections among ideas. The detailed description and representative quotations of "interrelated knowledge" across domains were given in Table 4.40.

Table 4.40 "Interrelated knowledge" code across domains with representative quotes

Speed of Learning Code	Domain (Frequency)	Description	Representative Quote
Interrelated Knowledge	Environment (5)	Knowledge that requires connections is learned slowly.	PST 4: Hmm, it seems to me that s/he learns 40% slowly since s/he may not know some specific things in terms of establishing connections. For instance, there is a lake and there is an issue of pollution in this lake. In the first place, s/he understands that it is polluted; however, this learned percentage is very low. That is, knowledge that the lake is polluted. This corresponds only 10% of entire subject and s/he learns it right away; however, when s/he comes to deep part the speed of learning will be slower. R: What do you mean by deep? PST 4: To make detailed, establish more connections, how can I say?
	Biology (3)		PST 4: I say that 30% is fast. Hmm, 30% is moderate learning and the remaining is slow. Probably, the slow percentage is much more. Let's 40%. Learn 40% slow since biology is detail. It is too much related. For instance, in cell there is not only one thing instead there are a thousand things for protein synthesis such as rRNA and nucleus. How should I say? To know protein synthesis s/he [the smart learner] should also know all remaining things.
	Physics (4)		PST 11: The average student can learn fast 10% of physical knowledge. S/he can learn slowly 50% of it and 40% can be moderate. I gave fast learning less since physics is such something that it ranges from simple concepts to so complex ones. Well, I thought that the average student can learn that basic things fast; however, learning or understanding can be slow as s/he comes to more complex ones. R: What do you mean by complex? PST 11: How should I say? For instance, a topic is told. In the second lesson, you add another topic to previous one. In that time, you tell new one. Well, as it goes like that new one is added which makes the first one more difficult and complex.
	Chemistry (1)		PST 2: 20% [slow learning], 50% [moderate learning], 30% [fast learning]. The percentage of moderate learning is much more since that percentage again requires connections.
	Mathematics (2)		PST 4: In mathematics, fast learning is about 10%, moderate is 40%, and slow learning is 50%. Slow learning in mathematics is more than that in environment since it seems to me that in mathematics there will be many details. S/he [the average student] will learn the detailed part slowly since s/he must establish connections.

From frequencies presented in Table 4.37 and Table 4.40, it was observed that the "interrelated knowledge" code was mostly stated in the domain of environment with below representative quotation:

> PST 4: Hmm, it seems to me that s/he learns 40% slowly since s/he may not know some specific things in terms of establishing connections. For instance, there is a lake and there is an issue of pollution in this lake. In the first place, s/he understands that it is polluted; however, this learned percentage is very low. That is, knowledge that the lake is polluted. This corresponds only 10% of entire subject and s/he learns it right away; however, when s/he comes to deep part the speed of learning will be slower.
> R: What do you mean by deep?
> PST 4: To make detailed, establish more connections, how can I say?

From this particular answer, it was observed that the PST hold sophisticated epistemological beliefs regarding speed of learning since s/he believed that large percentage of environmental knowledge requires construction of connections among ideas which takes time.

In accordance with what has been told and illustrated up to this point, one can conclude the followings regarding speed of learning across domains:

1. Investigation of the PSTs' epistemological beliefs regarding speed of learning dimension in the domain of environment through comparing with other domains indicated that the vast majority of the PSTs did not hold so sophisticated epistemological beliefs regarding speed of learning in the domain of environment as in other domains in that they thought that knowledge acquisition in the domain of environment takes less time than that in other domains since environmental knowledge is more concrete than knowledge in other domains.

2. Investigation of the underlying reasons for why learning is slow or fast process revealed that speed of learning was related to nature of knowledge in that slow learning in the domains of environment and biology was associated with knowledge's being interrelated while slow learning in the

domains of mathematics, physics, and chemistry was attributed to abstract nature of knowledge in those domains.

CHAPTER 5

DISCUSSIONS, IMPLICATIONS, AND RECOMENDATIONS

This chapter aims to present discussions drawn from the findings of the present study, implications, and recomendations for further studies.

5.1. Discussions

In the present study, it was aimed to explore the PSTs' personal epistemological beliefs regarding the domain of environment through comparing with other domains. As it is seen from the aim, this study primarily examined the construct of personal epistemology. Consequently, in the first paragraphs there are discussions drawn from the findings of the study regarding this construct. The study also examined the PSTs' personal epistemological beliefs by using multiplicity approach. As a result, after having discussed the findings regarding the construct of personal epistemology in general, further detail information about five dimensions of personal epistemological beliefs were presented.

One of the remarkable findings of this study was that the PSTs hold different level of sophistication across epistemological belief dimensions. For instance, the PSTs believed that ability to learn in the domain of environment is acquired after the birth (sophisticated epistemological belief regarding control of learning dimension). Yet, at the same time they conceived of learning in the domain of enviroment as quick (naive epistemological belief regarding speed of learning dimension). Thus, it might be considered that the PSTs have a system of beliefs that are more or less independent which corresponds that the PSTs' personal epistemological beliefs are multidimensional. This finding is consistent with findings of other studies (e.g., Buehl & Alexander, 2001; Hofer, 2000; Schommer, 1990, 1993; Schommer-Aikins, 2008).

Another finding of the present study, which is worthy of notice was that the PSTs' epistemological beliefs may vary across domains. For instance, concerning justification of knowledge the PSTs stated different ways to understand the truth of knowledge across domains. The most of the PSTs believed that knowledge is justified through direct observations in the domains of environment and biology unlike other domains where knowledge is justified either on the basis of probability (i.e., physics and chemistry), by authority (i.e. mathematics), through experiments (i.e., chemistry) or proofing (i.e., mathematics). These findings provided further evidence that epistemological beliefs may be domain-specific. In this respect, this study shows some similarities with previously conducted studies that indicated the domain-specificity of epistemological beliefs (e.g., Estes et al., 2003, Hofer, 2000; Stodosky et al., 1991). Yet, this study extends the literature by examining epistemological beliefs in a different domain i.e., in the domain of environment.

In the present study, in addition to knowledge beliefs (i.e., source, justification, stability, and structure of knowledge) learning beliefs (i.e., control and speed of learning) were also investigated. The analyses of speed of learning beliefs revealed that learning in the domains of environment and biology takes less time due to concrete nature of knowledge in those domains. On the other hand, learning in the domains of chemistry, physics, and mathematics is a gradual process due to abstract nature of knowledge in those domains. These findings suggest that beliefs about speed of learning are closely related to beliefs about nature of knowledge. Thus, it might be considered that learning beliefs are also important aspects of personal epistemolgy. In literature, there is a debate whether learning beliefs should be included or excluded from the definition of personal epistemology (Schommer-Aikins et al., 2000). The findings of the present study raise doubt on Hofer and Pintrich (1997)'s concept of epistemological beliefs since they argued that epistemological beliefs should be limited to beliefs about knowledge for a clarity for the research and theorizing in the field of personal epistemology. However, the finding support Schommer-Aikins (2008)'s view that for a deeper understanding of learner both knowledge and learning beliefs should be investigated concurently since these two types of beliefs appears to be closely related to each other.

Concerning to what degree the PSTs believe experts across domains, the analysis indicated that although most of the PSTs put much faith in experts, they expressed the least confidence in experts in the domain of environment. Similar to environmental experts, Johnson and Scicchitano (2000) claimed that there is a decline in public trust for most public institutions over the last two decades. In related to this issue, it is generally acknowledged that the mass media play a crucial role in the formation of public opinion (Roll-Hansen, 1994). Given that vast majority of the PSTs considered newspapers and TV as source of their environmental knowledge and there is an increasing attention to environmental topics in visual and printed media (Baykan, 2009), it is not unusual or suprising to say that less trust in environmental experts may be due to the PSTs' perception of the mass media as a source of environmental knowledge. The PSTs may think that due to overt and covert governmental influences, pressure from advertisers or commercial interest of their owners, the mass media may not report all available stories and facts about environmental issues. That is, the PSTs may consider information about environmental issues in the mass media as less credible. According to a survey conducted by the American Society of Newspaper Editors, a third of editors stated that they hesitate to run a news story that was demaging to their owners' company (as cited in Edwards & Henderson, 2000). In addition to the mass media bias, uncertainty of environmental knowledge that is caused by measurement may lead the PSTs to believe less in environmental experts. In their study, Estes et al. (2003) indicated that both undergraduates from the United State and the United Kingdom expressed less confidence in the conclusions and advice of experts in the field of psychological development than biological development. The analysis of the participants' explanations indicated that the most important reason for more negative views of research on psychological development is the difficulty in measuring phenomena of psychological development. Similarly, in the present study the PSTs expressed the uncertainty in measurement mostly for the domain of environment among the domains of biology, physics, chemistry, and mathematics. Finally, complexity of environmental knowledge expressed by the PSTs can also be a reason for their less trust in environmental experts since in their study Estes et al. (2003) also indicated that complexity of psychological developmenment is one of the reasons for negative views of research on psychological development.

In the present study, the finding related to source of knowledge indicated that to acquire knowledge most of the PSTs were content to depend on external sources such as formal education and experts' scientific investigations. These external authority figures obtained across domains may be due to the PSTs' educational experiences. Given that students' epistemological beliefs are shaped by their precollege schooling experiences (Schommer & Dunnell, 1994) and possecondary educational experiences (Schommer, 1998), it can be said that the PSTs might have been exposed to expository teaching methods in their formal education. That is why they might have perceived teachers or scientists as source of knowledge instead of viewing themselves as active constructor of knowledge.

Another finding related to source of knowledge indicated that the nature of omniscient authority shows some variations across domains. In this study, most of the PSTs believe that knowledge comes mainly from formal school education and some from informal sources such as family, friends, and mass media for all domains except the domain of environment. For the domain of environment, both formal and informal influences were given with the same percentages. This finding suggests that environmental knowledge consists of both formal and informal knowledge. That is to say, there are different types of environmental knowledge comes from different sources. In this respect, the present study supports the findings of Hungerford and Volk (2001) since they also identified different environmental knowledge such as knowledge of environmental action strategies, knowledge of ecology, and knowledge of the consequences of behavior.

In addition to this, having indicated that the PSTs bring their environmental knowledge from informal sources such as mass media, the present study also supports the studies of Arbuthnot (1977) and Chan (1999). For instance, concerning the relationship between the use of mass media and environmental knowledge Chan (1999) found that secondary school students in Hong Kong had the least knowledge about identification of causes and effects of polution. Chan attributed this finding to the low priority of environmental issues among the print and electronic media. This suggested that students' environmental knowledge was shaped by television news about environment in Hong Kong. In addition to mass media (i.e., informal sources of environmental knowledge such as newspapers and magazines) the study of Arbuthnot (1977) suggests that environmental knowledge also comes from educational based knowledge (i.e., formal source of environmental knowledge).

The finding of this study regarding justification of knowledge indicated that unlike other domains, vast majority of the PSTs conceive of their direct observations as a basis for justification of environmental knowledge. This belief may be due to the following reasons. First, the PSTs may have a perception that environmental knowledge is not as important as other science disciplines (Crawford, 2000). Finally, they feel themselves as more familiar to environmental knowledge since they either experience the outcomes of environmental problems in their daily lives or hear very frequently information about environment and environmental issues in the mass media. Consequently, they might found sufficient to use their direct observations for the evaluation of claims about environment and environmental issues. However, from PSTs who hold sophisticated epistemological beliefs regarding the justification of environmental knowledge it is expected to integrate critical reasoning into their observations to judge environmental claims. In addition to this belief, in this study other PSTs were content to simply accept what the authority says regarding environmental knowledge as an evidence of the truth. Concerning this naive epistemological belief, Roll-Hansen (1994) argued that expert consensus do not mean that experts do not make mistake. To explain his point of view, Roll-Hansen provided a British case described and analyzed by the environmentalist and sociologist of science, Brian Wynne. The sheep farmers of the Lake District of Cumbria experienced a radioactive pollution from a nuclear reactor accident at the Sellafield-Windscale site in 1957 (Wynee, 1996). This accident made the sheep farmers of the Lake District distrustful of government experts (Roll-Hansen, 1994). In May 1986, following the Chernobyl accident upland areas of Britain including Cumbria suffered from radioactive fall-out. At first, this radioactive fall-out was described as innocuous by experts and politicians but after six weeks a ban was suddenly imposed to movement and slaughter of sheep. And after the end of three weeks, instead of lifting of this ban, it was indefinitely prolonged because the experts initially made their predictions based upon a false scientific method (Wynee, 1996). This case suggests that what experts say might not always be true. Consequently, it can be said that critical thinking is crucial to evaluate claims about environmental issues.

One of the remarkable findings of the present study regarding stability of knowledge indicated that the PSTs believed that knowledge is more uncertain in the domain of environment among other domains. This belief may be related to the PSTs' epistemological beliefs regarding structure of knowledge since the study of Lemons (1996) suggested that as environmental become more complex; the certainty of known methods, data, and techniques is questionable. Interestingly, in the present study it was found that the organization of knowledge about environment and environmental issues is complex rather than simple. That is to say, the findings of this study regarding stability and structure of knowledge are consistent with the findings of Lemons' study (1996).

Another finding regarding stability of knowledge showed that there are different types of uncertainty in knowledge (i.e., discovery as enhancement, discovery as inventions, uncertainty in measurement, and uncertainty in complexity of knowledge). This finding seems to be consistent with the finding of Smith and Wenk (2006) since in their studies Smith and Wenk also found four different categories for uncertainty of scientific knowledge, which were temporary uncertainty, partial uncertainty, inductive uncertainty, and interpretive uncertainty.

Differently from the study of Wenk and Smith (2006), the present study indicated that the types of uncertainty in knowledge may vary across domains. More specifically, in the study discovery as enhancement was mostly obtained for the domains of biology, physics, and chemistry and discovery as inventions for the domains of environment and mathematics while uncertainty in measurement for the domain of environment; uncertainty in complexity of knowledge for the domain of biology. These differences in uncertainty of knowledge across domains may be due to the fact that different phenomena are investigated in each domain and different methods are used to acquire knowledge in these domains. Consequently, sources of uncertainty may be different across domains.

In this study, investigation of stability of knowledge in the domain of environment through comparing with other domains indicated that although the PSTs hold sophisticated epistemological beliefs regarding stability of environmental knowledge, viewing environmental knowledge as uncertain the reason for uncertainty of environmental knowledge was not so sophisticated. The reason for this was that in their explanations for the domain of environment the PSTs generally mentioned about dynamic state of nature rather than inherent uncertainty in knowledge unlike other domains where they could locate knowledge. Having the idea that interventions may influence individuals' epistemological beliefs (e.g., Kienhues et al., 2008; Tolhurst, 2007), the above finding may be due to the fact that in their program of science education PSTs in Turkey learn formally environmental knowledge if they take an elective course about environmental science unlike other domains (i.e., biology, physics, chemistry, and mathematics) which are taken as must courses. Consequently, daily life observations, experiences or informal sources such as mass media probably may play a crucial role in the PSTs' acquisition of environmental knowledge which seems to be supported by the findings of this study obtained in the source of knowledge part. Since in recent years the phenomenon of environment mostly appear as environmental problems and individuals are more interested in environmental topics due to having felt negative outcomes of environmental problems (Baykan, 2008), the PSTs might have perceived nature itself as the content of environmental science. Thus, they might have perceived uncertainty in environmental knowledge as uncertainty in natural phenomena. All in all, the things mentioned about suggest that for complete understanding of environmental knowledge there is a need for environmental science course that explicitly teach tentative nature of environmental knowledge as in the scientific knowledge.

