INTERACTION BETWEEN EXPERIENCED CHEMISTRY TEACHERS' SCIENCE TEACHING ORIENTATIONS AND OTHER COMPONENTS OF PEDAGOGICAL CONTENT KNOWLEDGE IN MIXTURES

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

INTERACTION BETWEEN EXPERIENCED CHEMISTRY TEACHERS' SCIENCE TEACHING ORIENTATIONS AND OTHER COMPONENTS OF PEDAGOGICAL CONTENT KNOWLEDGE IN MIXTURES

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The purpose of this study was twofold: The first one was to investigate all components of experienced chemistry teachers’ pedagogical content knowledge (PCK) which are science teaching orientations (STO), knowledge of learner, knowledge of curriculum, knowledge of instructional strategy and knowledge of assessment, and the second one was to examine the interactions between their science teaching orientations and the other components of PCK. Two experienced chemistry teachers participated in the study and the data were collected in mixtures unit through interviews, classroom observations and field notes. Results indicated that participants held teacher-focused beliefs about science teaching and learning. Moreover, their beliefs about the goals or purposes of science teaching was highly effected from nationwide examinations. None of the participants emphasized the aspects of the nature of science during the instruction due to the reality of nationwide examinations, time limitation and their ongoing habits. Beliefs about the goals or purposes of science teaching interacted with knowledge of learner and knowledge of assessment the most and knowledge of curriculum the least. Beliefs about science teaching and learning mostly interacted with knowledge of instructional strategies. Knowledge of assessment was the component of PCK that interacted the least with beliefs about science teaching and learning. Specially designed professional development programs should focus more on teachers' beliefs to manifest their STO which directs teachers' classroom practice. Moreover, in these programs alternative instructional methods and assessment techniques should be introduced to teachers in order to support them to develop more integrated PCK for teaching in an effective way. By this way, experienced in-service teachers may adopt reform-based practices easier.

Keywords: Pedagogical Content Knowledge, Science Teaching Orientations, Experienced Teachers, Science Teacher Education

ÖZ

DENEYİMLİ KİMYA ÖĞRETMENLERİNİN KARIŞIMLAR KONUSUNDAKİ FEN ÖĞRETİMİ YÖNELİMLERİ İLE PEDAGOJİK ALAN BİLGİLERİ ARASINDAKİ ETKİLEŞİM

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Bu çalışmanın amacı deneyimli kimya öğretmenlerinin pedagojik alan bilgisi (PAB) bileşenleri olan fen öğretimi yönelimleri, öğrenci bilgisi, öğretim programı bilgisi, öğretim yöntemleri bilgisi ve ölçme bilgisini incelemek ve fen öğretimi yönelimleri ile diğer PAB bileşenleri arasındaki etkileşimi araştırmaktır. Çalışma iki deneyimli kimya öğretmeni ile yürütülmüş ve çalışma verileri karışımlar konusunda görüşmeler, sınıf gözlemleri ve alan notları aracılığıyla toplanmıştır. Çalışma sonuçları katılımcıların fen öğretimi ve öğrenimi açısından öğretmen odaklı inanışlar sergilediğini göstermiştir. Ayrıca, öğretmenlerin fen öğretimine yönelik amaç ve hedefleri ülke genelinde uygulanan sınavlardan oldukça etkilenmektedir. Öğretmenlerin dersler süresince bilimin doğasına değinmedikleri belirlenmiştir. Bu durumun nedenleri arasında ülke genelinde uygulanan sınavlar, derslerdeki zaman kısıtlaması ve öğretmenlerin süregelen alışkanlıkları yer almaktadır. Öğretmenlerin fen öğretiminin amaç ve hedeflerine yönelik inanışları en çok öğrenci bilgisi ve ölçme bilgisi ile ilişkili iken, en az öğretim programı bilgisi ile ilişkilidir. Fen öğretimi ve öğrenimi ile ilgili inanışları ise en çok öğretim yöntemleri bilgisi ile ilişki göstermektedir. Ölçme bilgisi fen öğretimi ve öğrenimi ile en az ilişki gösteren PAB bileşenidir. Özel olarak tasarlanmış mesleki gelişim programları öğretmenlerin inanışlarını açığa

çıkarmak için onların sınıf içi uygulamalarını direkt olarak etkileyen fen öğretimi yönelimlerine odaklanmalıdır. Ayrıca bu programlarda alternatif öğretim metotları ve ölçme teknikleri öğretmenlere tanıtılarak onların etkili bir şekilde öğretim yapabilmesi için daha bütünleşmiş bir PAB geliştirmeleri desteklenmelidir. Böylece öğretmenlerin reform tabanlı uygulamalara uyumu daha kolay bir şekilde sağlanabilir.

Anahtar Kelimeler: Pedagojik Alan Bilgisi, Fen Öğretimi Yönelimleri, Deneyimli Öğretmenler, Fen Öğretmen Eğitimi

To my Mum and Dad,
for their never ending love and support

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LIST OF ABBREVIATIONS

AAAS: American Association for the Advancement of Science

ERIC: Educational Research Information Center

HEE: Higher Education Examination

IRB: Institutional Review Board

KofA: Knowledge of Assessment

KofC: Knowledge of Curriculum

KofIS: Knowledge of Instructional Strategies

KofL: Knowledge of Learner

MANOVA: Multivariate Analysis of Variance

NEI: Network of Education and Informatics

NCF: National Curriculum Framework

NME: National Ministry of Education

NOS: Nature of Science

NRC: National Research Council

PCK: Pedagogical Content Knowledge

R: Researcher

S: Student

STO: Science Teaching Orientations

TA: Teaching Assistant

TBI: Teacher Beliefs Interview

UPE: Undergraduate Placement Examination

VNOS-C: Views of the Nature of Science Questionnaire Form C

CHAPTER 1

INTRODUCTION

In recent years, there is a shift from traditional teacher-centered to activity-based student-centered classes in which student learning is supported with activities depending on reform-based science teaching and learning practices. Reform-based practices are determined to be consistent with the nature of science inquiry and reflect the values of scientific knowledge (American Association for the Advancement of Science [AAAS], 1993). In order to meet the requirements of the reforms, teacher education programs aims to prepare science teachers who understand the importance of reform-based teaching and learning practices and ready to employ them in their classes (AAAS, 1993; National Research Council [NRC] 1996). Considering in-service teachers, there is a need to change their traditional views on teaching and learning in order to support them keep pace with these reforms (Friedrichsen, 2002).

In Turkey, reforms for high school physics, chemistry and biology curricula have been proceeding for a while. Chemistry curricula was started to be changed in 2013 and the gradual transition to the new curricula will be completed in 2017 (National Ministry of Education [NME], 2013). In order to help in-service teachers with this change, their beliefs about science teaching and learning should be considered as the use of reform-based practices is affected from what teachers believe (Fletcher & Luft, 2011; Friedrichsen, 2002; Jones & Carter, 2007). Therefore, beliefs of teachers become an important construct since it effects how they teach (Hashwesh, 1996; Pajares, 1992; Jones & Carter, 2007).

Behaviors and decisions of teachers and thus how they enact in their classrooms were highly influenced by their beliefs (Pajares, 1992). Their classroom management, understanding of the events in classroom or even instructional decisions such as planning and use of a teaching approach are affected from what they believe (Jones & Carter, 2007; Pajares, 1992). For instance; while teachers with traditional beliefs tend to employ teacher-centered instruction and do not allow active participation of students; teachers with constructivist beliefs are likely to employ student-centered instruction to help students construct their own understanding (Tsai, 2002). So that, it is essential to give importance to teachers' beliefs in order to be informed about their teaching practices.

Besides what teachers believe, what they know should be taken into consideration. It is obvious that a teacher should have adequate subject matter knowledge but it is not solely satisfactory to be a good teacher. To be capable of teaching subject matter is also as important as having adequate subject matter knowledge (Tamir, 1988). In other words, while subject matter knowledge is an essential component of teacher knowledge, teachers also need to know about how to teach the related subject matter (Shulman, 1986). Transformation of subject matter knowledge into subject matter knowledge for teaching is first proposed by Shulman (1986) and introduced as "pedagogical content knowledge" (PCK). PCK is one of the categories of knowledge base for teaching and defined as the "special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding" (Shulman, 1987, p. 8). According to Shulman (1986, 1987), pedagogical content knowledge is the way teachers use to represent and formulate the subject matter knowledge in order to improve students' learning. Therefore, PCK is a special kind of knowledge a teacher must have to teach a topic in an effective way and make it more understandable for students. Hence, it is a kind of teacher knowledge that distinguish a teacher from a content specialist (Shulman, 1987).