The finding of this study regarding structure of knowledge indicated that knowledge in the domain of environment is more complex than knowledge in the domains of biology, physics, chemistry, and mathematics. Similar finding was reported by the study of Estes et al. (2003). In their studies, Estes et al. (2003) indicated that high school students consider field of developmental psychology as more complex domain than biological development. However, in our study the PSTs considered environmental knowledge as more complex due to complex relationships among the components of natural environment. This finding might be caused by one of the basic aim of environmental education endorsed by Tbilisi Decleration which is to make individuals understand the complex nature of natural environment (UNESCO-UNEP, 1978). In their depiction for the complexity of environmental knowledge, the PSTs generally mentioned about natural basis; however, they gave less attention to ethical, social, cultural, and economic as well as interdisciplinary nature of environmental knowledge. This may be also related to improper scope and content of textbooks and activities used in environmental education classes. This seems to be supported by Adler (1992) who claimed that using nature trails and camping in the wilderness is completely appropriate to teach American children to understand what they are seeing (i.e., learning about environment); however, it gives the children simple and misleading information about environmental issues (i.e., incomplete understanding of environmental issues).

In the present study, the findings regarding control and speed of learning revealed that much of the ability to learn environmental knowledge can be gained in time but more quickly. However, for other domains it can be gained in time but more slowly. The PSTs believed that in the domain of environment, knowledge is more concrete and ability to learn is related to having an interest so environmental knowledge can be learned quickly through observation with naked eye. On the contrary, in other domains knowledge is more abstract and ability to learn requires intelligence so learning takes time in these domains. The situation may be due to the PSTs' feeling that environmental knowledge is not as important as other science disciplines (Crawford, 2000). Moreover, the PSTs might have thought that environmental knowledge is more relevant to their daily life and so it is not difficult to learn it. This seems to be supported by the findings obtained in this study in such unlike other domains the PSTs believe that they can acquire and justify environment knowledge through their own observations and they can improve their ability to learn through their own experiences or observations. Concerning the relationships between epistemological beliefs and environmental literacy, Öztürk (2009) found that behavior component of environmental literacy has significant relationship with only innate ability and quick learning dimensions of epistemological beliefs. Thus, he claimed that preservice teachers would intent to act as environmentalist if they have sophisticated beliefs regarding innate ability and quick learning, viewing ability to learn in environment can be improvable throughout lifelong and learning about environment and environmental issues is a gradual process.

5.2 Implications and Recomendations

In this study, the PSTs' epistemological beliefs regarding dimensions of omniscient authority, stability and structure of knowledge, and control and speed of learning in the domain of environment through comparing with other domains were investigated. The findings suggest that the PSTs' epistemological beliefs develop more or less independent from each other since the PSTs elicited different levels of sophistication across dimensions. In related literature, it was indicated that epistemological beliefs may influence comprehension (Schommer, 1990; Schommer, Crouse, & Rhodes, 1992), motivation, persistence and problem solving approach (Kardash & Scholes, 1996; Schommer, 1994a), learning (Brownlee, Purdie, Boulton-Lewis, 2001; Buehl & Alexander, 2001; Hofer, 2001) and achievement (Schommer, 1993). Moreover, teachers' epistemological beliefs may affect their teaching practices in their classrooms (Windschitl, 2002). These influences suggest that epistemological beliefs hold by the PSTs who are going to be teachers of future are important. Having an idea that education influences individuals' epistemological beliefs, it is recommended that science teacher training program should focus on the development of appropriate beliefs regarding the nature of environmental knowledge and learning for better quality of environmental education.

This study also investigated epistemological beliefs within domain-specificity approach. The findings indicated that the domain of environment has different nature in terms of knowledge and learning when compared with other domains. In literature, there are studies that indicated epistemological beliefs may vary across cultures (e.g., Gottlieb, 2007). In related to the importance of culture, Reybold (1996) stated that she agrees with Kaschak (1992) that one's mental processes of thinking and knowing is related to cultural parameters. These studies lead one to wonder whether domain-specific epistemological beliefs found in this study are applicable to all cultural settings. The cultural contexts within which individuals learn may affect to some extent their beliefs regarding the nature of knowledge and learning in a particular domain. At this point, it is suggested that future studies should be conducted to investigate to what extent culture is an influential factor in the shaping or development of domain-specific epistemological beliefs.

The findings of the present study regarding omniscient authority dimension indicated that the PSTs depends on either external sources or their observations to acquire and justify environmental knowledge. By considering these findings, some implications can be drawn for teacher educators in the design and development of science teacher education programs. Science teacher education programs should promote learning by analysis of and reflection on environment and environmental issues instead of receiving what delivered by authority figures or learning by just using senses. Similarly, textbooks about environment and environmental issues should not only focus on knowledge obtained through senses but also promote readers to make decision by critically thinking from multiple perspectives regarding environment and environmental issues.

In this study, in addition to omniscient authority dimension the PSTs' epistemological beliefs regarding stability of knowledge dimension were investigated in the domain of environment through comparing with other domains. The findings revealed that the PSTs conceive of environmental knowledge as more uncertain than other domain knowledge. Concerning stability of knowledge, Lemons, Shrader-Frechhette, and Craner (1997) claimed that uncertainty about environmental problems can affect the decision about whether taking an action is required to lessen a particular environmental problem regardless of the uncertainties or whether taking an action may be delayed until being more knowledgeable about that problem. Similarly, Johnson and Scicchitano (2000) argued that scientific uncertainty in solving environmental problems may affect individuals' willingness to take an active role in solving environmental problems. This finding seems to suggest that there is a relationship between uncertainty and taking action towards environmental problems. Having indicated in this study that uncertainty of environmental knowledge is related to the difficulty in measuring natural phenomena and the possibility of future discoveries, further studies can be conducted to explore the relationships between the nature of environmental uncertainty and taking action towards environmental problems.

The present study indicated that the PSTs hold sophisticated epistemological beliefs regarding stability of knowledge in the domain of environment, viewing environment knowledge as uncertain. However, when the underlying reasons for why knowledge is uncertain were investigated, it was found that there are different types of uncertainty, each of which does not have the same level of sophistication. This finding seems to recommend that personal epistemology research should focus on underlying reasons for knowledge's being uncertain (i.e. the participants should not be labeled as whether they consider knowledge as certain or uncertain) for better understanding of epistemological beliefs because reason behind uncertainty of knowledge cannot be as sophisticated as it was expected.

The findings of this study regarding structure of knowledge across domains indicated that the PSTs believe that environmental knowledge is highly complex unlike knowledge in other domains. This findings suggest that complexity of environmental knowledge is crucial since it was shown that beliefs regarding the complexity and structure of knowledge can affect adults' willingness to think deeply and reflectively about controversial, complex everyday issuesin such "the more the participants believed in complex and tentative knowledge, the more likely they were to appreciate multiple perspectives, be willing to modify their thinking, withhold ultimate decisions until all the information was available, and to acknowledge the complex, tentative nature of everyday issues" (Schommer-Aikins & Hutter, 2002, p.5). Consequently, the findings seem to suggest that environmental education should make the PSTs understand the complexity and uncertainty of environmental knowledge.

As in the source and justification of knowledge, the PSTs gave importance to experiences in control of learning dimension. They believed that they can improve their ability to learn environment and environmental issues through their experiences. These findings seem to have an implication for curriculum developers in that environmental education should both focus on and promote learners' gaining experiences in environment.

Finally, the findings regarding speed of knowledge indicated that the PSTs hold naïve epistemological beliefs, viewing learning in the domain of environment as quick. Given that the number of environmental problems have been increased sharply in recent years, it is important that individuals should allocate more time solving environmental problems. Öztürk (2009) claimed that believing gradual learning is likely to influence preservice teachers' anticipitated time investment in the solution of environmental problems. Consequently, the findings seems to suggest further research should be conducted on how to develop epistemological beliefs regarding speed of learning in the domain of environment and the effect of these beliefs on responsible environmental behavior.

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APPENDICES

APPENDIX A

PARTICIPANT PERSONAL INFORMATION SHEET

Yapacağımız mülakatlardaki yanıtları daha kapsamlı değerlendirebilmek için size bir kaç kişisel soru sormak istiyoruz. Bu bölümde ve mülakatlarda vereceğiniz yanıtların gizli tutulacağını unutmayınız.

1. Adınız ve Soyadınız: ………………………………...
2. Cinsiyetiniz: ○ Erkek ○ Bayan
3. Yaşınız: ……………
4. Bölümünüz: …………………………………………..
5. Sınıfınız: …………..
6. Genel not ortalamanız (GPA): …………
7. Annenizin Eğitim Durumu: ○ İlkokul ○ Ortaokul ○ Lise ○ Üniversite
8. Babanızın Eğitim Durumu: ○ İlkokul ○ Ortaokul ○ Lise ○ Üniversite
9. Şimdiye dek yaşadığınız bölge aşağıdakilerden hangisi ile tanımlanabilir? ○ Kırsal alan, çiftlik ○ Küçük kasaba (nüfusu 25 000 ile 100 000 kişi arasında) ○ Büyük şehir (nüfusu 100 000 kişiden fazla)

10. Anne ve babanızın çevre problemlerine ilgisi konusunda ne düşünüyorsunuz?

○ Yetersiz ○ Az ○ Yeterli ○ Çok İyi

11. Lisansta çevre ile ilgili aldığınız dersler nelerdir?

……………………………………………………………………………………..

12. Çevre konuları hakkında bilgi seviyenizi nasıl tanımlıyorsunuz?

○ Yetersiz ○ Az ○ Yeterli ○ Çok İyi

13. Herhangi bir çevre kuruluşuna üye misiniz?

○ Evet ○ Hayır

14. Çevre konularına ait bilgilerinizi arttırmak için neler yapıyorsunuz?

A. Çevre konuları ile ilgili **televizyon programları** izlerim.

○ Evet ○ Hayır

Hangi sıklıkla bu programları takip ediyorsunuz?

○ Her zaman ○ Sık Sık ○ Bazen ○ Hiç

B. Çevre konuları ile ilgili **gazete yazıları** okurum.

○ Evet ○ Hayır

Hangi sıklıkla bu yazıları takip ediyorsunuz?

○ Her zaman ○ Sık Sık ○ Bazen ○ Hiç

C. Çevre konuları ile ilgili **dergileri** takip ederim.

○ Evet ○ Hayır

Hangi sıklıkla bu dergileri takip ediyorsunuz?

○ Her zaman ○ Sık Sık ○ Bazen ○ Hiç

D. Çevre konuları ile ilgili **internet sayfalarını** takip ederim.

○ Evet ○ Hayır

Hangi sıklıkla bu internet sayfalarını takip ediyorsunuz?

○ Her zaman ○ Sık Sık ○ Bazen ○ Hiç

APPENDIX B

EPISTEMOLOGICAL BELIEFS INTERVIEW PROTOCOL

The following questions serve as a guide in the interview. Wording can change to make the dialogue more natural. Non-leading probes such as "Could you tell me more?", and "What do you mean by that?" can be used in order to allow the PSTs to elaborate on their ideas without undue influence from the researcher. The questions 3-11 will be asked for the domains of environment, physics, chemistry, biology, and mathematics one by one.

1. What were the courses related to environment that you have taken? What were they?

2. Did you enjoy them?

3. Where do you think (environmental/ physical/ chemical/ biological/ mathematical) knowledge comes from?
[Source of knowledge in the domains question]

4. How do you know when information about (environment/ physics/ chemistry/ biology/ mathematics) is true or not?
[Justification of knowledge in the domains question]

5. To what degree do you believe experts in the field of (environment/ physics/ chemistry/ biology/ mathematics)?
Assign a percentage of time that you believe experts.
[Trust in authority in the domains questions]

6. Now I want you to think about the certainty or uncertainty of (environmental/ physical/ chemical/ biological/ mathematical) knowledge.

Remember that this is your point of view. Assign percentages to each of the following categories that represent (environmental/ physical/ chemical/ biological/ mathematical) knowledge. You are free to assign 0% or 100% or anything in between. When you finished assigning percentage, the total all percentages should equal to 100%.

__Percent of (environmental/ physical/ chemical/ biological/ mathematical) knowledge that is unchanging

__Percent of (environmental/ physical/ chemical/ biological/ mathematical) knowledge yet to be discovered

__Percent of (environmental/ physical/ chemical/ biological/ mathematical) knowledge that is always changing or evolving

[Stability of knowledge in the domains question]

7. Imagine that you are a psychologist. How would you describe the typical organization of information regarding (environment/ physics/ chemistry/ biology/ mathematics) inside the mind of a **good student**? Explain why did you use this analogy for the good student? (Although the PSTs were provided rationales with analogies, they were expected to present their own rationale.)

Use an analogy to help me understand you and explain why you used that analogy for the good student.

Legos: the toy made of sticks and connectors, the organization can vary with many connections and many re-connections when the need arises.

Puzzle: always fitting pieces of knowledge together and seeing how they fit. The pieces only fit in one place. Once the pieces are together you can see the whole picture.

Sorting Program: a computer program that places information into separate files, e.g., all the information about Japan goes in the Japan file, all the information about the food goes in the food file, etc.")

[Structure of knowledge in the domains question]

8. How about for the **poor student**? How would you describe the typical organization of information regarding (environment/ physics/ chemistry/ biology/ mathematics) inside the mind of a **poor student**? Explain why did you use this analogy for the **poor student**?

[Structure of knowledge in the domains question continued]

9. Some people think that the ability to learn in (environment/ physics/ chemistry/ biology/ mathematics) is mostly inborn, that is, some people are born good learners, others are not. On the other hand, some people think that we actually learn how to learn. We can literally improve our ability to learn. What do you believe about the ability to learn?

Assign percentages to the following two categories. You are free to assign 0% or 100% or anything in between.

____Percent of ability to learn (environment/ physics/ chemistry/ biology/ mathematics) due to genetical predisposition.

____Percent of ability to learn (environment/ physics/ chemistry/ biology/ mathematics) due to learning how to learn.

[Control of learning in the domains question]

10. How would you describe the typical speed of learning in (environment/ physics/ chemistry/ biology/ mathematics) for the **average student**?

In the same manner assign percentages to the following categories.

___The percent of (environmental/ physical/ chemical/ biological/ mathematical) knowledge learned slowly

___The percent of (environmental/ physical/ chemical/ biological/ mathematical) knowledge learned moderately slow (in between slow and fast)

___The percent of (environmental/ physical/ chemical/ biological/ mathematical) knowledge learned fast

[Speed of learning in the domains question]

11. How about **a really smart student**, how long do you think it typically take them to learn in (environment/ physics/ chemistry/ biology/ mathematics)?

In the same manner assign percentages to the following categories.