Using the PCK framework in research on teacher knowledge let researchers to gain information about the transformation of teachers' subject matter knowledge to subject matter knowledge for teaching. Therefore, it is a useful tool to capture the connection between students and teacher during the instructional practices (van Driel, Verloop, de Vos, 1998). What teachers know about students' knowledge, how they organize the topics and present them to the students and how they assess student learning are all related to pedagogical content knowledge of teachers. Therefore, it is a useful framework to understand the logic behind teachers' instructional decisions and classroom practice (Grossman, 1990).

Pedagogical content knowledge is the construct that is the combination of teachers' beliefs and knowledge (Magnusson, Krajcik & Borko, 1999). Magnusson et al. (1999) proposed five components of PCK which are science teaching orientations (STO), knowledge of learner (KofL), knowledge of curriculum (KofC), knowledge of instructional strategies (KofIS) and knowledge of assessment (KofA). While KofL is related to teachers' knowledge about students prior knowledge about a topic, their misconceptions and learning difficulties about that topic; KofC considers teachers' knowledge about the curricular goals and objectives and the organization of the topics stated in the curriculum. Moreover, while KofIS regards teachers' knowledge about the use of subject and topic specific instructional strategies; KofA considers teachers' knowledge on the use of assessment methods to assess student learning. Science teaching orientations "represents a general way of viewing or conceptualizing science teaching" (Magnusson et al., 1999, p. 97). It is seen as the overarching component influencing teacher practice by shaping other components of PCK (Magnusson et al., 1999; Friedrichsen, van Driel & Abell, 2011). What is more, among the five components of PCK, it is the one that is related to mostly beliefs of teachers.

Magnusson et al. (1999) proposed nine categories to define teachers' orientations however, this categorization have some issues according to Friedrichsen et al.

(2011). They criticized Magnusson et al.'s (1999) categorization of science teaching orientations claiming that orientations are complex belief systems and teachers might hold more than one orientation; therefore, assigning a teacher's orientation to one the nine categories or labeling it using only the dominant orientation of the teacher is not possible. Moreover, Friedrichsen et al. (2011) addressed science teaching orientations studies in the literature and put forward four issues related to them. The issues are using orientations in different and unclear ways, unclear and absent relationship between orientations and other model components, assigning science teachers to one the nine orientations, and ignoring the overarching orientation component. To clarify the definition of science teaching orientations Friedrichsen et al. (2011) proposed to examine this construct under three dimensions which are beliefs about the goals or purposes of science teaching, beliefs about science teaching and learning and beliefs about the nature of science.

Borko and Putnam (1996) suggested that "Experienced teachers' attempts to teach in new ways are highly influenced by what they already know and believe about teaching, learning and learners" (p. 684). Therefore, understanding what teachers believe is important to improve teaching and learning practices as what they believe can only be changed only if it is made explicit (Freeman, 1996). Considering that experienced teachers mostly focus on student learning different from beginning teachers who mostly rely on their subject matter knowledge and hold more general orientations, revealing what experienced teachers believe not only help us understand their teaching practices but also shed light on how teacher preparation should be (Lee & Luft, 2008; Kind, 2009). For this aim, PCK framework will be helpful for us, as it is including both the knowledge and beliefs that a teacher need to know in order to teach a subject matter in an understandable way to students (Shulman, 1986; Magnusson et al., 1999).

Science teaching orientations as the overarching component of PCK (Grossman, 1990) has a major role in determining the quality of PCK. Therefore, research on the interaction between science teaching orientations and the other components of PCK plays a significant role to determine the quality of teachers' PCK (Abell, 2008). These interactions will inform researchers about the quality of the whole PCK of teachers in which the components are dominated by teachers' STO. As identified by many researchers (Aydin & Boz, 2013; Aydin, Demirdogen, Akin, Uzuntiryaki-Kondakci & Tarkin, 2015; Park & Chen, 2012) having more interactions between the components is the criterion of a well-developed and complex hence more qualified PCK.

1.1. Significance of the Study

Beliefs are complex structures (Friedrichsen & Dana, 2005; Fletcher & Luft, 2011) and resistant to change (Kagan, 1992; Nespor, 1987). The complex and stable nature of beliefs may play like a filter that influence the instructional decisions of teachers (Luft & Roehrig, 2007). Science teaching orientations, the central component of PCK which is related to the beliefs of teachers, direct the way teachers teach (Kind, 2016). Therefore, identifying teachers' science teaching orientations and how it effects teachers' classroom practice is worth to detect to prepare highly-qualified teachers. For this purpose first of all the beliefs of the teachers should be made visible (Luft & Roehrig, 2007).

Depending on the claims of Magnusson et al. (1999) science teaching orientations can be seen as the overarching component of PCK. Even though science teaching orientations play such a major role among the components of PCK, in most of the PCK studies it is ignored and not empirically investigated (Friedrichsen et al., 2011). Abell (2008) stated "…PCK is more than the sum of these constituent parts" (p. 1407) and therefore, all components of PCK should be studied together to see the whole picture. However, while knowledge of learner and knowledge of instructional strategies components take the lead in those studies, science teaching orientations component is often neglected. Moreover, although it is defined as the central component of PCK which influence and is influenced by the other components, the relationship between science teaching orientations and the other components of PCK is either unclear or absent in the PCK literature (Abell, 2008; Friedrichsen et al., 2011).

PCK, especially science teaching orientations component of it, is an important indicator of teachers' classroom practice (Grossman, 1990; Gess-Newsome, 2015) and has an effect on how teachers enact in their classrooms (Kind, 2016). It means, instructional decisions of teachers like planning a lesson, choosing a teaching approach to teach the topic, determining the assessment method to assess student understanding and decisions about the class objectives which are actually related to the components of PCK are all affected from teachers science teaching orientations (Borko & Putnam, 1996). Therefore, knowing more about STO and PCK and the interactions between the components help researchers to find ways in developing more qualified teachers (Kind, 2016).

Magnusson et al. (1999) proposed nine categories to define science teaching orientations of teachers which are process, academic rigor, didactic, conceptual change, activity-driven, discovery, project-based science, inquiry and guided inquiry. However, orientations are complex belief structures that cannot be labeled under one of these categories and a teacher cannot hold just one distinct orientation (Friedrichsen et al., 2011). Considering the complex nature of teacher beliefs and messiness about the definition of science teaching orientations, this construct needed to be clarified. For this purpose, Friedrichsen et al. (2011) proposed three dimensions to define science teaching orientations which are beliefs about the goals or purposes of science teaching, beliefs about science teaching and learning and beliefs about the nature of science. This study will be one of the first empirical study examining experienced in-service teachers STO and its interaction between other components of PCK regarding the definition of Friedrichsen et al. (2011).

Science teaching orientations are mostly investigated for prospective teachers and empirical studies with secondary teachers are few. More studies conducted with in-service teachers are needed to clarify and understand more about their science teaching orientations (Abell, 2008; Friedrichsen & Dana, 2005; Friedrichsen et al., 2011). Studies investigating the interactions between in-service teachers' science teaching orientations and other components of PCK are needed as most of the interaction studies were conducted with prospective teachers, too (Friedrichsen et al., 2011). It is important to identify the PCK of in-service teachers to be informed about the training of prospective and beginning teachers (Kind, 2009; Abell, 2008; Henze, van driel, & Verloop, 2008; Schneidler & Plasman, 2011). Therefore, this study have some implications not only for in-service teacher training but also for pre-service teacher education programs and beginning teachers.

Another important thing about PCK research is that it should be studied in the context. Teachers' classroom should be chosen as the context of the PCK studies, especially to capture the complex interactions among the components of PCK (Baxter & Lederman, 1999; Friedrichsen & Dana, 2005; Gess-Newsome, 2015). Abell (2008) called for research in the classrooms of teachers to see what value classroom observations add to the PCK research.

In chemistry PCK is studied in some topics such as chemical reactions (e.g. van Driel, de Vos, Verloop, & Dekkers, 1998a), chemical equilibrium (e.g. Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu, 2008), particulate nature of matter (e.g. Canbazoğlu, Demirelli, & Kavak, 2010), acid-base chemistry (e.g. Drechsler & Van Driel, 2008), electrochemistry (e.g. Aydin, 2012;) radioactivity (e.g. Aydin, Friedrichsen, Boz, & Hanuscin, 2014). In this study mixtures was chosen as the chemistry topic to study.