___ The percent of (environmental/ physical/ chemical/ biological/ mathematical) knowledge learned slowly

___ The percent of (environmental/ physical/ chemical/ biological/ mathematical) knowledge learned moderately slow (in between slow and fast)

___ The percent of (environmental/ physical/ chemical/ biological/ mathematical) knowledge learned fast.

[Speed of learning in the domains question continued]

APPENDIX C

PERMISSION of ETHICAL COMMITTEE

1956

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22 Ocak 2010

Gönderilen: Doç. Dr. Özgül Yılmaz Tüzün
İlköğretim Bölümü

Gönderen : Prof. Dr. Canan Özgen
IAK Başkan Yardımcısı

İlgi : Etik Onayı

"Fen Bilgisi Öğretmen Adaylarının Çevre Alanı Hakkında Sahip Oldukları Kişisel Epistemolojik İnançlarının Diğer Alanlarla Karşılaştırılarak İncelenmesi" başlığıyla yürüttüğünüz çalışmanız "İnsan Araştırmaları Etik Komitesi" tarafından uygun görülerek gerekli onay verilmiştir

.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

22/01/2009

Prof.Dr. Canan ÖZGEN
Uygulamalı Etik Araştırma Merkezi
(UEAM) Başkanı
ODTÜ 06531 ANKARA

APPENDIX D

TRANSLATED INTERVIEW QUOTATIONS

1. Quotations taken from source of knowledge part

PST 9: In chemistry…Indeed, all of them [environmental, biological, physical, chemical, and mathematical knowledge] occur at first through somebody's triggering. Again, the knowledge I gained in the courses maybe after, this also necessitates an interest. For example, I cannot learn any chemistry. That is, since I do not like chemistry, if I have an interest I read carefully and the details remain in my mind. However, in chemistry according to me a teacher is needed. I cannot learn chemistry by myself. Since I am not interested in chemistry teaching of a course is required for me.	FÖA 9: Kimyada… Aslında genelde hepsi [çevre, biyoloji, fizik, kimya ve matematik bilgisi] zaten biraz önce birinin tetiklemesiyle olacak şey. Yine derste aldığım bilgileri belki sonrasında bu da ilgi gerektiren. Ben mesela hiç kimya öğrenemem. Yani kimyayı hiç sevmediğim için ilgim olsa onları daha dikkatli okuyup detayları aklımda kalır ama kimya da bana göre sadece hocanın vermesi gerekiyor. Ben kendim öğrenemem kimyayı. İlgim olmadığı için işte derste anlatılması gerekir benim için kimya öğrenmek için.
PST 5: There are many accumulated knowledge. We learn from books. From teachers, from the university, the courses that we took, from TV. We learn from many sources.	FÖA 5: Artık çok fazla birikmiş bilgi var. Kitaplardan öğreniyoruz, yetişemediklerimizi. Öğretmenlerimizden, üniversiteden, aldığımız derslerden, televizyondan birçok kaynaktan öğreniyoruz.
PST 1: Again, in the first place, school. Well, since we saw like that. To my mind, it comes school, teacher.	FÖA 1: Yine hani ilk etapta hani okul. Hani öyle gördüğümüz için. Aklıma okul, öğretmen geliyor.
PST 3: Physical knowledge is directly from school R: Does it directly come from school? Why? PST 3: Because, well, you learn reasons at school. Well, you learn it is like that at school. Since your family does not explain that look this is buoyancy force or this is the case.	FÖA 3: Fizik bilgisine okul derim direk. A: Direk okuldan mı gelir? Neden? FÖA 3: Çünkü şey sebeplerini filan okulda öğreniyor. İşte onun öyle olduğunu aslında okulda öğreniyor. Ailesi oturupta bir çocuğa bak bu kaldırma kuvvetidir ya da bu şöyledir diye anlatmıyor o yüzden.
PST 2: Well, we learn from our environment but we do not name it. Well, if the meal stays outside in the summer, it spoils. However, we cannot explain the reason of it. It was caused by bacteria. We cannot do this but we reach this knowledge: if the meal stays for a long time in the summer then it spoils. I see this from my experiences but I learn at the courses that this is related to this topic or the reason of this event is directly this.	FÖA 2: Hani yaşadığımız çevre ile öğreniyoruz ama isim koymuyoruz buna. Hani yemek dışarıda kalırsa yazın bozulur ama biz bunun sebebini açıklayamıyoruz. Bakterilerden kaynaklandı. Hani onu şey yapmıyoruz ama şu bilgiye ulaşıyoruz: yemek yazın sıcakta uzun süre kalırsa bozulur. Ben bunu yaşadığım şeylerden görüyorum ama bunu şu konuya giriyor ya da sebebi direk şu diye derslerde öğreniyorum.
PST 1: Definitely from the school R: School? PST 1: From primary school. It starts from the first class to forever.	FÖA 1: Okuldan kesinlikle. A: Okuldan FÖA 1: İlkokuldan. 1. Sınıftan başlar sonsuza kadar.

PST 7: Well, there is environmental knowledge in elementary level. Again, you know, this knowledge emerges from daily life experiences. You know, even a person who not deal with any science can reach that knowledge just by observing it. That is, I think that environmental knowledge is emerged from people's direct observations or from academic studies.

FÖA 7: Hani bu elementary seviyeye indirebileceğimiz de çevresel bilgiler var. Bunlar hani yine günlük yaşantımızdan ortaya çıkar. Hani yani hiç bir bilimle ilgili uğraşmayan bir insanın bile sadece gözlemleyerek ulaşabileceği bilgilerdir. Yani hani insanların direk gözlemlerinden veya akademik çalışmalarından ortaya çıkacağını sanıyorum çevresel bilginin.

PST 6: As I said since biology is more related to the human beings maybe it is easier to see. Indeed, in my opinion we can think environment as if it is a sub-branch of biology. That is why in biology some things maybe the simplicity in the biology is that we can do more personal observations or it is originated from knowing the things in our body. It is strange that I have never understood biology but I think that it does not also change in it. In biology, it depends on observations and further interpretations.

FÖA 6: Dediğim gibi biyoloji biraz daha insana yönelik olduğu için belki görmemiz daha kolaylaşabilir. Aslında çevre de biyolojinin bir alt dalı gibi bence düşünebiliriz. O yüzden de biyolojide de bir şeyleri belki biyolojideki kolaylık daha bireysel gözlemleyebiliyor olmamız ya da vücudumuzdaki şeyleri bizimde biliyor olmamızdan kaynaklı bir şey. Ben hiçbir zaman biyolojiyi anlayamamışımdır bu da garip bi şey olsa gerek ama bence onda da değişmez. Onda da gözlem ve daha sonraki yorumlarımıza bağlı.

PST 12: It seems that in all positive sciences, there should be a problem so that a solution would be proposed. Well if there was not a problem, it would not be solved. If we look at every thing as a problem then it seems that all positive sciences originate from a problem. Well, the existence of the world was a problem. How did it exist? Big Bang happened. This is a solution. The solution of it becomes a theorem.

FÖA 12: Bütün pozitif bilimlerde bir problem olması gerekiyor ki onu çözüme gidilmesi gerekiyormuş gibi geliyor. Bir yandan hani fiziksel bir problem olmasaydı o çözülmezdi. Her şeye problem gözüyle bakarsak o zaman bütün pozitif bilimler bir problemden doğuyormuş gibi geliyor. Hani dünyanın var oluşu bir problemdi. Nasıl var oldu? Big bang oldu. Bu bir çözüm. Onun çözümü de fiziksel bir kuram oldu.

PST 4: Well, in general chemistry is in daily life. I do not know! Such as it snowed; snow will melt; it rained. I do not know! We see water droplets on the window of the room. Why did this happen? This was caused by evaporation or tea kettle boils. It [chemistry] comes first from the daily life but we learn it without knowing.

FÖA 4: Yani genel olarak kimya günlük hayatta. Ne bileyim! İşte kar yağdı, kar eriyecek, yağmur yağdı. Ne bileyim! Odanın camında su damlacıkları görürüz. Bu neden oldu? O buharlaştığı ya da çaydanlık kaynar. O günlük hayattan önce gelir ama onun olduğunu bilmeden öğreniriz.

PST 5: Again, I think that it was emerged from the need. As I just mentioned, I should determine the area of my field so that I would plant a tree or I should build a barrier so that the man near me would not enter my garden. Therefore, I have this much square meter garden. I need to explain this to him. I have to tell. Or I should plant the seeds with a distance of 10cm or 1 hand span so that their roots would not intermingle. If we look at the first needs. Therefore, even if it is a hand span there is a measurement there and math starts there, anyway.

FÖA 5: O da yine bence ihtiyaçtan çıkmış. İşte biraz önce bahsettiğim: tarlamın alanını belirlemeliyim ki o sınıra bir ağaç dikmeliyim ki ya da oraya bir set çekmeliyim ki yanımdaki adam benim bahçeme girmesin. Dolayısıyla benim şu kadar metrekare bahçem var. Bunu ona açıklamam lazım. Anlatmam lazım. Ya da 10cm ya da 1 karış mesafede tohumları dikmeliyim ki kökleri birbirine karışmasın, ilk ihtiyaçlara bakarsak. Dolayısıyla karış bile olsa bir ölçüm giriyor işin içine ve matematik orada başlıyor zaten.

PST 7: These are, well environmental knowledge, I think something that can arise more by one to one field research that researchers did. That is, collection of data, analyzing these data. Mostly these make up environmental knowledge. Well, mostly in academic level.

FÖA 7: Bunlar, işte çevresel bilgi, bence daha çok hani araştırmacıların bire bir hani yaptıkları field researchlerle falan ortaya çıkabilecek şeyler. İşte data toplamaları, onları analiz etmeleri. Bunlar hani daha çok çevresel bilgiyi oluşturur. Hani daha çok akademik seviyede oluşturur.

PST 11: Environmental things are the things that are already around us. It is more like only scientists and we come out and by observing we decided as this is this, that is that and this knowledge is like that. You know maybe there is a basic knowledge but we were in fact able to investigate this in more depth by the development of technology.
R: what about biological knowledge?
PST 11: Biological knowledge is like environment.

FÖA 11: Environmental şey etrafımızda zaten olan şeyler. Sadece bilim adamları ve bizler çıkıp onu gözlemleyip. Hani bu budur, şu şudur, bu bilgi şöyledir diye hani karar vermiş olduk daha çok. Belki hani bir basic bir bilgi vardır ama teknolojinin de gelişmesiyle bunu daha derinlemesine inceleyebildik aslında.
A: Peki biyoloji bilgisi?
FÖA 11: Biyoloji bilgisi çevre gibi.

PST 10: Hmm…Again comes from the actual events that occur in nature. The scientists come to my mind directly. Hypotheses are formulated…That is to say, any event in the nature, by formulating hypotheses, by doing various observations and if it is possible by doing experiments by testing we can reach that knowledge.

FÖA 10: Hımm...Yine doğada olan hani gerçek olaylardan. Bilim adamları aklıma geliyor direk. Hipotezler kuruluyor… yani doğadaki her hangi bir olayı hipotez kurarak, çeşitli gözlemler yaparak diyeyim ve yapabiliyorsak eğer deneyler yaparak, test ederek o bilgilere ulaşabiliriz.

PST 7: Chemical knowledge depends more on experiments, of course… This is also hmm…chemical knowledge is, you know, somethings such as the properties of the substances. Their, well, knowing the properties of each substance, knowing the atomic structures, these are not observable things. That is to say, by mean of observation, I mean they are not one to one observable. You know, it [knowledge] is got through some things like experiment and inferences. I again want to say that it [knowledge] is something that experts reach.

FÖA 7: Kimyasal bilgi daha çok deneye dayanıyor tabii ki… Bu da hımm…kimyasal bilgi derken mesela maddedelerin özellikleri hani tarzında şeyler. Bunların hani her maddenin özelliğini bilmek işte atomik yapılarını filan bilmek bunlar gözlemsel şeyler değil zaten o kadar da. Hani gözlemsel derken bire bir hani gözlemsel değil. Hani deney yapılır, inference bir şeklinde şeylerle varılır. Yine bilim adamlarının ulaştığı şeyler demek istiyorum ama.

PST 8: Mathematics, you know mathematics comes to me so abstract, to tell the truth.
R: Where does this knowledge come from?
PST 8: Well, I will say from the theories…
R: What do you mean by the theories?
PST 8: You know, theories, for example, there are derivations, integral, and so on in mathematics. For instance, these come to me so abstract. These come to me as theories. That is to say, there is no logic.

FÖA 8: Matematik yanii matematik çok soyut geliyor bana açıkçası
A: Nereden geliyor bu bilgi?
FÖA 8: Yani teoriler diyecem…
A: Teoriler derken ne demek istiyorsun?
FÖA 8: Yani hani teoriler mesela o yaptığımız türev, integral falan filan var ya matematikte. Mesela onlar bana çok soyut gelmiştir. Onlar hani teori olarak geliyor bana. Hani hiç bir mantığı yok.

PST 4: In the first place, I think that it [environmental knowledge] comes from the family. If the family inspires in the child environmental knowledge, a love of nature it seems to me that by being based on this the child would construct knowledge in the future and this knowledge, at the same time, primary school teachers you know especially in kindergarten and first, second, and third grade, teachers are the models. The children behave as how their teachers behave. For example, classroom arrangement, classroom cleaning if the teacher at least as a model inspires this in the child then this becomes the children's character. This knowledge, at first, comes from the family then primary school and from the child's circle of friends. Well, even if the family has given a good education if there are other children around the child who hit and break trees, the child may think that what would happen even if I do.	FÖA 4: İlk once ben bunun aileden geleceğini düşünüyorum. Aile çevre bilgisini, çevre sevgisini zaten çocuğa aşılarsa çocuk zaten onu ileride üzerine yapılandırır gibi geliyor ve bu bilgi aynı zamanda ilkokul öğretmenleri de zaten çocukların hani özellikle anaokulu ve birinci, ikinci, üçüncü sınıflar bir modeldir öğretmenler. Öğretmen nasıl davranırsa çocuklar da öyle davranır. Mesela sınıf düzeni, sınıf temizliği. En azından bir örnek olarak öğretmen iyi aşılarsa bunu çocukların artık karakteri olur o oturur onlarda artık. Bu bilgi önce aile olmakla beraber ilkokuldan gelir ve çevreden gelir çocuğun arkadaş çevresinden. Hani aile iyi bir eğitim vermiş olsa bile çocuğun çevresinde hani vurup kıran ne bileyim ağaçlara zarar veren çocuklar olursa belki çocuğun aklı gidebilir. Belki ben yapsam ne olur falan gibisinden.
PST 2: Well, it [biological knowledge] seems to me as the same [with chemical and physical knowledge]. Again, we observe. In fact, we learn it [biological knowledge] in a way - mouth, nose, eyes- but with an informed family perhaps s/he learns more professionally. However, if the family is not conscious s/he does not learn the detailed knowledge such as it goes through throat and digested in there. But in general I think that s/he still learns.	FÖA 2: Yani o da aynı gibi geliyor bana. Yine gözlemliyoruz. Gerçi onu yine öğreniyoruz bir şekilde: ağız, burun, göz ama ailenin bilgili olmasına nazaran daha belki profesyonel öğreniyor ama aile çok bilinçli değilse hani öyle çok hani işte boğazından gidiyor şurda sindiriliyor falan gibi detaylı bilgi edinemiyor ama genel yine hani öğreniyor bence.
PST 1: I think that in physics I have to learn from the teachers or by reading books. Although we are not aware of we have intimate relationships with it. But there must be compulsorily an instructor.	FÖA 1: Sanirim fizikte mecburen bir öğretmen ya da kitap okuyarak öğrenmek zorundayım. Hani farkında olmasak da hani iç içeyiz ama mecburen bir öğretici olması lazım.
PST 1: Chemistry is same with Physics. I think that it is again teacher as well as book, supplementary books.	FÖA 1: Kimya, fizikle aynı. O da yine öğretmen onun dışında kitap, yardımcı kaynaklar.
PST 1: Maybe by means of some people, such as friends, mother, father. That is to say, since it is mathematics it seems to me that it is more difficult to learn by your own without [help from] people.	FÖA 1: Belki birilerinin vasıtasıyla arkadaş, anne, baba. Hani insan olarak onun dışında kendi kendine oturup öğrenmesi biraz daha zor gibi geliyor bana, matematik olduğu için.
PST 10: Well, these phenomena are, in fact, present in the nature. People's curiosities, because of their curiosities people investigate and reach that knowledge.	FÖA 10: Doğamızda hani zaten o olaylar var. İnsan merakını, merakından dolayı araştırıp hani o bilgilere ulaşıp ulaşıyoruz.