Considering all of the above, this study aims to investigate in-service chemistry teachers all PCK components which are science teaching orientations, knowledge of learner, knowledge of curriculum, knowledge of instructional strategies and knowledge of assessment and then to examine the interactions between science teaching orientations and the other components of PCK in mixtures unit.

1.2. Research Questions

i) What knowledge do experienced in-service chemistry teachers have regarding their pedagogical content knowledge while teaching mixtures unit?

ii) How do the science teaching orientations of experienced in-service chemistry teachers interact with the other components of pedagogical content knowledge?

1.3. Sub-research Questions

i) What knowledge do experienced in-service chemistry teachers have regarding their pedagogical content knowledge while teaching mixtures unit?

a. What knowledge do experienced in-service chemistry teachers have regarding their science teaching orientations while teaching mixtures unit?
b. What knowledge do experienced in-service chemistry teachers have regarding their knowledge of learner while teaching mixtures unit?
c. What knowledge do experienced in-service chemistry teachers have regarding their knowledge of curriculum while teaching mixtures unit?
d. What knowledge do experienced in-service chemistry teachers have regarding their instructional strategies while teaching mixtures unit?
e. What knowledge do experienced in-service chemistry teachers have regarding their knowledge of assessment while teaching mixtures unit?

ii) How do the science teaching orientations of experienced in-service chemistry teachers interact with the other components of pedagogical content knowledge?

a. How do the science teaching orientations of experienced in-service chemistry teachers interact with their knowledge of learner?
b. How do the science teaching orientations of experienced in-service chemistry teachers interact with their knowledge of curriculum?
c. How do the science teaching orientations of experienced in-service chemistry teachers interact with their knowledge of instructional strategies?
d. How do the science teaching orientations of experienced in-service chemistry teachers interact with their knowledge of assessment?

1.4. Definitions of Important Terms

Pedagogical content knowledge is a "teacher's understanding of how to help students understand specific subject matter" (Magnusson et al., 1999, p. 96). According to Magnusson et al. (1999) PCK can be examined under five components which are (a) orientations toward science teaching, (b) knowledge and beliefs about science curriculum, (c) knowledge and beliefs about students' understanding of specific science topics, (d) knowledge and beliefs about assessment in science, and (e) knowledge and beliefs about instructional strategies for teaching science.

Science teaching orientations can be defined as interrelated sets of beliefs that have three dimensions which are beliefs about the goals or purposes of science teaching, beliefs about science teaching and learning, beliefs about the nature of science (Friedrichsen et al., 2011).

Knowledge of learner is the component of PCK refers to teacher knowledge about students including two categories which are the requirements for learning specific science concepts (i.e. students' prerequisite knowledge) and areas of science that students find difficult (i.e. students' difficulties and misconceptions about the topic) (Magnusson et al., 1999).

Knowledge of curriculum is another component of PCK that includes knowledge of goals and objectives, and specific curricular programs and materials stated in the curriculum (Magnusson et al., 1999).

Knowledge of instructional strategies is one of the other components of PCK includes subject and topic specific instructional strategies that a teacher must know to instruct a specific topic to the students (Magnusson et al., 1999).

Knowledge of assessment is the last component of PCK consisting of two categories knowledge of the dimensions of science learning that are important to assess, and knowledge of the methods by which that learning can be assessed.

Experienced teacher is defined by Lieberman and Mace (2009) as any teacher, who through years of practice has the knowledge and ability to reflect on their work and speak to the complexity of teaching in the world of educational reform. According to Berliner (2001) years of practice on teaching should be 5 or more years in order to develop expertise in teaching.

CHAPTER 2

LITERATURE REVIEW

Literature review related with the (a) history and the models of pedagogical content knowledge (PCK), (b) history of science teaching orientations (STO), (c) studies on STO and (d) studies on interactions between STO and other PCK components was presented throughout this chapter.

2.1. History and the Models of PCK

Lee Shulman was the first scholar that conceptualized PCK. In 1986, he examined teachers' content knowledge under three dimensions which were subject matter content knowledge, pedagogical content knowledge and curricular knowledge. For him, pedagogical content knowledge is a kind of content knowledge "which goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" (Shulman, 1986, p. 9). He included two constructs in PCK: "the ways of representing and formulating the subject that make it comprehensible to others" (p.9) and "understanding of what makes the learning of specific topics easy or difficult:" (p. 9). While the previous one was related to the teachers' knowledge of instructional strategies, the latter was related to the teachers' knowledge of learner.

In 1987, Shulman published his second paper related to the teacher knowledge. In this paper, PCK was one of the constructs of Shulman's design called *knowledge base for teaching.* Knowledge base, which defines types of knowledge a teacher should possess, consists of seven main constructs. These constructs are (a) content knowledge, (b) pedagogical content knowledge, (c) curriculum knowledge, (d) general pedagogy, (e) learners and their characteristics, (f) educational contexts, and (g) educational purposes (Shulman, 1987). Among these constructs Shulman gave a special importance to pedagogical content knowledge as it identifies different structure of knowledge for teaching. PCK "represents the blending of content and pedagogy into an understanding of how particular topics, problems, or issues are organized, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (p. 8). It is also the most likely construct of the knowledge base that distinguishes the understanding of a teacher from a subject matter specialist.

The concept of pedagogical content knowledge is developed over time after the suggestion of Shulman and researchers proposed different designs regarding PCK (Cochran, De Ruiter, & King, 1993; Grossman, 1990; Magnusson et al., 1999; Marks, 1990). In Figure 1, different conceptualizations regarding PCK was given utilizing from the table created by Park & Oliver (2008).

After Shulman's suggestion of PCK as one of the teacher knowledge, in 1988, Tamir proposed six types of teacher knowledge which are (a) general liberal education, (b) personal performance (c) subject matter, (d) general pedagogical, (e) subject matter specific pedagogical, and (f) foundations of the teaching profession. Subject matter specific pedagogical knowledge was actually used to define what Shulman called pedagogical content knowledge and it consisted of four dimensions: curriculum knowledge, knowledge of students, instruction (teaching and management) knowledge and evaluation knowledge. The difference of Tamir's PCK conceptualization from Shulman's was that he included knowledge of curriculum and knowledge of assessment in PCK as subcategories. Shulman defined knowledge of curriculum as a distinct knowledge base from PCK and did not mention about knowledge of assessment as one dimension of PCK. Figure 2 presented the framework suggested by Tamir about teacher knowledge.

Scholars	Knowledge of								
	Purposes for teaching a subject matter	Student understanding	Curriculum	Instructional strategies and representations	Media	Assessment	Subject matter	Context	Pedagogy
Shulman (1987)	D	O	D	O			D	D	D
Tamir (1988)		O	O	O		O	D		D
Grossman (1990)	O	O	O	O			D		
Marks (1990)		O		O	O		O		
Smith and Neale (1989)	O	O		O			D		
Cochran et al. (1993)		O		N			O	O	O
Geddis et al. (1993)		O	O	O					
Fernandez-Balboa and Stiehl (1995)	O	O		O			O	O	
Magnussonet al. (1999)	O	O	O	O		O			
Hasweh (2005)	O	O	O	O		O	O	O	O
Loughran et al. (2006)	O	O		O			O	O	O

D Author placed this subcategory outside of PCK as a distinct knowledge base for teaching; *N* author did not discuss this subcategory explicitly (Equivalent to blank but used for emphasis); *O* author included this subcategory as a component of PCK.