PST 12: …from curiosity, from the need, from being necessary. I think it is a requirement. It should be. There is no reason. You have to learn biology. Well, because, if people want to know themselves, people first need to recognize their own body; where can you learn that body? I think that it seems you can recognize it only from biology.	FÖA 12: Meraktan hem ihtiyaçtan hem olması gerektiğinden. Gereklilik bence. Yani olması gerekiyor. Bir sebebi yok. Biyolojiyi öğrenmek zorundasın. Yani, ne bileyim çünkü insan kendini tanımak istiyorsa eğer ilk başta kendi bedenini tanıması gerekiyor o bedeni de nereden tanıyabilirsin ancak biyolojiden tanıyabilirsin gibi geliyor bence.
PST 11: There are definitely observations. All in all, you observe something. You are curious about it and you do in-depth investigations in that how it happened or how it can happen.	FÖA 11: Gözlem kesinlikle var. Sonuçta bir şeyi gözlemleyip onu merak edip onu derinlemesine araştırıyorsunuz. Onun nasıl olmuş, nasıl olabilir diye?
PST 6: It also does not change. Maybe the observation part can be narrowed a bit. Since it is composed of very small particles and very small things, it is difficult to observe. But, for instance in a chemical reaction since we observe color change, we wonder what is going on here. We apply the same process and we make an inference by saying that this happened because of these. That is why, it does not change.	FÖA 6: O da değişmez. Belki gözlem şeyi biraz daha daralabilir. Çünkü çok küçük parçacıklarla ve çok küçük şeylerle oluştuğu için gözlemlememiz biraz zor. Ama sonuçta atıyorum kimyasal bir tepkimede renk değişimini gözlemlediğimiz için burada ne oluyor acaba diye merak ediyoruz. Aynı işlemleri uygulayıp bir çıkarım yapıyoruz, bunlardan dolayı bunlar oluyordur diye. O yüzden de bence fark etmiyor.
PST 11: The curiosity looks strange in that a couple of people wondered and then others wondered about these previous people’s curiosity. R: What do you mean by curiosity? Can you explain how it can come from curiosity? PST 11: For example, the numbers came out. Well, you have many numbers in your hand. Well, what can these be? What would happen if I add this? For example, if we think the easiest, in four operations we can say that how can I make a connection between this and that? What can be between these numbers? By thinking like that, for instance, human can find addition. After discovering addition, well I can think that I can find another number by adding these numbers. Another number may come out. Then by saying that whether I can play this in a different way I can discover division, subtraction. At the same time, since physics was developed the ones in physics use it. This might have gone on like that. These [ones in mathematics] look at physics and said that something else may happen if these [ones in physics] did like that.	FÖA 11: Merak garip olacak: merak etmiş bir kaç tane adam daha sonra onun meraklarından başkaları merak etmiş falan diye. A: Merak diyerek ne demek istedin? Nasıl meraktan gelir biraz açıklayabilir misin? FÖA 11: Mesela sayılar ortaya çıktı. Hani elinizde bir sürü sayı var. Hani bunlar ne olabilir? Bunla, bunu toplarsam nasıl olabilir? Mesela en basitini düşünürsek 4 işlemde bunla bunun arasında nasıl bir ilişki kurabilirim; bu sayılar arasında hani neler olabilir diye insan bir düşünüp toplamayı bulabilir mesela. Toplamayı bulduktan sonra ya ben bunları hani toplayıp başka bir sayı bulabiliyorum. Başka bir rakam çıkarabiliyor. Bunla acaba daha farklı oynayabilir miyim deyip ne biliyim bölmeyi, çıkarmayı bulabilirim. Aynı sırada fizik de geliştiği için fiziktekiler kullanılır. Bunlar [matematikçiler] fiziğe bakıp ya bunlar [fizikçiler] böyle yapmışlar, şöyle bir şeyde olabilir deyip öyle de gitmiş olabilirler.

PST 10: Again, studying on it. Well, it is not curiosity but how do I say? Can it be with trial and error method? R: What do you mean by trial and error method? Can you explain it? PST 10: That is, well, when we want to reach a formula it is not like that its formula is this. Well, how do I say? Well, without knowing whether it is true they [experts] had done operations; however, the same result had always been obtained. Well, it had followed the same logic and well, s/he had obtained that knowledge. Through trial and error; however, I could not explain it. R: Do you mean with many trials and repetition? PST 10: Yes, many trials and repetition. Little logic is included in it.	FÖA 10: Yine üzerinde çalışarak. Hani merak değil ama yani nasıl desem? Deneme yanılma yoluyla olabilir mi? A: Deneme yanılma yöntemiyle ne demek istiyorsun? Nasıl bir şey açıklayabilir misin? FÖA 10: Yani hani bir formüle ulaşmak istediğimizde hani bunun formülü şudur değil de. Yani nasıl desem? Hani doğru olduğunu bilmeden bir işlemler yapmıştır ama hep aynı sonucu vermiştir. Hani aynı mantık içerisinde gitmiştir ve hani o bilgiye ulaşmıştır deneyerek ve yanılarak. Çok açıklayamadım ama. A: Birçok deneme tekrarlama mı diyorsun? FÖA 10: Evet, birçok deneme tekrarlama. Birazcık mantık giriyor işin içerisine.
PST 7: I see mathematics as an element that is used for formulating model to understand physics, chemistry, and biology that are in general called as earth science. I mean mathematics alone does not express anything. I think that mathematics is functional only when I create mathematical modeling of topics related to physics or again related to chemistry. I mean, mathematics, in fact, is something created by humans. That is, it doesn't have a nature. You cannot observe mathematics outside. I mean, you can express what you have observed outside as mathematics but it is not mathematics that does it. That is why they see mathematics as an abstract thing. In mathematics, well, I will come to the question that where does mathematical knowledge come from, right? I think that mathematical knowledge also comes from people's imagination and such as comparisons they made based on their imaginations and constructing such relationships.	FÖA 7: Ben matematiği şöyle görüyorum. İşte fiziği, kimyayı, biyolojiyi yani genel olarak işte Earth Science denilen olayı anlamak için kurduğumuz hani model kurmamıza yarayan bir unsur olarak görüyorum. Yani matematik tek başına bir şey ifade etmez. Matematik modellemesi yaparsam fizikle ilgili bir konuyu ya da matematik modellemesi yaparsan hani yine kimya ile ilgili, ancak o zaman matematiğin işlevselliği olduğunu düşünüyorum. İnsanlar tarafından yapılmış bir şeydir zaten matematik hani. Doğası yoktur yani. Dışarıda gözlemleyemezsin matematiği. Yani dışarıda gözlemlediğin şeyi matematik olarak ifade edebilirsin ama matematik değildir onu yapan. Matematiği onun için zaten soyut bir şey olarak görüyorlar. Matematikte yani matematik bilgisinin nerden geldiğine geleceğim değil mi, buradan? Matematik bilgisi de insanların hani hayal gücünden ve hani bu hayal gücünden yola çıkarak yaptıkları işte kıyaslamalar olsun işte bu tarz ilişki kurma olsun onlardan doğduğunu düşünüyorum.

2. Quotations taken from justification of knowledge part

PST 3: I do not believe the truth of their [physical, chemical, and mathematical] knowledge, anyway. Well, it seems to me that all of them are assumptions. One emanated and said that this is like that. May be after 5, 10 years or 50, 100 years it will change. I think like that for mathematics and also for chemistry. There is present-day knowledge. You know there are accepted things; however, there is no truth or wrong.	FÖA 3: Ben onların doğruluğuna inanmıyorum zaten. Hani şey gibi geliyor bana hepsi öyle bir varsayım. Birisi çıkmış bu böyle demiş. Belki 5, 10 yıl sonra ya da 50, 100 yıl sonra bu değişir. Yani matematik için de, kimya için de benim düşüncem öyle. Şuandaki fikirler ve şuandaki şeyler var. Hani kabul edilmiş şeyler var ama doğrusu ya da yanlışı yok.

PST 6: I think that it cannot be known. I mean, if it fits only your ideas, it may come to you as true; however, something related to environment is true or not? As I said before, it remains as something that depends on our own inferences. You and I can make the same inference; however, someone else might think differently. As a result, we cannot know whether it is true or not. There can be doubt within us at every time.

FÖA 6: Bence bu bilinemez. Yani sadece sizin fikirlerinizle uyuyorsa size doğru gibi gelebilir ama doğru mu yanlış mı çevreyle ilgili bir şeyi biraz önce de dediğim gibi sonuçta kendi çıkarımlarımıza bağlı bir şey olarak kalıyor. Sizle ben aynı çıkarımı yapabiliriz ama başka birisi çok farklı düşünebilir. O zaman da doğru mu yanlış mı bence bilemeyiz. Her zaman için bir şüphe içimizde olabilir.

PST 10: I mean that any new information that may come can also change it [the existing knowledge in Biology] because perhaps I say this by thinking only one topic in my mind but this can be for every topic. Well, a new knowledge can change.

FÖA 10: Yani herhangi gelebilecek yeni bir bilgi değiştirilebilir diye düşünüyorum onu da [var olan biyoloji bilgisini]. Çünkü yani belki şu an tek aklımdan bir konuyu düşünerek düşünüyorum ama her konuda olabilir. Hani yeni bir bilgi değiştirebilir.

PST 2: Nowadays, I start to think that we know a lot of information but in practice while we are doing in laboratories we make a lot of mistakes. Perhaps, we cannot see exactly…it seems to me that as if we try to make that knowledge true…At this point, I fall into doubt. I wonder how many experiments were done or from which of them we obtain the truth so that there is such an acceptance or such something is taught as certain … it seems to me that we may not be doing somethings because of not knowing or because of our inexperience.

FÖA 2: Bu aralar şey düşünmeye başladım. Biz birçok bilgiyi biliyoruz hani söz olarak ama uygulamada hani laboratuardan dönerken bir sürü hatalar yapıyoruz. Belki tam göremiyoruz… Sanki o bilgiyi doğru çıkartmak için uğraşıyoruz…Hani o noktada şüpheye düşüyorum. Acaba bundan kaç deney yapıldı. Kaçından doğru alındı ki böyle bir kabul var ya da böyle bir şey kesin öğretiliyor…Bazı şeyleri de bilmediğimizden yapamıyor olabiliriz ya da deneyimsizliğimizden dolayı da yapamıyor olabiliriz gibi de geliyor.

PST 10: Again, the same thing is valid for me. Both of them [physics and chemistry]...are in the field of science. That is, a field that experiments can be done. I mean that the absoluteness of any knowledge, that is, this is definitely that, the truth is this. We cannot ever say this. With observations or experiments, it was tried to be proven in some ways.

FÖA 10: Yine aynı şey geçerli hani benim için. İkisi de [fizik ve kimya]... fen alanında. Yani deneylerin yapılabildiği bir alan. Yani kesinliği tam olarak hiç bir bilginin. Yani bu kesinlikle şudur, gerçek budur asla zaten diyemeyiz. Yine yapılan ya gözlemlerimizle, yapılan deneylerle bir şekilde olsun kanıtlanmaya çalışmıştır.

PST 6: In mathematics, a lot of different that is there can be different theories that come up with the same result or there can be different results but the starting point is the same. That is why, it can always change. We cannot know.

FÖA 6: Matematikte bir sürü farklı yani aynı sonuca varan farklı teoriler olabiliyor ya da farklı sonuca varan çıkış noktası aynı olan teoriler oluyor. O yüzden de her zaman için değişebiliyor. Bilemeyiz.

PST 3: I investigate a little bit. I read on such as generally from the Internet, articles or when I followed the news although I cannot do self observations through the long term research it is emerging that this is like that. Well, we can benefit from it saying whether it is true or not by following the latest things.

FÖA 3: Araştırırım biraz. Üzerine okurum işte genelde internetten oluyor makalelerden ya da haberleri takip ettiğim zaman biz kendimiz gözlemleyemesek de uzun bir süreçte yapılan araştırmalar sonucunda onun öyle olduğu ortaya çıkıyor. Hani ondan faydalanabiliyoruz daha çok güncel şeyleri takip ederek gerçekten doğru mu değil mi diye?

PST 12: Again, we can find it [the truth] from the evidences. If it was proven and the people of higher authorities said that yes this is true, I may believe its truthfulness.

FÖA 12: Yine onu kanıtlardan falan bir şekilde bulabiliriz. Kanıtlanmışsa eğer bir şekilde ve bunu çok yüksek mercideki insanlar: Evet, bu doğru demişse onun doğruluğuna inanabilirim.

PST 10: So far, for example, we learned the information in the courses by saying that this is that without ever questioning or by saying that this is that we learn formulas, solve questions based on these. However, we have never accepted the other point of view by saying whether it could be true or by thinking the exact opposite. In Turkey, it is like that. Well, it is accepted. But, I think that we accept it like that maybe due to the fact that scientists approved it. All in all, they do experiments.

FÖA 10: Şimdiye kadar mesela derslerde öğrendiğimiz bilgileri hiç sorgulamadan bu budur deyip öğrendik ya da bu budur deyip formülleri öğreniyoruz, sorular çözüyoruz onlara dayalı olarak ama hani hiç bir zaman bu doğru mudur? Acaba diyip onun tam tersini düşünüp kabul etmemezlik yapmadık hani. Türkiyede de bu böyle. Hani kabul ediliyor. Ama bilim adamlarının onayladığı bir şey olduğu için belki de hani öyle kabul ediyoruz. Sonuçta onlar deneyler yapıyorlar.

PST 10: All in all, since scientists did we accept. In physics, in chemistry, up to now, we accepted… Like questioning, trying or doing what they found is not possible, anyway. Well, when their findings say that these are true, their true is also mine. I accept them only by reading their studies, well, what they did, and their interpretations. Well, it is important that there is more than one scientist. Well, according to this I accept.

FÖA 10: Sonuçta bilim adamlarının yaptığı için hani kabul ediyoruz. Fizikte olsun, kimyada olsun şimdiye kadar kabul ettik… Sorgulama gibi bizim onların yaptıklarını denememiz, yapmamız mümkün değil zaten. Hani bulguları bunlar doğrudur dediklerinde, onların doğrusu benim. Bir yerde kabul ederim ama yaptığı çalışmaları okuyup hani neler yapmışlar, yorumlarını. Hani birden çok bilim adamı olması önemli. Hani ona göre kabul ederim.

PST 8: All in all, the men had built the theory. Well, related to derivatives, integrals, related to many things there are lots of theories that we need to know. Through these theories we can say whether it is true or wrong. However, how are these theories formulated? Who found the theories? Or are the theories correct? We do not know this or we do not have the capacity to question this.

FÖA 8: Sonuçta adamlar teori kurmuşlar. yani türevle ilgili, integralle ilgili, pek çok şeyle ilgili, o kadar çok teori var ki bilmemiz gereken. Bu teoriler üzerinden doğru mu, yanlış mı olduğunu söyleyebiliyoruz. Ama o teoriler nasıl olmuş? Teorileri kim bulmuş? Teoriler doğru mu? Onu bilmiyoruz ya da onu sorgulayabilecek kapasitede değiliz.

PST 11: I say that it can be understood via observations at first… well, all in all, the things happen in environment are related to something else rather than theories. The other things [other domains] are linked to theories much more. Generally, these [things happen in environment] are as law. For example, you say that this is green and you put the dot there.

FÖA 11: İlk başta gözlemlerle olur diyorum. Yani sonuçta çevrede olan şeyler teoriden çok, diğer şeylere bağlanıyor. Diğer şeyler [diğer alanlar] daha çok teorilere bağlanıyor. Genelde bunlar [çevrede olan şeyler] kanun gibi. Mesela bu yeşildir dersin, nokta koyarsın.

PST 8: Anyway, since biology investigates the living things it [truth of biological knowledge] is by direct observation. Well, in biology, all in all we can observe whether it is true or not.

FÖA 8: Zaten biyoloji canlıları incelediği için [biyoloji bilgisinin doğruluğunu] direk gözlemle. Yani biyolojiyi de sonuçta doğru mu, yanlış mı gözlemleyebiliriz.

PST 10: In others [environment, biology, physics, chemistry] it can be through our observations. Everything does not depend on experiments. All in all, there are topics in which experiments cannot be done.

FÖA 10: Diğerlerinde [çevre, biyoloji, fizik, kimya] gözlemlerimizde olabilir. Her şey deneye de bağlı değil. Sonuçta deney yapılamayacak konular var.

PST 1: Well, it seems like that mathematics and physics are a bit certain. Well, if one person says in these or if one expert says then it is true. However, when it is environment I think that it seems like more relative. That is why one source may not be enough. Well, I think that I may need more research. R: Why may you need more research? PST 1: Well, since it is environment everyone can observe differently. That is why, observations can be different.	FÖA 1: Hani, matematik, fizik biraz daha sabit gibi geliyor. Hani onlarda bir kişi söylediyse ya da bir uzman söylediyse doğrudur. Ama çevre olunca bu daha bir göreceli diye düşünüyorum. O yüzden bir kaynak yeterli olmayabilir. Hani daha çok araştırmam gerekebilir diye düşünüyorum. A: Neden daha çok araştırman gerekebilir? FÖA 1: Hani çevre olduğu için herkes farklı gözlemleyebilir. O yüzden gözlemler farklı olabilir.
PST 12: We hear so many things around. This is not just for the environment but for all positive sciences. Well, something that is good for today may not be good for the next day to the environment or body, or against anything. That is why it seems to me that it is needed to get the more present day knowledge. Let's say not [knowledge of] 10 years ago but today's [knowledge] and it is needed to be researched from too many resources.	FÖA 12: Etrafta o kadar çok şey duyuyoruz ki. Bu sırf çevre için de değil bütün pozitif bilimler için. Hani bir gün iyi olan bir şey ertesi gün iyi olmayabiliyor, çevreye karşı ya da bedene ya da herhangi bir şeye karşı. Onun için daha çok bugünün bilgisini elde etmek lazım. Atıyorum 10 yıl öncesinin [bilgisi] değil de bugünün [bilgisi] ve çok fazla kaynaktan araştırılması gerekiyormuş gibi geliyor bana.
PST 4: When I apply now if I obtain a correct result then I understand that it is true. For instance, balance. For example, in physics let's a person says to me that here there is 5m mass, here there is m mass and these remain in balance. When I apply this and when I do not see that it is true then I say wrong to that knowledge. However, when I can prove that it is true, I say that yes that knowledge is true.	FÖA 4: şimdi uyguladığımda eğer doğru bir sonuç alıyorsam onun doğru olduğunu anlıyorum. Mesela denge. Mesela fizikte birisi bana dese ki burada 5m kütlesi var burada m kütlesi var bu dengede kalır dese. Ben bunu uyguladığımda onun gerçek olduğunu görmediğimde yanlış derim o bilgiye ama doğru olduğunu ispatlayabildiğim zaman evet bu bilgi doğruymuş derim.
PST 11: I mean through the things you do, I do not know, with atomic number you can also see it [truth of knowledge] on paper by saying if this combines with that, this emerges; if that combines with this, this emerges.	FÖA 11: Yani yaptığın işte ne biliyim atomun numarasıyla onunla birleşirse bu çıkar şu bunla birleşirse bu çıkar diyip kağıt üzerinde de [bilginin doğruluğunu] görebilirsin.
PST 4: By putting in the formula. By proving one to one. However, for environment this proof at least for me is not under consideration. I cannot do.	FÖA 4: Formüle koyarak. Birebir ispat ederek. Ama çevre için bu ispat en azından benim için söz konusu değil. Yapamam.
PST 8: By doing experiment we can observe whether it [environmental knowledge] is true or wrong. If this knowledge comes from the environment and that knowledge is true, if the results of the experiment and the data support this, that knowledge is true.	FÖA 8: Deney yaparak bunun [çevre bilgisinin] doğru ya da yanlış olduğunu gözlemleyebiliriz. Gerçekten bu bilgi çevreden geldiyse o bilgi doğruysa deney sonuçlarımız, aldığımız datalar da bunu desteklerse bu bilgi doğrudur.
PST 5: In biology, there are experiments, there are many observations. When we look, there are inferences. There is a data collection. All are available in biology.	FÖA 5: Biyolojide, deney de var, gözlem çok var. Çıkarım var baktığımız zaman. Bilgi toplama var. Hepsi var biyolojide.

PST 8: Since chemistry also includes the information which can be observed in the laboratory environment if the information coming from the environment is chemical knowledge or related to chemistry we can observe whether that information is true or wrong if there are proper materials, if there is a proper laboratory environment and if there are available technological materials. R: We observe via doing experiment? PST 8: Yes, via doing experiment. R: Well, if I can observe, it is true; if I cannot, it is wrong? PST 8: If we observe yes it is true; however, if we cannot observe this does not mean that it is wrong. Maybe we made a mistake in the experiment. There is an experimental error. That is why; we control our data with the experiment. We do it again.	FÖA 8: Kimya laboratuar ortamında da gözlemleyebileceğimiz bilgiler içerdiği için çevreden gelen bir bilgi eğer kimyasal bir bilgi ise kimyayla ilgiliyse onun doğru veya yanlış mı olduğunu uygun materyaller varsa ya da uygun laboratuar ortamı varsa ve elimizde teknolojik aletler varsa o bilgi doğru mu yanlış mı gözlemleyebiliriz. A: Deneyler yaparak gözlemleriz? FÖA 8: Evet. Deneyler yaparak A: Yani gözlemleyebiliyorsam doğrudur, gözlemleyemiyorsam yanlıştır? FÖA 8: Gözlemliyorsak doğrudur evet, ama gözlemleyemiyorsak yanlış olduğu anlamına gelmez. Belki biz deneyde bir hata yapmışızdır. Deneysel bir hata vardır. O yüzden o deneyin üstüne verilerimizi tekrar kontrol ederiz. Tekrar yaparız.
PST 5: How do we examine whether it is true or wrong? In physics, there are many variables. We ignore some things such as the friction of air while we are solving problems. However, except small experimental error we can again do experiment. Via experiment. Via repeatedly doing experiments.	FÖA 5: Doğru ya da yanlış olduğunu nasıl sınarız? Fizikte çok fazla değişken var. Bazı şeyleri yok sayıyoruz. Örneğin, havanın sürtünmesi filan bazı soruları çözerken ama küçük hata hesapları dışında onda da deneyebiliyoruz. Deneyerek. Defalarca deneyerek.
PST 12: Chemistry…In chemistry, there are things which are concrete and observable. More concrete things. How is it [truth] obtained in Chemistry? In chemistry, it seems to me that it is needed to do more experiments. You try more. You will look at the result. It either happens or not. Of course, those experiments are not one-time experiment. All in all, one experiment can sometimes give different results. It seems to me that it depends more on experiments. It seems coming from the experiment.	FÖA 12: Kimya…Kimyada daha böyle elle tutulur gözle görülür şeyler var. daha somut bir şeyler. Onda [kimyada doğru] nasıl elde edilir? Onda daha çok deney falan yapmamız gerekiyormuş gibi geliyor, kimya da. Daha çok deneyeceksin, bakacaksın sonucuna olursa olur, olmazsa olmaz. Tabii o deneyler, bir kerelik deneyler değil. Sonuçta bir deney bazen farklı sonuçlar verebiliyor. Daha çok deneye dayalıymış gibi geliyor bana. Deneyden geliyormuş gibi.
PST 5: Mathematics is abstract. How do we know in mathematics? Mathematics has testing methods in itself. There are proofing methods. You introduce a problem. You approach it from the right and you find a result. Then you said that let’s look at whether it is true and you also approach the problem from the left. You find a result for it. It likes walking in the dark. There is an object in the middle of a dark room. It is a testing method whether you will be able to find the same thing by applying the same method when you enter the room from this door as well as from the other door. If we find it with two methods or several testing methods we accept it as true.	FÖA 5: Matematik soyut. Matematikte nereden biliriz? Matematiğin kendi içinde sınama yöntemleri var. İspat yöntemleri var. Bir sorunu ortaya koyuyorsunuz. Bir sağından yaklaşıyorsunuz bir sonuç buluyorsunuz. Bir de doğru mu bakalım, bir de solundan gelelim bakalım diyorsunuz. Onun sonucunu buluyorsunuz. O bence karanlıkta yürümek gibi bir şey. Karanlık bir odanın ortasında bir cisim var. Şu kapıdan girince bulduğunuz şeyi acaba öbür kapıdan girince de aynı yöntemi uygulayarak bulabilecek misiniz diye bir sınama yöntemi. İki türlü de bulabiliyorsak ya da birkaç sınama yöntemiyle o zaman doğru kabul ediyoruz.

3. Quotations taken from stability of knowledge part

PST 2: Well, I think that basic knowledge can be certain but they are also open to be changed… Well, probably newly discovered things will change that knowledge.	FÖA 2: Hani temel bilgilerin kesin olabileceğini düşünüyorum ama onlar da değişmeye açıklar… Hani belki yeni bulunan şeyler o bilgiyi değiştirecektir.
PST 4: Now it is said that the cell consists of this and this but it can be missing. In the past, there was no electron microscope. We could not observe that much detail but now we have and observe. Maybe with a better microscope we will observe in more details.	FÖA 4: Şu anda belki hücre şu şu şundan oluşuyor diyoruz ama aslında eksik söylüyoruzdur. Eskiden elektron mikroskopları yoktu. O kadar detayını göremiyorduk ama şimdi var ve görüyoruz. Belki daha iyi bir mikroskopla daha detayını görücez.
PST 11: For physics, hmm, discovered but I mean it changes such as development of technology…well, these changes are as if there was knowledge in the past and we change it know…That is why, I want to give much more to this. It is 50%. R: Which one? PST 11: Changing or evolving. I want to say 30% to yet discovered and 20 remains for unchanging. Why did I do this like that? As I said that well we can change previously existing knowledge by means of continuously developing technology or newly invented tools or different perspective of someone else. As a result, I think that it is in a situation that there are still many ongoing changes.	FÖA 11: fizik için, hımm, discovered ama şimdi o ne bileyim değişiyor mesela teknolojinin gelişmesi… hani bu değişim demesi hani eskiden bir bilgi vardı artık şimdi onu değiştiriyoruz gibi…Bu yüzden onu daha fazla demek istiyorum. Ona %50 diyeceğim. A: Hangisi? FÖA 11: Changing, evolving en sondakine. Yet discovered a %30 demek istiyorum. Unchanginge de 20 kaldı. Bunu niye böyle yaptım? Şimdi dediğim gibi hani önceden var olan bilgiyi daha sonradan sürekli değişen teknolojiyle, yeni icat edilen aletlerle veya başka bir insanın bakış açısıyla onu değiştirebiliyoruz. Onun için çok fazla sürekli bir değişim halinde olduğunu düşünüyorum hala.
PST4: Mathematics seems to me something that develops continually. There are thing not certain yet. It is also similar in physics, chemistry, and mathematics…There are theories not proven yet. For instance, there is not absolute certainty in atom theory. I think that these show that it can develop.	FÖA 4: Matematik sürekli ilerleyebilecek bir şey gibi geliyor bana. Daha henüz tam kesin olmayan şeyler var. Fizik, kimya ve matematikte de aynı şekilde…Henüz ispatlanmamış teoriler var. Mesela atom teorisi tam bir kesinlik söz konusu değil. Bence bunlar ilerleyebileceğini gösteriyor.
PST 12: In biology, of course there seems to be many things that will be discovered.	FÖA 12: Biyolojide tabii ki keşfedilecek çok şey varmış gibi geliyor.
PST 12: Percent of environmental knowledge that is unchanging… it is not stable, definitely not. R: We will give percentages to all of them [three categories of stability of knowledge]. PST 12: knowledge yet to be discovered… open being discovered… I absolutely give 100% to this. Always changing or evolving… well, we do not say to this always… I mean there are many places, animals, plants, etc. that are not discovered yet.	FÖA 12: Percent of environmental knowledge that is unchanging… stable değil kesinlikle değil. A: hepsine [bilginin değişmezliği ile ilgili 3 kategoriye] yüzde vereceğiz. FÖA 12: Knowledge yet to be discovered… open being discovered… tabii ki % 100 verebilirim buna. Always changing or evolving… always demiyelim ona ya. Yani bence daha keşfedilmemiş birçok yer, hayvan, bitki bir sürü şey var.
PST 3: I mean that there are many undiscovered things in physics… Still we are in the Earth or busy to pollute the Earth's atmosphere but the beyond is absent.	FÖA 3: Yani daha çok bulunmamış bir sürü şey var fizik açısından… Daha sadece dünyadayız ya da Dünya'nın atmosferini kirletmekle meşgulüz ama ötesi yok.

PST 7: I mean that now it is said that there are that number of elements in the periodic table but you know the presence of other elements can emerge. I think in chemistry there can be much more discoveries in the future.

FÖA 7: Yani şimdi diyorlar ki periyodik tabloda işte şu kadar element var ama hani başka elementlerin varlığı da ortaya çıkabilir. Ben kimyada çok daha fazla gelişmelerin olabileceğini düşünüyorum ilerde.

PST 11: It seems that there are many undiscovered things… Well, tomorrow something will emerge, the day after tomorrow again something will emerge since it is not depended on anything definite it seems that anything can occur anytime even more could happen.

FÖA 11: Çok var keşfedilmeyen şey gibi geliyor… Hani yarın bir şey çıkcak ondan sonraki gün yine bir şey çıkcak belli bir şeye bağlı olmadığı için her an herşey olabilirmiş hatta daha fazla şey olabilirmiş gibi geliyor.

PST 4: There are always living things ultimately movement and change. I mean that chemical structure always changes such as rain and snow. In addition, characteristics of living things change. Human beings also interfere. For example, we are also changing environment by moving some things from somewhere to another place. Therefore, there do not remain so many stable things.

FÖA 4: Sürekli canlılar var sonuçta hareket, değişim. Yani sürekli kimyasal yapısı da değişiyor işte yağmurdu kardı. Sonra canlıların özellikleri değişiyor. İnsanlar da müdahale ediyor. Mesela ordan oraya aldığımızla biz de çevreyi değiştiriyoruz. O yüzden sabit pek bir şey kalmıyor.

PST 9: In biology, it seems to me that it cannot be gone too deep. For example, in the cell, I think that there are more unknown than known things since the interactions among proteins and enzymes cannot be known for certain. When one factor is known the other cannot be known seperately due to continuous interactions among each other. That is, we cannot do something about that topic separately. Therefore, it is not understood fully. Each of them is too related to each other.

FÖA 9: Biyolojide çok derine inilemiyor gibi geliyor. Mesela hücrede bilinenden daha çok bilinmeyen şey var çünkü o proteinlerin enzimlerin birbiriyle etkileşimi kesin bilinemiyor. Bir faktör bilinirken diğeri ayrı olarak bilinemiyor birbirini sürekli etkilediği için. Yani o konuda ayrı olarak birşeyler yapılamıyor. Dolayısıyla tam olarak bilinemiyor. Herbiri birbiriyle çok bağlantılı.

PST 6: Because in physics, it cannot be said imagination, since we are dealing such things that we cannot observe and are small, I suppose that something which can escape notice or we ignored for today, for example, can in fact be very important for tomorrow. For that reason, I think that physics is more open to change.

FÖA 6: Çünkü fizikte biraz daha bir hayal denmez de daha gözlemleyemediğimiz ve daha küçük şeylerle uğraştığımız için sanırım gözden kaçabilecek ya da bugün için mesela yok saydığımız bir şey yarın için aslında çok önemli bir şey olabilecek. O yüzden de daha değişime açık olduğunu düşünüyorum.

PST 6: In environment, if one stores a bottle 10 days or 10 years and looks at it, s/he can see that it will not disappear. That is, since these are more observable things it is easier to understand. For that reason I think it is easier to explore. That is why I think that the error rate is a bit lower but I think that it will not be like that in chemistry and physics.