Figure 1. Components of pedagogical content knowledge from different conceptualizations (Park & Oliver, 2008, p. 265)

1. GENERAL LIBERAL EDUCATION
2. PERSONAL PERFORMANCE How do I look, speak, listen, move in class?
3. SUBJECT MATTER
    - 3.1 Knowledge: Major ideas and theories of a particular discipline
    - 3.2 Skills: How to use a microscope
4. GENERAL PEDAGOGICAL
    - 4.1 Student
        - 4.1.a Knowledge: Piaget's development levels
        - 4.1.b Skills: How to deal with hyperactive students
    - 4.2 Curriculum
        - 4.2.a Knowledge: The nature, structure, and rationale of Bloom's Taxonomy
        - 4.2.b Skills: How to prepare a learning unit
    - 4.3 Instruction (Teaching and management)
        - 4.3.a Knowledge: Different ways of assigning turns to students in class discussion
        - 4.3.b Skills: How to formulate a high level question
    - 4.4 Evaluation
        - 4.4.a Knowledge: Different types of tests
        - 4.4.b Skills: How to design a multiple choice item
5. SUBJECT MATTER SPECIFIC PEDAGOGICAL
    - 5.1 Student
        - 5.1.a Knowlege: Specific common conceptions and misconceptions in a given topic
        - 5.1.b Skills: How to diagnose a student conceptual difficulty in a given topic
    - 5.2 Curriculum
        - 5.2.a Knowledge: The pre–requisite concepts needed for understanding photosynthesis
        - 5.2.b Skills: How to design an inquiry oriented laboratory lesson
    - 5.3 Instruction (Teaching and management)
        - 5.3.a Knowledge: A laboratory lesson consists of three phases: pre–lab discussion, performance, and post–laboratory discussion.
        - 5.3.b Skills: How to teach students to use a microscope
    - 5.4 Evaluation
        - 5.4.a Knowledge: The nature and composition of the Practical Tests Assessment Inventory
        - 5.4.b Skills: How to evaluate manipulation laboratory skills
6. FOUNDATIONS OF THE TEACHING PROFESSION

Figure 2. Tamir's framework for teacher knowledge (1988, p. 100)

Two years after Tamir, in 1990, a PhD student of Shulman, Pamela Grossman introduced a model of teacher knowledge where PCK is at the heart of the other three components which are subject matter, general pedagogical knowledge and contextual knowledge. These three constructs are not only influenced by PCK but they also influence it. She identified four components of PCK which are conceptions about conceptions of purposes for teaching a subject matter, knowledge of students' understanding, curricular knowledge, and knowledge of instructional strategies. Among these components she labeled the first component as the overarching component which influences the other components of PCK. In Figure 3 Grossman's model of teacher knowledge can be seen.

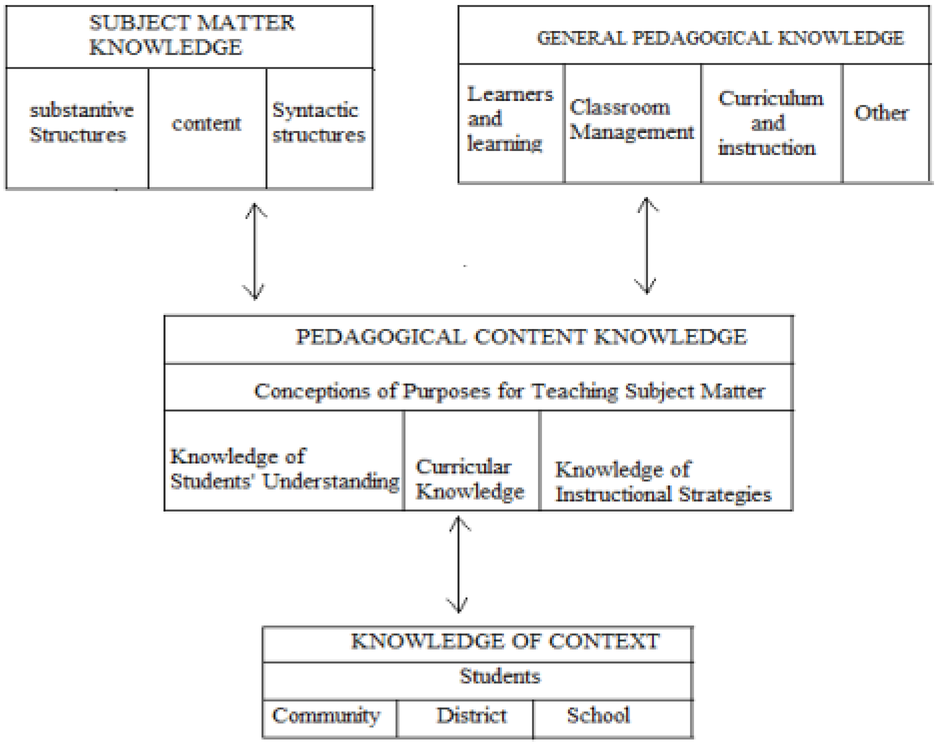

Figure 3. Grossman's model of teacher knowledge (1990, p. 5)

Considering the existing conceptualizations of PCK, in 1990, Marks aimed to represent PCK in mathematics and suggested revisions to general PCK depending on the results of the empirical study with elementary mathematics teachers. He conducted the study with 8 teachers through task-based interviews in the fifth grade fractions unit. As the tasks, participants were asked to plan an instruction, criticize on a videotaped instruction and then eliminate students' misconceptions throughout the interviews. As a result of the analysis of the data Marks proposed the following structure of PCK given in Figure 4. In this model, PCK was the combination of the four structures which were subject matter for instructional purposes, students' understanding of the subject matter, media for instruction in the subject matter and instructional processes for the subject matter.

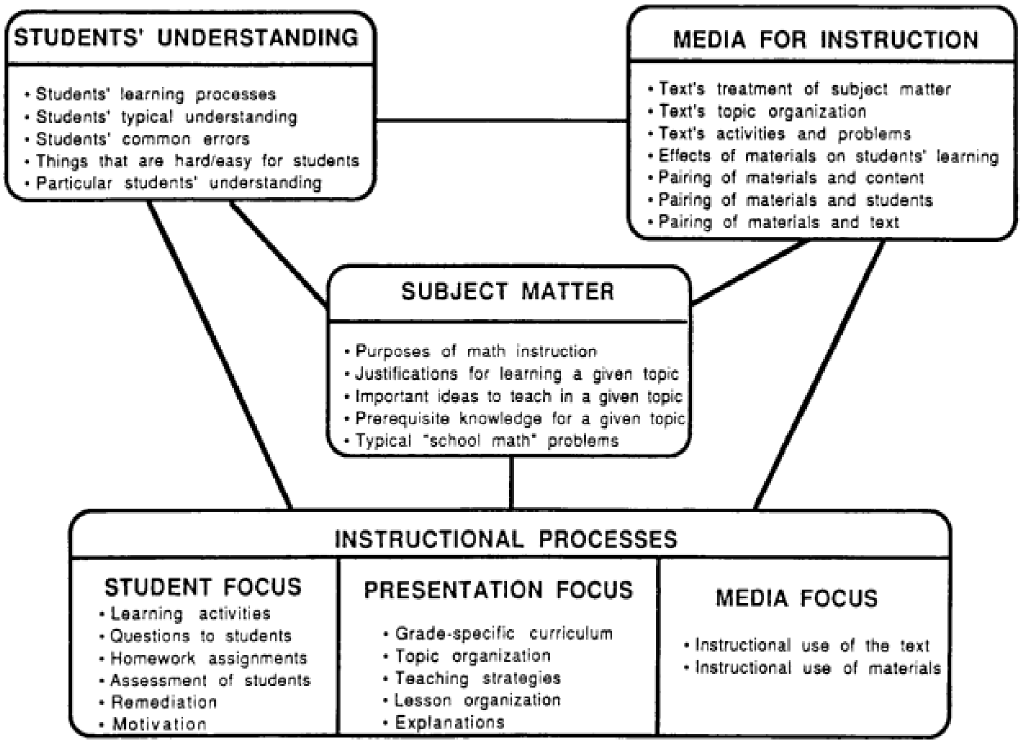

Figure 4. Mark's structure for pedagogical content knowledge (1990, p.5)

Different from the studies conducted with teachers, Fernandez-Balboa and Stiehl (1995) studied with 10 university professors to examine their generic PCK. They used phenomenological interviews to collect data and analyzed the data considering the PCK components proposed by Grossman (1990). However, the results showed differences from Grossman's PCK components. Fernandez-Balboa and Stiehl suggested five components of PCK which are knowledge about the subject matter, the students, the instructional strategies, the teaching context, and one's teaching purposes. Different from Grossman, Fernandez-Balboa and Stiehl excluded curricular knowledge from PCK and included knowledge about the subject matter to PCK as a component.

Research in science education widely used the PCK model of Magnusson et al. (1999). Magnusson et al.'s (1999) model of teacher knowledge, shown in Figure 5, is a modified version of Grossman's model. In this model pedagogical content knowledge was illustrated in the middle of three knowledge domains which are subject matter knowledge, pedagogical knowledge and knowledge of context. These knowledge domains influence and is influenced by PCK.

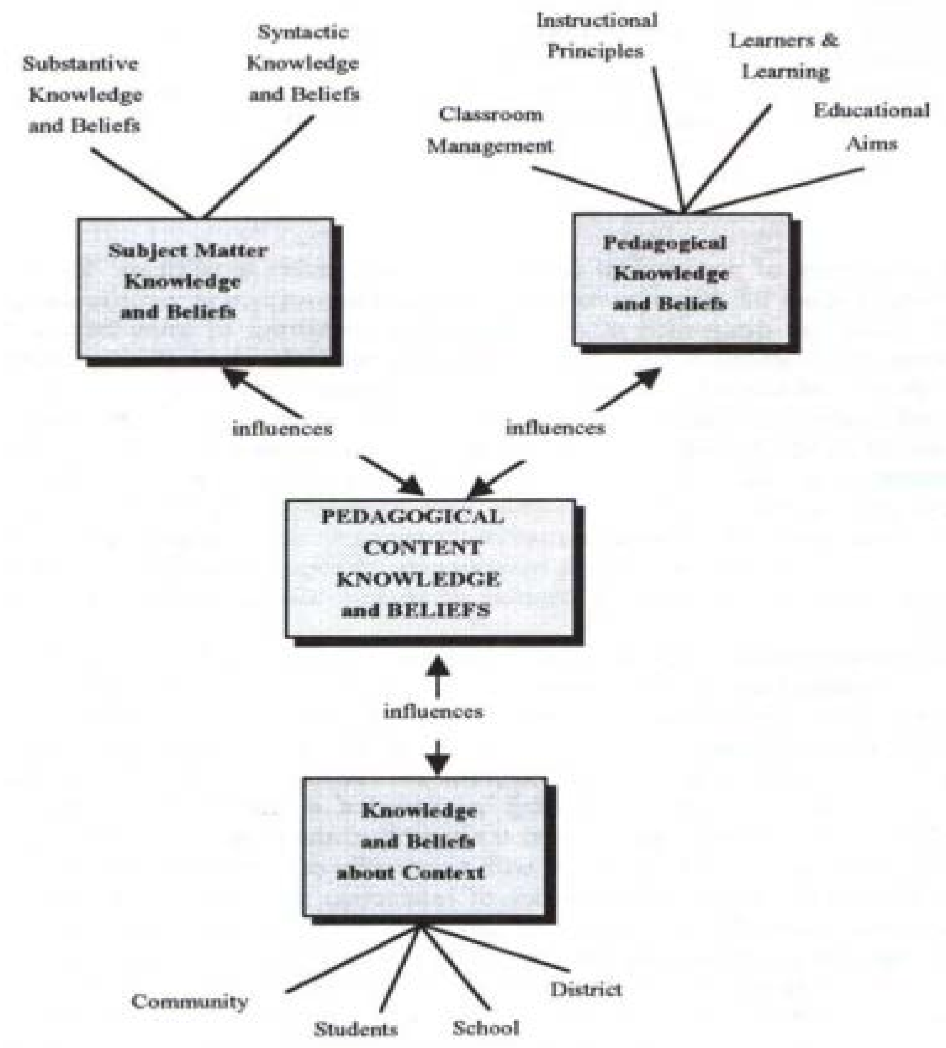

Figure 5. A model of the relationships among the domains of teacher knowledge (Magnusson et al., 1999, p. 98)

Magnusson et al. (1999) claimed that PCK consists of five components which are orientations toward science teaching, knowledge of the curriculum, knowledge of science assessment, knowledge of science learners and knowledge of instructional strategies. Orientations toward science teaching was defined as “teachers’ knowledge and beliefs about the purposes and goals for teaching science at a particular grade level” (p. 97). In knowledge of curriculum, making connections between lessons and units, organizing lessons in specific order, making decisions about what to teach and what not to teach is important. In knowledge of science assessment, a teacher should use formal and informal ways of assessment, develop skills for students' discussion and questioning and give immediate feedback to the students. A teacher should also give importance to the students' level, their prior knowledge, interests, learning difficulties and misconceptions before designing the instruction regarding knowledge of student understanding. The instructional strategy and the teaching methods used during the instruction is also important. A teacher should know to use different teaching methods, motivating activities and s/he should have the ability to select them considering the knowledge of instructional strategies. Figure 6 shows the components of PCK for science teaching proposed by Magnusson et al. (1999).

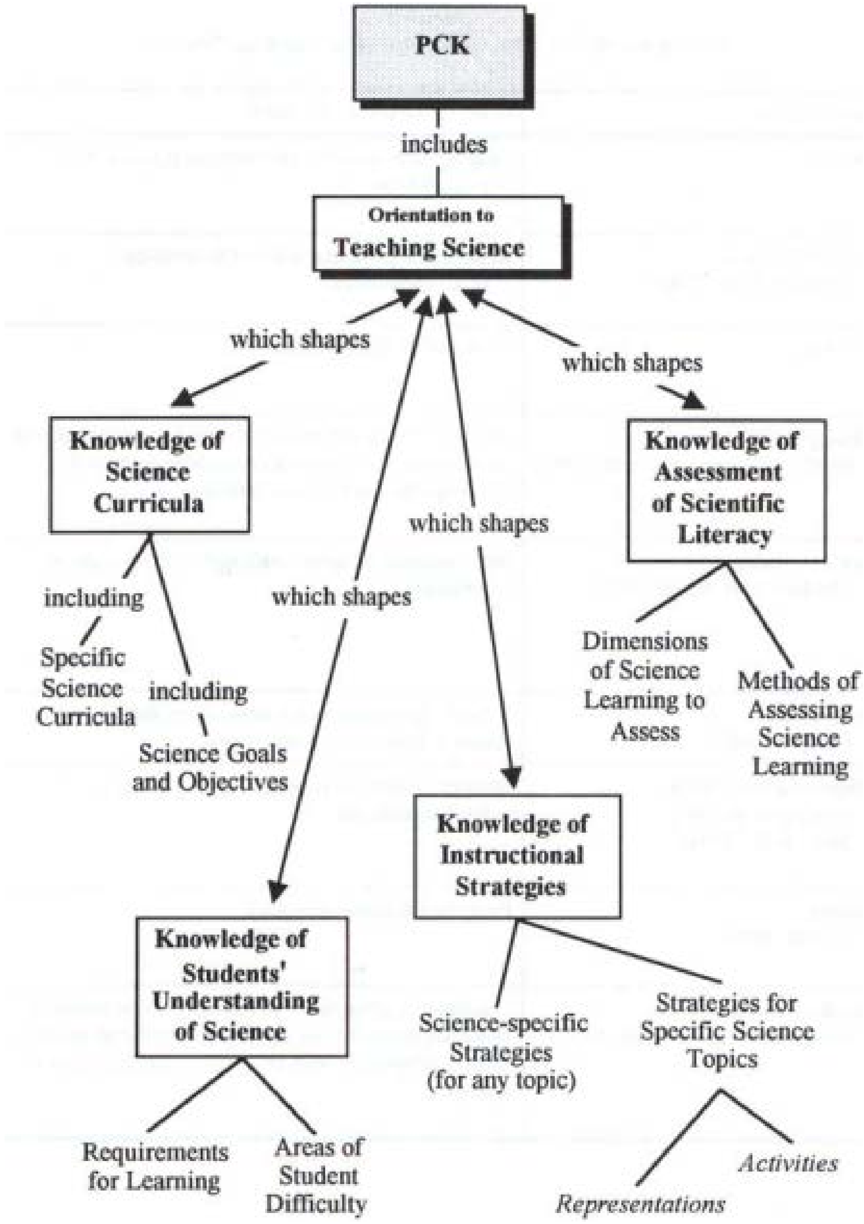

Figure 6. Components of pedagogical content knowledge for science teaching proposed by Magnusson et al. (1999, p. 23)

Years after Magnusson et al. (1999), in 2008, Park and Oliver suggested a new model called hexagonal model depending on the pentagonal PCK model of Magnusson et al. (See Figure 7) The main difference between these two models is that Park and Oliver (2008) added teacher efficacy as a component to the model. As a result of their research conducted with three experienced teachers working in the same high school, they concluded that efficacy of teachers affect the use of their PCK in the classroom. They observed the teachers during the teaching of three units and used non-participant observations, semi-structured interviews, field notes and many more written documents provided from the teachers like reflections, lesson plans, and students' work samples to collect data. The results of the study indicated that reflection-in-action and reflection-on-action had an effect on the development of teachers' PCK. Also, they emphasized that PCK was idiosyncratic and teacher efficacy had an effect on PCK. Moreover, the results showed that students and their misconceptions had a significant role in shaping teachers' PCK.