FÖA 6: Çevrede birisi 10 gün ve ya 10 yıl saklasa bir pet şişeyi ve buna baksa o da onun kaybolmayacağını görebilecek. Yani daha gözle görülebilir şeyler olduğu için daha anlaşılması kolay olduğunu düşünüyorum. O yüzden de keşfetmesinin daha kolay olduğunu düşünüyorum. O yüzden hata oranının da aslında biraz daha az olduğunu düşünüyorum ama fizikte ve kimyada öyle olmayacağını düşünüyorum.

PST 3: In biology, we do not add up knowledge on the previous one. We are moving on by relating to it [knowledge] rather than directly adding up. For instance, [in physics] we state that the gravity is this and we directly construct our aircraft or other things according to that, directly taking gravity as a reference. I mean that in biology we associate more rather than add up directly.	FÖA 3: Biyolojide şu şöyledir deyip de onun üzerine kat kat çıkmıyoruz. Onları [bilgileri] ilişkilendirerek ilerliyoruz ama direkt onun üzerine çıkmıyoruz. Mesela [fizikte] yer çekimi şöyledir diyoruz. Yer çekimi öyle olduğu için uçağımızı ya da başka şeylerimizi ona göre yapıyoruz. Direkt yer çekimini baz alarak. Yani biyolojide daha çok ilişkilendiriyoruz bence direk üstüne koymuyoruz.
PST 5: When I think the World, many places have been investigated now. I mean that status of lakes, living things such as unicellulars, even the ones whom we do not see, or climate change. Now, we know the status of the pole. We can calculate at which Celsius degrees icebergs start to melt or we can go and observe directly.	FÖA 5: Dünyayı düşündüğümde birçok yer gözlemlendi artık. Yani göllerin durumu, yaşayan canlılar, tek hücrelilere hatta göremediklerimize varana kadar ya da iklim değişiklikleri. Şu anda kutbun ne durumda olduğunu biliyoruz. Ne kadar ˚C de buz dağının eridiğini hesaplayabiliyoruz ya da gidip bizzat gözlemleyebiliyoruz.
PST 11: I look at the existing knowledge. Well, I do not think that there are more things that can be investigated related to our body. When I look the things around us; for example, I think that we already reached many things about fungi.	FÖA 11: Var olan bilgilere bakıyorum. Hani vücudumuzla ilgili daha fazla araştırabileceğimiz bir şey olduğunu düşünmüyorum. Çevremizle alakalı şeylere baktığımda fungilerle ilgili birçok şeyin artık bulunduğunu düşünüyorum.
PST 5: You say optic and the points where it [physics] can come had been figured out years ago actually. I think that the things or topics which would be investigated are a bit limited in there [in physics].	FÖA 5: İşte ne diyorsunuz? Optik diyorsunuz ve yıllar önceden hani varabileceği noktalar ve her şeyi hesaplanmış aslında. Sanırım biraz daha sınırlı orada [fizikte], konular ve incelenebilecek şeyler.
PST 9: It seems that chemistry is more stable than environment. Well, through experiments, many things, many developments had been already made and many things had been already discovered. So, it seems that the percentage of knowledge that yet to be discovered is less.	FÖA 9: Kimya çevreye göre daha kesin geliyor. Yani deneylerle birçok şey birçok ilerleme kat edilmiş ve bulunan birçok şey bulunmuştur. Bu yüzden daha bulunacak yüzde daha az gibi geliyor.
PST 5: I mean when you think too in-depth calculations are done. Especially, after the usage of computer we could reach the numbers including many zeros. As I know, calculations of higher exponents, integrals, differentiations are able to be made. As a result, I thought that we probably reached the point where mathematics can come.	FÖA 5: Yani düşününce çok derinlemesine hesaplar yapılıyor. Hele de bilgisayarın kullanımından sonra, çok fazla sıfırlı sayılara da ulaşılabiliyor. Çok yüksek üslü hesaplamalar, integraller, türevlerde alınabiliyor, bildiğim kadarıyla. Dolayısıyla her halde ulaşılabilecek sınırlara ulaşılabilmiştir artık diye düşündüm.
PST 6: In environment, if one stores a bottle 10 days or 10 years and looks at it, s/he can see that it will not disappear. That is, since these are more observable things it is easier to understand. For that reason I think it is easier to explore. That is why I think that the error rate is a bit lower.	FÖA 6: Çevrede birisi 10 gün ve ya 10 yıl saklasa bir pet şişeyi ve buna baksa o da onun kaybolmayacağını görebilecek. Yani daha gözle görülebilir şeyler olduğu için daha anlaşılması kolay olduğunu düşünüyorum. O yüzden de keşfetmesinin daha kolay olduğunu düşünüyorum. O yüzden hata oranının da aslında biraz daha az olduğunu düşünüyorum.

PST 8: Biology, in fact, in biology I say 70% for stable knowledge; 10% for yet to be discovered. There is more stable knowledge in biology since we can observe.	FÖA 8: Biyolojide aslında biyolojide %70 diyorum sabit bilgi için; %10 henüz keşfedilmemiş için. Daha sabit bilgi var biyolojide çünkü gözlemleyebiliyoruz.
PST 6: I think that since other fields [physics and chemistry] are obtained in laboratory environment, they can be measured more accurately. That is why I think that the known is more close to the truth.	FÖA 6: Diğerlerinin [fizik ve kimya] daha laboratuar ortamında olduğunu düşündüğüm için onların daha iyi analiz edilebileceğini düşünüyorum. O yüzden de bilinenlerin daha doğruya yakın olduğunu düşünüyorum.
PST 5: Well, chemistry seems to me a more stable field. A reaction…you put something, there occurs an interaction and the result is definite since it was observed. For instance, when I combine hydrochloric acid with another component, it gives only one result or when you change it you calculate and see the ones that can change.	FÖA 5: Kimya bana çok net bir alan gibi geliyor. Bir tepkimeyi…bir şeyi ortaya koyuyorsunuz. Bir etkileşim oluyor ve sonucu belli çünkü gözlemlenmiş. Örneğin, hydrochloric asitle, başka bir bileşeni birleştirdiğinizde bir tek sonuç veriyor ya da onu değiştirdiğinizde hesaplıyorsunuz ve görüyorsunuz değişebilecek olanları.
PST 8: Well, in mathematics since we cannot do observations or we cannot do experiments related to this field it is more stable. So, let's give 90% to the stable part. R: We cannot do observations in mathematics. If we cannot do, PST 8: It is certain. I directly accept as if it is true.	FÖA 8: Yani matematikte gözlem yapamayacağımız için, deney yapamayacağımız için bu alanla ilgili daha çok sabittir. O zaman o unchange kısmını %90 yapalım. A: Matematikte gözlem yapılamıyor, yapılamıyorsa o zaman, FÖA 8: direk sabittir. İşte direk doğru kabul ediyorum.

4. Quotations taken from structure of knowledge part

PST 4: I can emulate my environmental knowledge to the legos because I can disconnect and then reconnect them. I can change legos' places since I think that the environmental knowledge is not fixed in this manner.	FÖA 4: Çevre bilgimi legoya benzetebilirim çünkü çevre bilgimi en bastan söküp tekrar yapabilirim. Yerlerini değiştirebilirim çünkü çevre bu şekilde sabit bir şey degil bence.
PST 10: A good learner connects the third lego after analyzing previously placed two legos. However, once s/he learns something new, this organization can change. Well, the new knowledge can comes into different categories.	FÖA 10: İyi bir öğrenci önceden kurulan 2 legoyu analiz ettikten sonra 3. legoyu birleştirir ama yeni bir şey öğrendikçe bu organizasyon değişebilir. Hani yeni bilgi farklı kategorilere girebilir.
PST 4: It seems to me that physics is open to being changed. So, I choose the legos. I can disconnect and reconnect legos but in the puzzle every piece has a definite place and if I put the pieces to wrong places I can observe the wrongfulness. However, in the legos there is no wrongfulness.	FÖA 4: Fizik değişmeye açık geliyor bana. O yüzden legoları seçerim. Legoları baştan söküp takabilirim ama yapbozda her bir parçanın yeri bellidir ve eğer yanlış yerlere koyarsam yanlış olduğunu gözlemleyebilirim ama legolarda yanlış yok.

PST 2: The change in organic chemistry; in other topics, again change in the knowledge regarding atoms can affect it [matter topic]. That is, there is an event of being affected in legos. When I take one of them [a lego], it can change the knowledge in the other. However, here [at puzzle] it may not be a change rather remains as missing.	FÖA 2: Organik kimya olsun; başka bir konuda, yine atomdaki bilginin değişmesi onu [madde konusunu] etkileyebilir. Yani o etkileme olayı var legoda. Birini [bir legoyu] aldığımda diğerindeki bilgiyi de değiştirebilir. Burada [yapbozda] belki değişiklik değil de eksiklik olarak kalır ama.
PST 4: My every knowledge, the new knowledge I have learned can be applied onto other knowledge as in the legos. The puzzle seemed to me as more strict. So, mathematical knowledge is not like puzzle. I think that mathematical knowledge changes continually as in the legos.	FÖA 4: Her bilgim yeni ögrendigim bir bilgiyi başka bir şeyin uzerine uygulayabilirim, legoda olduğu gibi. Puzzle bana biraz daha strict geldi. O yuzden matematik bilgisi puzzle gibi olmaz. Matematik bilgisinin sürekli değişeceğini düşünüyorum, legoda olduğu gibi.
PST 8: The student does not understand a piece without completion of another piece. That is why the student should use this piece in its most proper place. Otherwise, since the knowledge will not fit there, s/he will not make its explanation. If this knowledge is used for only here and the student tries to benefit from this knowledge in different topic it will not explain, support that. I say puzzle.	FÖA 8: Öğrenci bir parçasını tamamlamadan diğer parçasını anlamaz. Bu yüzden öğrenci bu parçayı en uygun yerinde kullanmalıdır. Diğer türlü bilgi oraya uymayacağı için onun açıklamasını yapamayacak. Bu bilgi sadece burada kullanılıyorsa öğrenci de başka bir konuda bu bilgiden yararlanmaya çalışıyorsa o onu açıklamayacak, desteklemeyecektir. Puzzle diyorum.
PST 12: In biology, it is like a puzzle. Well, knowledge is related to each other as in the puzzle but the links in biology are not as in the legos. Legos are different since in legos the connection of a lego with the other legos gives a different result. However, in biology there is not such a thing.	FÖA 12: Biyoloji de puzzle gibidir. Hani puzzleda olduğu gibi bilgiler birbiriyle ilişkilidir ama biyolojideki ilişkiler legodaki gibi değil. Lego çok farklı çünkü legoda her parça diğer parçayla farklı bir sonuca ulaşabiliyor ama biyolojide böyle bir şey yok.
PST 8: To me physical topics are in integrity. So, a good student should do a puzzle. That is, if the student use a formula or a theory in a different place instead of its particular place, the result of this question will be wrong.	FÖA 8: Bence fizik konuları bir bütünlük içerisinde. Bu yüzden, iyi öğrenci puzzle yapmalı. Yani şurada kullanacağı bir formülü veya bir teoriyi tutup başka bir yerde kullanırsa o sorunun sonucu yanlış çıkar.
PST 8: I can say a puzzle for chemistry since we cannot use a particular topic in a different topic in chemistry. For example, we cannot use Boyle Mariotte in volume or I do not know in the other things related to another theory.	FÖA 8: Kimya için puzzle söyleyebilirim çünkü bir konuyu tutup da başka bir konuda kullanamayız. Mesela Boyle Mariotte' yu tutup hacimde ne bileyim başka bir şeyle ilgili bir yasada kullanamayız.
PST 10: It seems to be that mathematical knowledge is not always changing. How should I tell? I thought that s/he [good learner] considers each new incoming as the one piece of the puzzle and by adding these pieces together s/he can reach the whole.	FÖA 10: Matematik bilgileri sürekli değişmiyor gibi geliyor. Nasıl anlatsam? Her yeni geleni bir puzzle ın bir parçası gibi düşünüp ekleyerek bütüne ulaşıyor diye düşündüm.

PST 3: Environmental knowledge, I think something which is interwoven but I could not find an analogy now.
R: How interwoven?
PST 3: Like a water cycle. In a tick, water cycle came to my mind. It can be a chain but in chain all follow each other. However, in environment it can be daisies consisting of many chains. I mean one does not depend only on the other instead all factors are interdependent.
R: What can it be?
PST 3: May be something like a road map. I mean on it [road map] there is an environment where everything is always connected to each other. For instance, any disturbance in one road always affects others.

FÖA 3: Çevre bilgisi, içiçe bir şey düşünüyorum ama şimdi ona bir analoji bulamadım.
A: Nasıl içiçe?
FÖA 3: Su döngüsü gibidir. Su döngüsü geldi aklıma bir anda. Zincir olabilir ama zincirde hepsi birbirini takip ediyor ama çevrede zincirlerden oluşmuş papatyalar olabilir. Hani biri sadece diğerine bağlı değil bütün etmenler birbirine bağlı.
A: Ne olabilir?
FÖA 3: Belki yol haritası gibi bir şey olabilir. Orada [yol haritasında] sürekli birbiriyle iletişim halinde bir ortam var. Mesela bir yoldaki bozukluk diğerlerini de hep etkiliyor.

PST 6: My analogies for biology, physics, chemistry, and mathematics do not change. I think that it is required to relate all of them to each other all the way since none of them are indeed separated things from each other. All of them support each other…. Also within physics, there is chemistry. Also within chemistry, there is physics. Mathematics is already in each of them.

FÖA 6: Biyoloji, fizik, kimya ve matematik için analojilerim değişmez. Hepsinin her şekilde birbiriyle bağıntısının kurulması gerektiğini düşünüyorum ben çünkü hiçbiri hiçbirinden ayrı şeyler değil aslında. Hepsi birbirini destekliyor… Fiziğin içinde de kimya var, kimyanın içinde de fizik var. Matematik zaten hepsinin içinde.

PST 12: Why lego? Since in lego the pieces are related to each other and we can make new pieces. Also in environment, it is like that. I mean all things are related to each other but as I said I am saying this by thinking new solution or different solutions can be generated. As I said before, while solving an environmental problem there is not only one solution. If I want, let's say, I can find six solutions. In fact, by placing different pieces to different places I can generate different things related to environmental knowledge.
R: Why is it not a puzzle?
PST 12: In puzzle there are also relationships but you cannot put this piece to another place. It has a fixed place.

FÖA 12: Neden lego? Çünkü legoda parçalar birbirleriyle ilişkili ve yeni parçalar yapabiliyoruz. Çevrede de öyle. Yani bütün herşey birbiriyle ilişkili ama dediğim gibi bu problemlere yeni çözümler, başka farklı çözümler üretilmesinden yola çıktım ben. Hani daha önce dediğim gibi çevresel bir problem çözerken onun tek bir çözüm yolu yoktur. Ben istesem atıyorum 6 tane çözüm yolu bulabilirim. Bu da farklı parçaları farklı yerlerle birleştirerek aslında farklı şeyler üretebilirim çevre bilgisiyle ilgili. Ama bunların hepsi de birbiriyle ilişkili.
E: Neden puzzle değil?
G: Puzzleda da ilişkiler vardır ama şu parcayı burdan alıp buraya takamazsınız. Onun yeri bellidir.

PST 4: For example, I had built but when I take a look I might have built it poorly so it collapses. Why? That is to say I have forgotten to put something in the base of it. I mean that below that basic knowledge my main piece is missing. Therefore, I suppose, I emulate my environmental knowledge to a lego.

FÖA 4: Mesela inşa etmişimdir ama bir bakarım ki kötü inşa etmişimdir, devrilir. Neden? Demek ki temelinde bir şey koymayı unutmuşumdur. Yani o temel bilginin altında ana bir parçam eksik. O yüzden legoya benzetirim herhalde çevre bilgimi.