The study of Park and Oliver (2008) revealed two important terms understanding and enactment, the dimensions of PCK that are connected to each other with teachers' efficacy. When teachers enact their understanding, their efficacy increase, when their efficacy increase they encouraged to learn more and their understanding developed. Another important feature of this study was that reflection-on-action and reflection-in-action were added to the PCK. Reflection-in-action refers to teachers' response to an unexpected situation during teaching, and reflection-on-action refers to teachers decisions after the teaching. Knowledge developed as a result of reflection-in-action is dynamic, however, knowledge developed as a result of reflection-on-action is static.

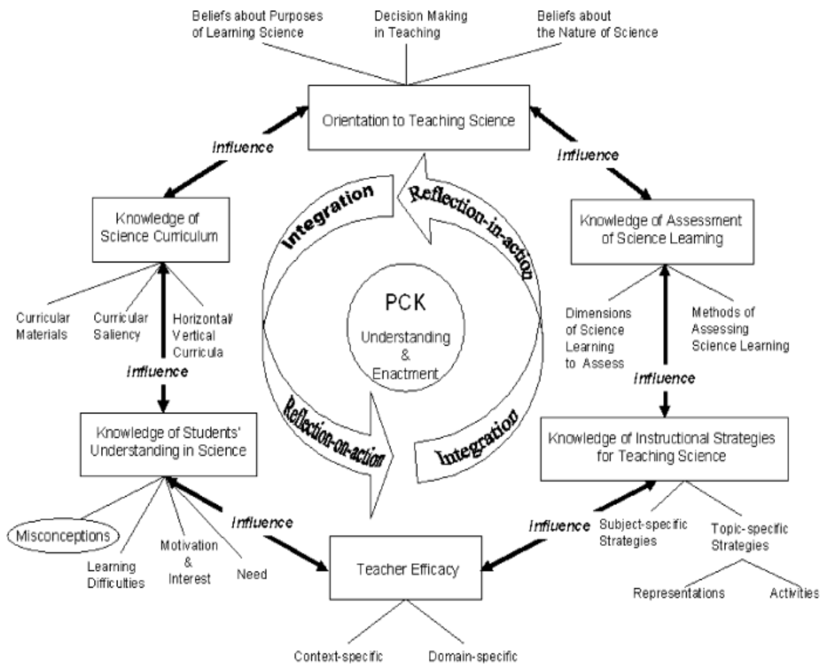

Figure 7. Hexagon model of pedagogical content knowledge for science teaching developed by Park and Oliver (2008)

Since it was first revealed by Shulman, researchers have proposed different models of PCK and used various conceptualizations in their studies. To re-examine the construct of PCK, 22 PCK researchers came together in a PCK Summit in 2012. As a result of the discussions on teacher knowledge and PCK models a new model for teacher professional knowledge and skills (TPK&S) in which PCK is included was formed by the researchers. Figure 8 shows the new teacher professional knowledge model generated in the PCK Summit.

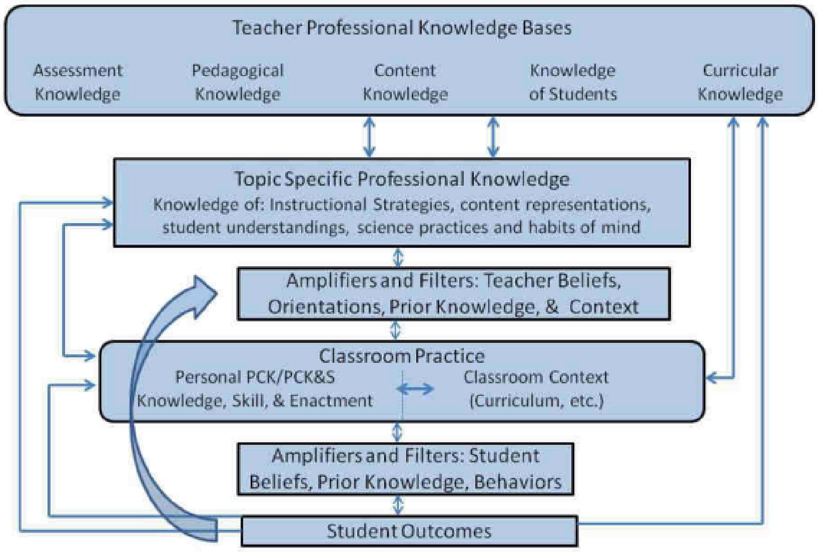

Figure 8. Model of teacher professional knowledge and skill including PCK and influences on classroom practice and student outcomes (Gess-Newsome, 2015, p. 31)

According to this model, teacher professional knowledge bases (TPKB), which are assessment knowledge, pedagogical knowledge, content knowledge, knowledge of students and curricular knowledge, informed and is informed by topic specific professional knowledge (TSPK). Teacher beliefs and orientations play a role as an amplifier or a filter on teachers' topic-specific professional knowledge and classroom practice. Moreover, in this model classrooms was emphasized as the context in which PCK should be studied. Another important point was that student outcomes were made explicit in this model. Those classroom practices and student outcomes informed TPKB and TSPK and thus had an effect on teachers' PCK.

2.2. History of the science teaching orientations as a component of PCK

Throughout the PCK history, scholars used different terms to refer to science teaching orientations. If I start from the beginning, Shulman's original model of PCK did not include science teaching orientations as a component. Grossman

(1990), proposed a component of PCK named *conceptions of purposes for teaching subject matter* for the first time. She placed this component at the top of the other three components of PCK as she believed it was the overarching component of PCK (see Figure 3). She described that conceptions of purposes for teaching subject matter "includes knowledge and beliefs about the purposes for teaching a subject at different grade levels. These overarching conceptions of teaching a subject are reflected in teachers' goals for teaching particular subject matter" (Grossman, 1990, p. 8).

According to Magnusson et al. (1999) "An orientation represents a general way of viewing or conceptualizing science teaching" (p. 97) and orientations of teachers direct many of their instructional decisions. For instance; a particular strategy can be used by different teachers holding different orientations. What is important for Magnusson et al.'s view is that the teachers' science teaching orientations is determined by the purpose of using a particular teaching strategy instead the use of it. To clarify, Magnusson et al. (1999) gave an example to teaching of parallel and serial circuits by three teachers who had different orientations which are discovery, conceptual change and guided inquiry. Although teachers teach the same subject their planning and enactment of the subject was different. While teacher with discovery orientation led students to discover the concepts by following their own questions using the materials given, teacher with conceptual change may begin with a talk with students to have them become aware of their ideas, the other students' ideas or the misconceptions they held. In contrast with these two orientations, a teacher with guided inquiry orientation may assign tasks to the students to find a problem related to the subject and then design a model to solve that problem.

Magnusson et al. (1999) defined orientations toward science teaching under nine categories which are activity-driven, didactic, discovery, conceptual change, process, academic rigor, inquiry, project-based science and guided-inquiry. While the first four orientations was the same with the orientations proposed by

Anderson and Smith (1987) the rest of them was originated from different sources in the literature (e.g. guided inquiry originated from Magnusson & Palinesar, 1995).

In their chapter, Anderson and Smith (1987) described the strategies for effective teaching and concluded that in order to use these strategies in a successful way teachers must have proper orientations to teaching and learning, good subject matter knowledge and information about the students they are teaching. They defined teachers' orientations toward science teaching and learning as "general patterns of thought and behavior related to science teaching and learning" (p. 99). Regarding teachers' orientations to science teaching and learning they described four general patterns which are activity-driven teaching, didactic teaching, discovery teaching and conceptual change teaching.

Activity-driven teaching was seen mostly on elementary school teachers who are uncomfortable teaching science. These teachers depend on the instructions stated in the textbooks and rely on activities fulfilled in the classroom like demonstrations, answering questions…etc. They actually are not sure about how student learning occurs because they do not know the rationale behind the classroom activities on student understanding they carried out.

In didactic teaching teachers accept their role as presenting the information and they expect their students to study and learn the content. They do not consider students' thinking and any misconceptions students might have. According to Anderson and Smith (1987) didactic orientation is the most common orientation among the teachers at all levels.

In discovery teaching, teachers let their students to draw their own conclusions as a result of an experiment instead of giving the answers to them, assuming that students learn the scientific explanations. However, students might draw their conclusions depending on their misconceptions and learning from an experiment would be more procedural than being conceptual as students experience science process skills like observation or measurement…etc.

The last orientation to science teaching and learning proposed by Anderson and Smith (1987) was conceptual change teaching. In conceptual change teaching, first of all teachers should be careful about understanding what their students think. Depending on three type of knowledge which are knowledge of content, knowledge of student and knowledge of instructional strategies, teachers can implement conceptual change teaching.

In Table 1, the goals of teaching science and the nature of instruction associated with each of the nine orientation is given depending on Magnusson et al. (1999).

Magnusson et al.'s categorization of science teaching orientations was used in many studies (Volkmann, Abell, & Zgagacz, 2005; Park & Oliver, 2008; Aydin et al., 2015) however, Friedrichsen et al. (2011) examined the categorization of Magnusson et al. and criticized this categorization claiming that assigning a teacher to one of the nine orientations which is more dominant is problematic. In their position paper, Friedrichsen et al. also examined the other studies related to science teaching orientations and suggested three more issues related to the use of science teaching orientations in the literature. The first issue is that researchers use orientations in different and unclear ways in their studies. As there is not a unique definition of science teaching orientations researchers used different definitions in their studies. The second issue is that there is unclear or absent relationship between orientations and the other model components. Researchers either not investigated the relation between the orientations and the other components even though orientations were described as shaping the other components of PCK (Magnusson et al., 1999) or they did not give detailed explanation about how orientations shape them.

Table 1. Goals of teaching science and the nature of instruction associated with orientations (Magnusson et al., 1999, p. 100)

Orientation	**Goal of Teaching Science**	**Characteristics of Instruction**
Process	Help students develop the "science process skills." (e.g., SAPA)	Teacher introduces students to the thinking processes employed by scientists to acquire new knowledge. Students engage in activities to develop thinking process and integrated thinking skills.
Academic Rigor	Represent a particular body of knowledge (e.g., chemistry).	Students are challenged with difficult problems and activities. Laboratory work and demonstrations are used to verify science concepts by demonstrating the relationship between particular concepts and phenomena.
Didactic	Transmit the facts of science.	The teacher presents information, generally through lecture or discussion, and questions directed to students are to hold them accountable for knowing the facts produced by science.
Conceptual Change	Facilitate the development of scientific knowledge by confronting students with contexts to explain that challenge their naive conceptions.	Students are pressed for their views about the world and consider the adequacy of alternative explanations. The teacher facilitates discussion and debate necessary to establish valid knowledge claims.
Activity-driven	Have students be active with materials; "hands-on" experiences.	Students participate in "hands-on" activities used for verification or discovery. The chosen activities may not be conceptually coherent if teachers do not understand the purpose of particular activities and as a consequence omit or inappropriately modify critical aspects of them.
Discovery	Provide opportunities for students on their own to discover targeted science concepts	*Student-centered.* Students explore the natural world following their own interests and discover patterns of how the world works during their explorations.
Project-based Science	Involve students in investigating solutions to authentic problems.	*Project-centered.* Teacher and student activity centers around a "driving" question that organizes concepts and principles and drives activities within a topic of study. Through investigation, students develop a series of artifacts (products) that reflect their emerging understandings.
Inquiry	Represent science as inquiry	*Investigation-centered.* The teacher supports students in defining and investigating problems, drawing conclusions, and assessing the validity of knowledge from their conclusions.
Guided Inquiry	Constitute a community of learners whose members share responsibility for understanding the physical world, particularly with respect to using the tools of science.	*Learning community-centered.* The teacher and students participate in defining and investigating problems, determining patterns, inventing and testing explanations, and evaluating the utility and validity of their data and the adequacy of their conclusions. The teacher scaffolds students' efforts to use the material arid intellectual tools of science, toward their independent use of them.

The last issue is ignoring orientation component even if it is labeled as the overarching component (Grossman, 1990). In PCK research studying the other components of PCK, especially knowledge of learner and knowledge of instructional strategies is more common than the other. Of the five component, science teaching orientations is not drawn much attention from the researchers. Considering these issues to clarify the science teaching orientations construct Friedrichsen et al. (2011) define science teaching orientations as interrelated sets of beliefs combined from beliefs about the goals or purposes of science teaching, beliefs about science teaching and learning and beliefs about the nature of science. In this study Friedrichsen's conceptualization of science teaching orientations was used.

2.3. Research on science teaching orientations

There are limited number of studies on science teaching orientations of in-service teachers within the PCK framework. Therefore, in this section studies about science teaching orientations of both in-service and pre-service teachers were given. Also Hewson and Hewson (1989) developed an interview task to identify what they called teachers' conceptions of teaching science. They define conceptions of teaching science as:

> …it is the set of ideas, understandings, and interpretations of experience concerning the teacher and teaching, the nature and content of science and the learners and learning which the teacher uses in making decisions about teaching, both in planning and execution (p. 194).

They conducted their study with pre-service teachers and gave scenarios to the participants and wanted them to interpret whether science teaching is occurring there or not. For instance, one of the scenarios is "A student at home following a recipe for blueberry muffins" (p. 198). They interviewed with the participants using the interview protocol and analyzed data considering six categories which are nature of science, learning and learner characteristics, rationale for instruction, preferred instructional techniques and conception of teaching science. The latter, conceptions of teaching science includes not only one's conceptions of teaching science but also its relation with the previous five categories. Hewson and Hewson (1989) claimed that as the categories are so much dependent to each other, the last category, conceptions of teaching science, is used to define those relations.

Depending on the study of Hewson and Hewson (1989), Friedrichsen and Dana (2003) also used card sorting activity to elicit and clarify science teaching orientations which were seen to have tacit nature (Shulman, 1988). They prepared scenarios depending on the nine orientations of Magnusson et al., and other components of PCK and applied the activity to the prospective teachers in pairs. They wanted them to read the scenarios and choose the ones that the most and the least represents them. Interviews were conducted to support the activity. Card sorting activity lead prospective teachers to become aware of their goals about science teaching hence it helped to elicit the STO of prospective teachers. The card sorting activity used by Friedrichsen and Dana (2003) was different than Hewson and Hewson's (1989) use of card sorting activity as Hewson and Hewson did not label the orientations of teachers.

In 2003, Bryan studied belief systems of a prospective science teacher about science teaching and learning. This study appeared not to be related to science teaching orientations; however, belief sets including science teaching and learning, and the nature of science was examined in the study. Therefore, it was included in this section as a study related to science teaching orientations. In the study, Bryan (2003) observed pre-service teacher, Barbara, for two semesters during the time she was enrolled to science methods course and her teaching experience. The researcher videotaped Barbara's teaching and then interviewed her related to her teaching. During the interviews Barbara had chance to review the video episodes and give examples from them. Analysis of the data showed that Barbara had foundational and dualistic beliefs. While foundational beliefs were defined as beliefs that are more central than the others, dualistic beliefs were defined as sets of beliefs composed of two different belief sets in which one belief set is supported by the other one. Bryan called these sets of beliefs “nests”. In three areas; beliefs about the value of science and science teaching, the nature of science and science instruction, and control in science classroom, Barbara had foundational beliefs. In beliefs about how children learn science, teacher and student roles in science classroom, she had dualistic beliefs.

In another study, Friedrichsen and Dana (2005) examined highly regarded secondary biology teachers nature and probable sources of science teaching orientations. Due to the lack of empirical studies on science teaching orientations they intended to proposed substantive level theory of science teacher orientations. (See Figure 9) They studied with four highly regarded biology teachers and observed their instruction to collect data. Besides observations, they used interviews with teachers and card sorting activity to elicit participant STO.

In their paper, Friedrichsen and Dana (2005) argued that teachers’ did not hold one single orientation specific to science but held two or three orientations which are more complex than it is suggested by Magnusson et al. (1999). Therefore, assigning teachers to one orientation may not reflect the actual orientation of the teachers. As a solution, they preferred to use central and peripheral goals to describe teachers’ orientation, in which central goals refers to the dominant orientation, peripheral goals refers to the goals that has less influence on teacher instructional practices. These complex STO’s includes affective domain goals (e.g. developing positive attitude towards science), general schooling goals (e.g. preparation for college), and subject matter goals. Of the three subject matter goals were not always presented as central goals but sometimes peripheral.