PST 4: I think that for a good learner there is a much development. That is to say that the good learner uses the legos to build a ladder.

FÖA 4: İyi bir öğrenci için daha çok bir ilerleme vardır. Yani iyi bir öğrenci legoları merdiven yapmak için kullanır.

PST 2: There is some basic knowledge and new information comes onto this basic knowledge. In this way, it expands and grows. It seems more explanatory. Well, it is like that. Maybe when I remove one [lego], it will fall down. That is why I can say the legos for physical knowledge.	FÖA 2: Temel bazı bilgiler var. Yeni bilgiler ile üst üste gelip o daha bir genişleyip büyüyor. Hani daha açıklayıcı geliyor. Hani, böyle. Belki birini aldığımda yıkılacak. Gerçi şöyle bir şeyde, yorum yapılabilir. Bu yüzden fizik bilgisi için legolar diyebilirim.
PST 11: I think that in the beginning s/he [good learner] has a core of knowledge. As information comes on that knowledge, I think that his or her that knowledge further enlarges. I can emulate this to a snail shell. All in all, in someway they are also attached to each other. The rings in the shell grow up the end of the previous one. We can say in the structure of a snail or in the structure of a spiral shape.	FÖA 11: Bence [iyi bir öğrencinin] başta çekirdek gibi bir bilgisi var. Üzerine bilgi geldikçe o bilgisinin daha fazla genişlediğini düşünüyorum. Salyangoz kabuğuna benzetebilirim. Sonuçta bir şekilde onlar da birbirine bağlı. Kabuktaki bu çemberler diğerinin devamına gelerek büyüyor. Salyangoz biçiminde diyebiliriz, spiral şeklinde veya.
PST 2: My analogy is the same for mathematics. As in the legos, there is also basic knowledge in mathematics and new information builds upon this basic knowledge.	FÖA 2: Matematik için analojim aynı. Legolarda olduğu gibi matematikte de temel bilgiler var ve yeni bilgi bu temel bilginin üzerine kuruluyor.
R: For a poor student? PST 7: For a poor student, this [knowledge] is separated, well, like the filing. R: Do you say like the sorting program? PST 7: Yes, [poor student's knowledge] it is at different places. If s/he concentrated on this knowledge s/he forgets that other knowledge can help although s/he knows this other knowledge. This is something that is somewhat related to memorizing. Although it [knowledge] is in memory, s/he forgot that it is there and it can be helpful. That is to say s/he memorized without realizing it. Not establishing connections among knowledge indicates that s/he is a poor student and as I said it is like filing. When I think a while this does not show differences with respect to fields… I thought and it really does not differ. We mention study habits here. I mean this is being a good student and poor student.	A: Zayıf bir öğrenci için? FÖA 7: Kötü öğrenci için bunlar [bilgiler] ayrıdır. Hani o dosyalama gibi. A: Sorting program gibidir diyorsun? FÖA 7: Evet, [zayıf öğrencinin bilgileri] farklı yerdedir. Şu bilgisiyle yoğunsa o bilginin aslında yardıma gelebileceğini unutur, onu bilse bile. Bu biraz da ezberlemenin vermiş olduğu bir şey. Ezberinde olsa bile onun orda durduğunu ve yarayabileceğini unutmuştur. Yani fark etmeden ezberlemiştir. Onların arasındaki bağlantıyı kurmaması zayıf bir öğrenci olduğunu işaret eder ve o da dediğim gibi dosyalama gibi. Biraz düşündüğümde bu alanlara göre farklılık göstermiyor... Düşündüm ve bu hakikaten fark etmiyor. Çalışma alışkanlığından bahsediyoruz. Yani iyi öğrenci ve zayıf öğrenci olma.
PST 2: Sorting program since in sorting program there are not so much connections with one another. I understood sorting program as always placing information into one file. Well, a poor student will not see the connections among each other.	FÖA 2: Sorting program çünkü sorting programda çok fazla birbiriyle ilişki yok. Sorting programı hep bir dosyaya atıyor gibi anladım. Hani zayıf öğrenci o birbirleri arasındaki ilişkiyi göremeyecek. .
PST 3: I can say sorting program because a poor student will think separately. Well, s/he cannot relate much.	FÖA 2: Sorting program diyebilirim çünkü zayıf bir öğrenci ayrı düşünecektir. Hani çok ilişkilendiremez.
PST 5: I can say scattered files in a computer which are indeed connected. That is, I can say not being able to relate files which are in the same category.	FÖA 5: Bilgisayardaki birbiriyle ilişkili dosyaların dağılmış olması diyebilirim. Yani, aynı kategorideki dosyaların birbiriyle ilişkilendirilememesi diyeyim.

PST 2: I select the sorting program because in sorting program the student thinks each topic separately and does not establish so many connections.

FÖA 2: Sorting program’ı seçerim çünkü sorting programda öğrenci her konuyu ayrı düşünüyor ve aralarında çok fazla bağlantı kurmuyor.

R: Ok. What about your analogy for a poor learner?
PST 11: I do not believe that a poor student can think so complex. I do not also think that it is separated like sorting program. So, I think it [the structure of environmental knowledge] can be like a puzzle.
R: Why puzzle?
PST 11: Why I selected the puzzle. For example, a good student may think that living things can live in different environments and this can change; however, a poor student does not think that his or her knowledge can change or evolve instead s/he says that this is this, that is that. For example, s/he thinks a tree in the garden as only one piece of it.

A: Tamam. Peki, kötü bir öğrenci için analojin ne olur?
FÖA 11: Kötü bir öğrencinin o kadar kompleks düşünebileceğine inanmıyorum. Çok fazla sorting program gibi de ayrı ayrı olabileceğini düşünmüyorum. Bu yüzden onun [çevre bilgisinin yapısının] puzzle olabileceğini düşünüyorum.
A: Neden puzzle?
FÖA 11: Neden puzzle’ı seçtim. Mesela iyi bir öğrenci canlıların çeşitli ortamlarda yaşayabileceğini ve onun değişebileceğini düşünüyor olabilir. Fakat zayıf bir öğrenci bildiği bilginin değişebilir gelişebilir olduğunu düşünmeyip bu budur şu şudur der. Mesela bahçedeki bir ağacın bunun sadece bir parçası olduğunu düşünebilir.

PST 10: For a good learner, I think the legos because the organization of the existing knowledge changes in light of new information but for a poor student I can say the sorting program since it does not have a possibility of reconnection as in the legos.

FÖA 10: İyi bir öğrenci için legolar diye düşünüyorum çünkü var olan bilginin organizasyonu yeni bilgiler ışığı altında değişiyor ama zayıf bir öğrenci için sorting program diyebilirim çünkü onun legodaki gibi tekrardan yapılma olasılığı yok.

PST 12: In the mind of a poor learner, an apple goes into the apple file and a pear goes into the pear file. That is, knowledge in the mind of a poor student can be shown as completely certain knowledge.

FÖA 12: Zayıf bir öğrencinin kafasında alme elmaya armut armuta gider. Yani zayıf bir öğrencinin kafasındaki bilgi tamamen sabit bir bilgi olarak gösterilebilinir.

PST 10: I say sorting program again since the organization of the existing knowledge does not change in light of new information as in the legos.

FÖA 10: Yine sorting program derim çünkü Legolarda olduğu gibi var olan bilginin organizasyonu yeni bilgiler ışığı altında değişmiyor.

PST 12: I consider a poor student as a student who is not open to development. An apple goes into the apple file and a pear goes into the pear file. That is, the poor student prefers certainty whatever the domain.

FÖA 12: Zayıf bir öğrenciyi gelişmeye açık olmayan bir öğrenci olarak bakıyorum ben. Elma elmaya armut armuta gider. Yani zayıf öğrenci hangi bilim dalı olursa olsun sabitliği tercih eder.

PST 3: I can emulate to a road map. For a poor learner, the road map may consist of only the main roads and not have any freeway or pathway. This is due to not having so much information.

FÖA 3: Yol haritasına benzetebilirim. Zayıf bir öğrenci için yol haritası sadece anayollardan ibaret olabilir ve çevre yolu ya da patikalar olmayabilir. Bu da çok fazla bilgisi olmadığından.

PST 11: For a poor learner, it is something that remained missing. I cannot say sorting program. I think that there are much more missing things. A poor student can see knowledge in his or her mind as complete. I thought that this puzzle is in fact missing when we look at it; however, when s/he looks s/he sees it as complete.

FÖA 11: Kötü bir öğrenci için böyle eksik kalmış bir şey. Sorting program diyemiyorum. Daha fazla böyle eksik kalmış şeyler olduğunu düşünüyorum. Zayıf bir öğrenci kafasındaki bilgiyi tam olarak görebilir. Bu puzzle aslında biz baktığımızda eksik ama o baktığında tam olarak görüyor diye düşündüm.

PST 3: For a poor learner in chemistry, there are some missing pieces in the puzzle. When s/he completes those missing pieces, s/he will also be a good student.	FÖA 3: Kimyada zayıf bir öğrenci için yapbozda boşluklar vardır. O boşlukları tamamladığı zaman o da iyi bir öğrenci olacak.
PST 3: If we say that knowledge in the mind of a good learner is the number of keys in the toolbox, everything in the toolbox is ordered and s/he has many tools to use. However, for a poor learner the toolbox is small and not ordered instead it can be mixed.	FÖA 3: İyi bir öğrencinin kafasındaki bilgiyi alet çantasındaki anahtar sayısı olarak dersek alet çantasındaki her şey düzenli ve birsürü kullanacağı anahtarı var. Zayıf öğrencide de alet çantası küçük ve düzenli değil karışık olabilir.

5. Quotations taken from control of learning part

PST 6: Ability to learn environmental science…hmm I think that 20% is genetical predisposition and the remaining is related to learning how to learn. I actually think that there is a genetical percentage because as I said in some way it is related to interest and this is something that comes from genetic.	FÖA 6: Çevre bilimini öğrenebilme yeteneği… hımm % 20 genetical predisposition, geri kalanı da nasıl öğrenmeyi öğrenmemiz gerektiğiyle ilgili olduğunu düşünüyorum. Genetical lada ben payının olduğunu düşünüyorum açıkçası çünkü dediğim gibi bir şekilde de ilgi meselesi ve bu da genetikle gelen bir şey.
PST 6: Biology is same with environment since as I said it [ability to learn due to genetical predisposition] is something related to people's interest.	FÖA 6: Biyoloji çevre ile aynı çünkü dediğim gibi bu [öğrenme yeteneğinin doğuştan gelen kısmı] insan beyninin ilgisiyle alakalı bir şey.
PST 3: 30% may come from innate. I mean the thing coming from innate is, in fact, field of interest. For instance, for some people dealing with numbers comes more instructive; for some people reading comes more instructive.	FÖA 3: % 30 u doğuştan gelmiş olabilir. Yani şey doğuştan gelen aslında ilgi alanıdır. Mesela bazılarına sayılarla uğraşmak daha öğretici gelir; bazılarına sözel okumak daha öğretici gelir.
PST 12: Genetic is 40%. It is related to motivation. I mean some students already have internal motivation. They do not need a teacher; however, other students need to be motivated externally. I think that internal motivation is related to genetic.	FÖA 12: %40 genetik. Bu motivasyonla ilgilidir. Hani bazı çocuklar içten motivasyonludur zaten. Öğretmene ihtiyacı yoktur ama bazı çocuklar da dıştan motive edilmesi gerekiyordur. İçten motivasyonun genetikle ilgili olduğunu düşünüyorum.
PST 9: 20% is genetic effect. Actually, it is general since we mention about learning for all. So, percentages of learning are the same for all. However, for a person more interest may come from innate.	FÖA 9: %20 genetik etki. Aslında bu genel bir şey hepsi için öğrenmeden bahsediyoruz ya. Bu yüzden hepsi için öğrenme yüzdeleri aynıdır ama birinin ilgisi doğuştan fazla gelebilir.
PST 7: When you say physics, chemistry, mathematics even biology I will give the same [percentage] since they require a higher IQ. This depends more on mother and father. I will say this 70%.	FÖA 7: Fizik, kimya, matematik dediğimiz zaman hatta biyolojiye de aynı [yüzdeyi] vereceğim çünkü bunlar daha yüksek IQ gerektiriyor. Bu da anneyle babaya daha çok bağlı. Buna %70 diyeceğim.
PST 8: May be %10 is innate since physics is a bit abstract. No, it is not abstractness instead since physics requires more of an ability to think, intelligence.	FÖA 8: Belki doğuştan %10 çünkü fizik biraz soyut. Yok, soyutluk değil de hani fizik daha böyle düşünme yeteneği, zekâ gerektirdiği için.

PST 2: In chemistry like physics and mathematics, 40% [ability to learn due to genetical predisposition] to 60% [ability to learn due to learning how to learn] since it is more quantitative. Just now we say that we should use multiple intelligence… It seems to me that being good at in quantitative is genetical.

FÖA 2: Kimya; fizik ve matematik gibi %40'a [genetik eğilime bağlı öğrenme yeteneği] %60 [nasıl öğrendiğini öğrenmeye bağlı öğrenme yeteneği] çünkü daha sayısal. Şu anda multiple intelligence ı kullanalım diyoruz…sayısalımın daha iyi olması genetiksel gibi geliyor bana.

R: What do you think about the percentage of ability to learn is innate in mathematics?
PST 5: 40% is innate.
R: What about physics?
PST 5: 0%. It [ability to learn in physics] is not innate like biology, chemistry, and environment since to me mathematics is a bit related to intelligence; however, the others [physics, chemistry, biology, and environment] are more related to observation.

A: Matematikte doğuştan gelen öğrenme yeteneğinin yüzdesi hakkında ne düşünüyorsun?
FÖA 5: %40 doğuştan geliyor.
A: Peki, fizik?
FÖA 5: %0. [Fizikte öğrenme yeteneği] Doğuştan gelmiyor biyoloji, kimya ve çevre gibi çünkü matematik zekayla biraz ilgili bence, diğerleri [fizik, kimya, biyoloji ve çevre] daha çok gözlemle ilgili.

PST 3: I believe that there is an innate percentage; however, I do not believe that it [the ability to learn] is completely innate. For example, if a student is bad at Turkish in primary school or bad at in environment related issues I do not believe that there is such a thing that the whole life of that student will pass like that or the student will be strained so much in learning environmental science. However, after a while, for example, everyone has their own method to learn some things. I think that if s/he discovers how to learn by the help of teachers or self-questioning s/he can increase his or her ability to learn and I think that more of it is from the improvable one.

FÖA 3: Doğuştan gelen bir pay olduğuna inanıyorum ama tamamen de doğuştan gelmiştir diye bir şey olduğuna inanmıyorum. Bir çocuk mesela ilkokulda Türkçede kötüyse ya da çevreyle ilgili konularda kötüyse bütün hayatını öyle geçircek tamamen çevre bilimini öğrenmede çok zorlanacak diye bir şey olduğuna inanmıyorum. Ama bir süre sonra mesela herkesin kendi yöntemi vardır bir şeyleri öğrenmek için. Kendinin nasıl öğrendiğini keşfedebilirse öğretmenlerinin yardımıyla ya da sorgulayarak kendini öğrenme kapasitesini artırabilir diye düşünüyorum ve daha çoğunluğu da artırılabilecek olandandır diye düşünüyorum.

PST 6: I think that 20% is genetical predisposition; the remaining is related to learning how to learn. For example, I can learn biology easier when I relate it to chemistry or when I relate it to physics. In that case, it is actually needed to learn how we learn.

FÖA 6: % 20 genetical predisposition; geri kalanı da nasıl öğrenmeyi öğrenmemiz gerektiğiyle ilgili olduğunu düşünüyorum. Mesela ben biyolojiyi kimya ile bağladığım zaman ya da fizik ile bağladığım zaman çok rahat öğrenebiliyorum. O zaman aslında nasıl öğrenmemiz gerektiğini öğrenmemiz gerekiyor.

PST 9: I think that a large percentage is learning how to learn afterwards, 80% and 20% is genetic effect. Actually, it is general since we mention about learning for all. So, percentages of learning are the same for all [environment, physics, chemistry, biology, and mathematics]… Innate intelligence affect a little bit… No matter how much somebody works s/he actually learns how to learn.

FÖA 9: Bence büyük bi kısmı nasıl öğreneceğini sonradan öğrenir, %80; %20 de genetik etki. Aslında bu hep genel bi şey zaten hepsi için öğrenmeden bahsediyoruz ya hepsi [çevre, fizik, kimya, biyoloji ve matematik] için öğrenme şeyi yüzdeleri aynıdır… Doğuştan zeka bi nebze etkiler… Kimisi ne kadar uğraşsa da öğrenmeyi öğrenir aslında.

PST 11: 90% can be learned after the birth, 10% is innate since people all in all do not remember anything until 5 years old. Well, no matter how much s/he learned the things that other people said may come to her or him as a story until that age. That is why I think that it [ability to learn] does not depend more on genetic. Besides I see that although environment related knowledge at elementary school is very small piece, now it can be enormous range. Well, that is why I think that as I see my environment, listen from the others, and do observations I can learn it more and I can understand it more.	FÖA 11: %90 sonradan öğrenilebilir, %10 doğuştan gelir çünkü sonuçta insanlar ilk 5 yaşına gelene kadar hiçbir şey hatırlamaz. Hani ne kadar bir şeyler öğrenmiş olursa olsun, başkalarının söyledikleri o yaşına kadar hikaye gibi gelebilir. Onun için çok fazla genetiğe dayalı bir şey olduğunu düşünmüyorum. Bir de bakıyorum ilkokulda çevreyle ilgili bilgiler küçücük bir parçayken, şimdi kocaman bir alan olabiliyor. Hani onun için ben çevremi gördükçe, başkalarından dinledikçe, gözlem yaptıkça daha fazla onu öğrenebildiğimi, onu daha fazla anlayabildiğimi düşünüyorum.
PST 4: Chemistry, I say this, 30% [ability to learn due to genetical predisposition] and 70% [ability to learn due to learning how to learn]. It is same with environment since it is also a bit related to daily life.	FÖA 4: Kimya, buna %30 [genetik eğilime bağlı öğrenme yeteneği] ve %70 [nasıl öğrendiğini öğrenmeye bağlı öğrenme yeteneği] derim. Çevreyle aynı çünkü o da biraz günlük hayatla ilişkili.
PST 11: Again, I want to say 90% [ability to learn due to learning how to learn] to 10% [ability to learn due to genetical predisposition]… All in all, since biology is also in environment, even if nothing happens human can do observation his or her own body. Well, even going to kindergarden girls realize their being a female; boys realize their being a male. That is, because of something based on observation I said 90%. I do not think that doing observation is something that is acquired.	FÖA 11: Yine % 90'a [genetik eğilime bağlı öğrenme yeteneği], %10 [nasıl öğrendiğini öğrenmeye bağlı öğrenme yeteneği] demek istiyorum... Sonuçta biyoloji de çevrenin içinde olduğu için hiçbir şey olmasa bile insan kendi vücudunu gözlem yapar. Hani anaokula giderken bile kızlar kız olduklarını, erkekler erkek olduklarını fark ederler. Yani gözleme dayalı bir şey olduğundan dolayı, %90 dedim. Gözlem yapabilme sonradan kazanılmış bir şey olduğunu düşünmüyorum.
PST 3: I think this [ability to learn] in general. I mean that for instance, in fine arts it is also said that drawing is ability. Although little is innate if a person study s/he can draw after a while even s/he had bad drawing before.	FÖA 3: Bunu [öğrenme yeteneği] çok genel düşünüyorum. Yani mesela güzel sanatlarda da resim çizmek yetenek derler. Hani birazı ne kadar doğuştan gelmiş olsada çalışırsa bir insan hani kötü çizimi olan da çizebiliyor bir süre sonra.
PST 7: When you say physics, chemistry, mathematics even biology I will give the same [percentage] since they require a higher IQ. This depends more on mother and father. I will say this 70%. 30% is remaining for working, working hard.	FÖA 7: Fizik, kimya, matematik dediğimiz zaman hatta biyolojiye de aynı [yüzdeyi] vereceğim çünkü bunlar daha yüksek IQ gerektiriyor. Bu da anneyle babaya daha çok bağlı. Buna %70 diyeceğim. Çalışmaya da azimle çalışmaya hırsa % 30 kalıyor.

6. Quotations taken from speed of learning part

PST 3: I think that biology is again like environment. I think that it is easier to learn things coming from after terms. I mean that the s/he [average student] learns faster the things that s/he can observe. S/he is strained for other things like terms or concepts.	FÖA 3: Biyoloji de yine çevre gibi. Terimlerden sonrası kolay gelir diye düşünüyorum. Yani [ortalama öğrenci] gözlemleyebildiği şeyleri daha çabuk öğrenir. Terimde kalan concept şeylerde zorlanır.

PST 6: Moderate is 50%; fast is 30%; and gradually is 20%.
R: Why do you think that 50 percentage of environmental knowledge is learned moderately?
PST 6: Since environmental knowledge is something that we can completely see and understand. It is something that the average student himself or herself can observe. That is why I do not think that it is something too difficult to be understood or too incomprehensible. As I said, for instance, when a dam is constructed in a place it is not difficult to predict that living thing in there will die. I think that it is not difficult to accept this when you see this or in some ways read something related to this or watch. That is why I think that everyone can easily understand moderately.

FÖA 6: Moderate %50, fast %30, gradually %20.
A: Neden çevre bilgisinin %50 si ortalama hızla öğrenilebilir diyorsun?
FÖA 6: Çünkü çevre bilgisi tamamen görebildiğimiz ve anlayabileceğimiz bir şey. Kendisinin [ortalama öğrenci] de gözlemleyebileceği bir şey. Bu yüzden de anlaşılmasını çok zor ya da çok anlaşılmaz bir şey olmadığını düşünüyorum. Yani dediğim gibi mesela bir yerde baraj kurulduğunda oradaki canlıların öleceğini tahmin etmek bile çok zor değil ki. Bunu görürse ya da bir şekilde bununla ilgili bir şey okursa izlerse bunu kabullenmesinin çok zor olmadığını düşünüyorum. O yüzden de orta derecede herkesin çok rahat bir şekilde anlayabileceğini düşünüyorum.

PST 4: If I were a very smart student, I would do more observations in daily life. That is why fast percentage would increase for all… Since chemistry like physics can be turned into concrete fast part will be again high. For instance, if fast learning is 40%, moderate learning is 40% and slow part becomes 20%.

FÖA 4: Ben çok zeki olsaydım benim günlük hayattaki gözlemlerim daha çok olurdu. O yüzden de hızlı kısım artardı hepsi için… Kimya fizik gibi somuta döndürülebildiği için fast kısmı yine yüksek olacak. Mesela %40 hızlı öğrenme olursa ortalama öğrenme %40 olur ve yavaş kısmı %20 olur.

PST 8: For chemistry, fast learning is 50%; 30% [moderate learning I]; and 20% [slow learning]. As I said before, you say physical changes, evaporation of water, water boils at 100°C. All in all for instance we enter kitchen and all in all we cook. We are very involved with a chemical matter everywhere in our daily life. That is why for instance I think that even our mothers also have chemical knowledge… I mean we use and we observe. For that reason, we learn faster.

FÖA 8: Kimya için hızlı öğrenme %50; %30 [ortalama öğrenme] ve %20 [yavaş öğrenme]. Daha önce dediğim gibi fiziksel değişimler diyorsun, suyun buharlaşması, su yüz derecede kaynar. Sonuçta mesela mutfağa giriyoruz; sonuçta yemek yapıyoruz. Günlük hayatımızın her yerinde kimyasal bir maddeyle haşır neşir oluyoruz. O yüzden mesela annelerimizin bile kimyayla ilgili bilgisi olduğunu düşünürüm… Yani kullanıyoruz; gözlemliyoruz. O yüzden de daha çabuk şey öğrenebiliyoruz.

PST 4: Biology is also abstract. We are able to make experiments; however, we are able to do experiments for only a few parts. Hmm, probably slow learning part is 50%.

FÖA 4: Biyoloji de soyut. Deneylendirebiliyoruz ama az bir kısmını deneylendirebiliyoruz. Hımm yavaş öğrenme kısmı %50' dir herhalde.

PST 8: Physics. 40% [fast learning], 20% [moderate learning], 40% [slow learning]. Even you are smart you learn physics more slowly.
R: why do you think so?
PST 8: Due to its being abstract. It [learning physics] requires more time since they are abstract concepts.
R: what do you mean by abstract concepts?
PST 8: I mean observing or not observing in daily life as well as seeing with naked eyes. I do not know, when I think the things related to universe, in my opinion physics becomes abstract.

FÖA 8: Fizik. %40 [hızlı öğrenme], %20 [ortalama öğrenme], %40 [yavaş öğrenme]. Fizik zeki de olsa daha yavaş öğreniliyor.
A: Neden böyle düşünüyorsun?
FÖA 8: Soyutluğundan dolayı. Soyut kavramlar olduğu için [fiziği öğrenme] daha böyle zaman gerektirir.
A: Soyut kavram derken ne demek istedin?
FÖA 8: Hem günlük hayatla gözlemleyip gözlemlememek hem de onunla ilgili gözünle görmek yani. Ne bileyim uzayla ilgili kavramları düşününce fizik bence soyut bir hale geliyor.

PST 2: I can say the same thing [thing I said for physics] for chemistry. 40% [slow learning], 50% [moderate learning], 10% [fast learning]. The average student learns basic knowledge that s/he can observe from environment fast. As s/he goes into less observable s/he will learn more slowly since it will be more abstract and more theoretical.

FÖA 2: Kimya için aynı şeyi söyleyebilirim [fizikle için söylediğim şeyleri]. %40 [yavaş öğrenme], %50 [ortalama öğrenme], %10 [hızlı öğrenme]. Ortalama bir öğrenci temel bilgileri, çevresinde gözlemleyebildiği bilgileri daha hızlı öğrenebilir. Daha görülmeyene gittiğinde daha soyuta gittiği için daha teori kavramında şeyler olacağı için onu daha yavaş öğrenir.

PST 5: I think that gradual learning is 80%; 20% is moderate learning; and 0% is fast learning.
R: Is fast learning 0%?
PST 5: I think there is no since we learn by studying even abacus such that homework is given. It is not easy to digest mathematics instantly even for a smart student since in my opinion mathematics is abstract.

FÖA 5: % 80’ini aşamalı öğrenir bence, %20’sini de yavaş öğrenir ve % 0’ını hızlı öğrenir.
A: %0’ını hızlı öğrenir?
FÖA 5: Bence yok. Abaküsü bile çalışarak öğreniyoruz. Ödev veriliyor filan. Matematik soyut olduğu için bence onu bir anda hazmetmek zeki bir öğrenci için bile kolay değil.

PST 4: I say that 30% is fast. Hmm, 30% is moderate learning and the remaining is slow. Probably, the slow percentage is much more. Let’s 40%. Learn 40% slow since biology is detail. It is too much related. For instance, in cell there is not only one thing instead there are a thousand things for protein synthesis such as rRNA and nucleus. How should I say? To know protein synthesis s/he [the smart learner] should also know all remaining things.

FÖA 4: %30’una ben fast derim. Hımm ortalama öğrenmesi %30. Geri kalanda slow. Slow kısmı biraz daha çok olur herhalde. %40 olsa. %40’ını yavaş öğrenir çünkü biyoloji detay. Çok ilişkili. Hücre içinde mesela bir tane bir şey yok ki protein sentezi için 1000 tane şey var. İşte rRNA’lardır, çekirdektir. Nasıl deyim? Protein sentezini biliyor olması için [zeki bir öğrencinin] geri kalanının hepsini biliyor olması gerekiyor.

PST 11: The average student can learn fast 10% of physical knowledge. S/he can learn slowly 50% of it and 40% can be moderate. I gave fast learning less since physics is such something that it ranges from simple concepts to so complex ones. Well, I thought that the average student can learn that basic things fast; however, learning or understanding can be slow as s/he comes to more complex ones.
R: What do you mean by complex?
PST 11: How should I say? For instance, a topic is told. In the second lesson, you add another topic to previous one. In that time, you tell new one. Well, as it goes like that new one is added which makes the first one more difficult and complex.

FÖA 11: Fizik bilgisinin % 10’luk kısmı hızlı öğrenebilir. %50’lik kısmını yavaş öğrenebilir. %40’lık kısmı da moderate olabilir. Hızlı öğrenebileceği kısmı az tuttum çünkü fizik öyle bir şey ki çok basit kavramdan çok karmaşığa doğru gidebiliyor. Hani o basic şeyleri çabuk öğrenebilir ama karmaşığa doğru gittikçe hani algılaması, öğrenmesi birazcık daha yavaşlayabilir diye düşündüm.
A: Karmaşık dediğin ne anlam ifade ediyor?
FÖA 11: Nasıl diyebilirim. Mesela bir parça anlatılır. İkinci ders o parçanın yanına başka bir bir şey konu eklersin. Bu sefer onu anlatırsın. Hani böyle gittikçe ona eklenir. Bu onu birazcık daha zorlaştırır ve karmaşıklaştırır.

PST 2: 20% [slow learning], 50% [moderate learning], 30% [fast learning]. The percentage of moderate learning is much more since that percentage again requires connections.

FÖA 2: %20 [yavaş öğrenme], %50 [ortalama öğrenme], %30 [hızlı öğrenme]. Ortalama öğreneceği kısım daha fazladır yine bağlantı gerektirdiği için.

PST 4: In mathematics, fast learning is about 10%, moderate is 40%, and slow learning is 50%. Slow learning in mathematics is more than that in environment since it seems to me that in mathematics there will be many details. S/he [the average student] will learn the detailed part slowly since s/he must establish connections.	FÖA 4: Bence matematikte hızlı öğrenmesi %10 u bulur. Ortalama %40 ve yavaş öğrenme %50 olur. Yavaş öğrenme matematikte çevreden daha fazla çünkü matematik daha detay olacaktır gibi geliyor. [Ortalama bir öğrenci] detay kısmını daha yavaş öğrenecektir çünkü ilişkiler kurmalıdır.
PST 4: Hmm, it seems to me that s/he learns 40% slowly since s/he may not know some specific things in terms of establishing connections. For instance, there is a lake and there is an issue of pollution in this lake. In the first place, s/he understands that it is polluted; however, this learned percentage is very low. That is, knowledge that the lake is polluted. This corresponds only 10% of entire subject and s/he learns it right away; however, when s/he comes to deep part the speed of learning will be slower. R: What do you mean by deep? PST 4: To make detailed, establish more connections, how can I say?	FÖA 4: Hımm %40'ını yavaş öğrenir gibi geliyor çünkü çok spesifik bilmediği şeyler olabileceğini düşünüyorum bağlantı kurma açısından. Örneğin; bir göl vardır ve gölün kirliliği söz konusudur. İlk önce bunu hemen anlar kirlenmiştir bu ama öğrendiği kısım dar bir kısımdır. Bu da gölün kirlendiği bilgisidir. O bütün bir konunun belki %10'unu kaplar ama detayına indiği zaman bunun hızı yavaşlayacaktır. A: Derin demekle ne demek istiyorsun? PST 4: Detaylamak; daha ilişki kurmak. Nasıl deyim?