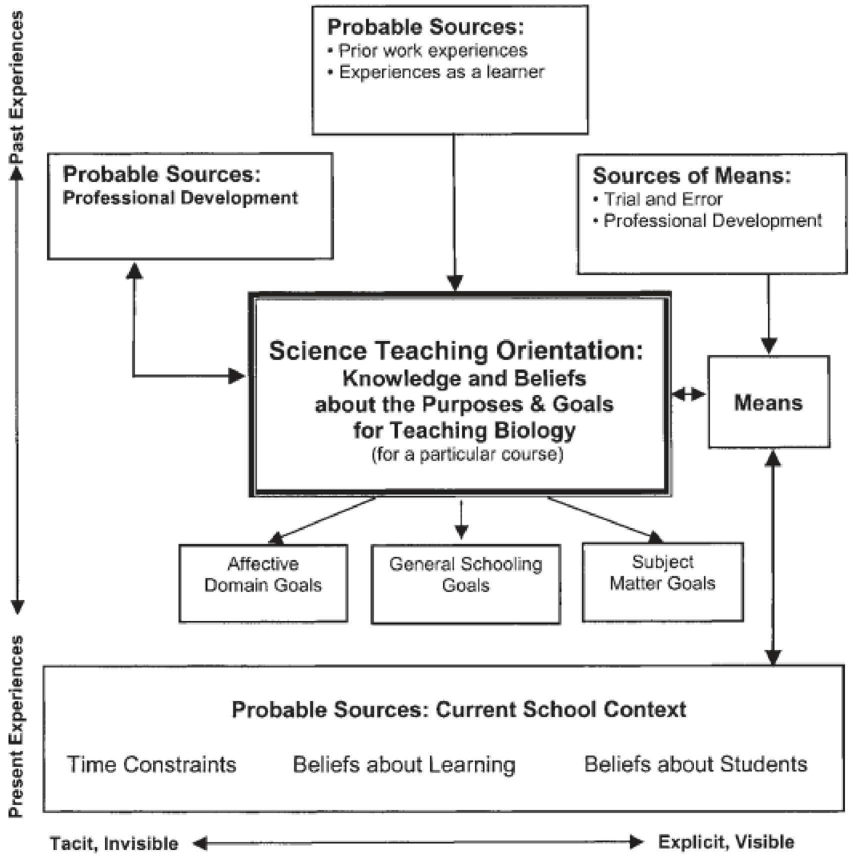

Figure 9. Substantive-level theory of science teaching orientations

In the study of Friedrichsen and Dana (2005), probable sources of teachers' science teaching orientations were presented. The first source is teachers work experiences before starting to teach and the second one is that professional development activities they attended. For instance, a teacher, Martha, worked as a lab technician before teaching. She gave importance to lab activities, lab reports and lab notebooks in her instruction and for professional development she attended to workshop related to new lab protocols.

Another factor affect teachers' means was their current school context. Researchers defined means as "the teacher's purposefully selected and visible use of curricula, as well as instructional and assessment strategies, for supporting students in achieving the purposes and goals of the biology course" (Friedrichsen & Dana, 2005, p. 225). Students' feedback, beliefs about learning and time constraints were put forward as factors that have influence on teachers' means. Teachers' believed that students' feedback has an influence on their instructional decisions, for instance, a teacher, Sharon, believed that students were bored in school, so she used teaching strategies that actively engage students to the lesson. Another factor was teachers' beliefs about learning. A teacher, Mike, believed when students are curious, learning opportunities can be used more effectively, so that he used interesting stories to teach the subject matter. The last factor is time constraints. Even though the teachers were experienced teachers, they saw class time something frustrating to achieve their goals.

In their self-study, Volkmann et al. (2005) investigated how a professor, a teaching assistant (TA) and students experience inquiry based science instruction in an undergraduate physics course during the teaching of electricity unit for 6 weeks. They focused on the science teaching orientations and did not consider the other components of PCK. Results of the study indicated that both the professor and the teaching assistant experienced some conflicts in terms of science learning goals, beliefs about science teaching and learning and beliefs about assessment. These conflicts were analyzed from the professor's, the TA's and students' perspective regarding three of the science teaching orientations the participants hold which are didactic, discovery, and guided inquiry orientations. While the professor held all this three orientations together, the TA had more didactic orientation and the students had discovery orientation. From the results of this study it can be concluded that a person can hold more than one orientation and orientations can manifest as interrelated sets of beliefs.

As mentioned in the previous section, Anderson and Smith (1987) defined science teaching orientations as ‘‘general patterns of thought and behavior related to science teaching and learning" (p.99). Nargund-Joshi, Park Rogers and Akerson (2011) used this orientation definition in their study in which they aimed to elicit Indian teachers' orientations toward science teaching and learning and explore whether their orientations are consistent with their practice or not. They also aimed to find out whether their orientations and practice corresponded with the goals of reform in India's National Curriculum Framework (NCF) introduced in 2005. They studied with two Indian secondary teachers by collecting data from observations, field notes of observations, interviews with teachers and artifacts developed either by the teachers or the students. Analysis of the data was summarized under four components that are orientations regarding the discipline of science, the teaching of science, assessing science learning, and the influence of external factors. Both teachers thought that science is objective and it is learnt to learn the truth. Also they believed that science is best learnt by doing activities. Their aim to assess students was to prepare them to the board exams, because they wanted their students to do well in those exams as those exams played an important role in the educational system of India. Researchers concluded that teachers' orientations were aligned with the goals of reform stated in NCF, however, what teachers practice in the classes did not correspond with their orientations thereby the goals of the curriculum.

Avraamidou (2012) used the conceptualization of Friedrichsen et al. (2011) in her study to identify prospective elementary teachers' science teaching orientations. However, she did not focus on pre-service teachers' beliefs about the nature of science but only examined their beliefs about the goals or purposes of science teaching and beliefs about science teaching and learning. She aimed to elicit prospective teachers' STO and the experiences that lead to development in their STO. The design of the study was narrative approach and to characterize participants' prior experiences with science, their drawings of the best science experiences and oral narratives were collected. The other sources of the data were written documents like reflective tasks, lesson plans, personal statements, researcher's observation of the participants' engagement in the methods course and semi-structured interviews. Results of the study showed that participants had similar purposes of science teaching like understanding how the world works.

Also participants did not have any enthusiasm until they were enrolled to university however, their orientations greatly developed by the help of the specially designed university courses. Female participants were highly effected from female instructors and saw them as role models, and this situation developed their science teaching orientations.

Similar to Avraamidou’s study, Campbell, Longhurst, Duffy, Wolf, Shelton (2013) also used the refined definition of Friedrichsen et al. (2011) to identify orientations of science teachers and their use of technology enhanced tools. Participants of the study were 10 science teachers teaching at eighth grade and they were participants of a professional development project focused on technology enhanced science instruction; however, data of the study were collected before the professional development project started. To analyze the beliefs about the goals or purposes of science teaching, they utilized from “knowledge of” and “knowledge for” described by Roberts (2007) and Luft and Roehrig’s (2007) categorization to analyze beliefs about science teaching and learning. The most difficult part to understand was the beliefs about the nature of science which was examined regarding the epistemology and ontology because not much data were provided from the teachers. Results of the study showed that two types of teacher orientations revealed: more traditional and toward a reform based teacher orientation profile. Regarding beliefs about the goals or purposes of science teaching both teacher orientation profiles have “knowledge of” beliefs. While traditional teacher orientation profile showed more teacher centered beliefs about science teaching and learning, toward a reform based profile showed student centered beliefs. For the last component of STO, beliefs about the nature of science, none of the orientations profile showed complex beliefs.

Boesdorfer and Lorsbach (2014) also used Friedrichsen et al.’s (2011) definition of science teaching orientations; however, similar to Avraamidou (2013) they did not include beliefs about the nature of science in their study due to not collecting data about beliefs about the nature of science. In this study, researchers’ purpose was to identify how science teaching orientations of a teacher were reflected or not reflected in her teaching practice. Study was conducted with an experienced chemistry teacher, Carla. They collected data in the unit of periodic table by observing the teaching of the teacher, interviewing with her and collecting the written materials like lesson plans and other teaching materials like worksheets used by the teacher. Also detailed field notes were taken by the researcher. They analyzed the data regarding beliefs about the goals or purposes of science teaching, beliefs about science teaching and learning and teachers' teaching practice. The most salient results of the study indicated that Carla had goals addressing to students lower-order thinking skills like solving problems, applying knowledge or do not memorizing the subject matter. She defined her role as a teacher planner and facilitator. She believed that learning is a social process and prior knowledge and experience is important in students' learning. Carla's beliefs about the goals or purposes of science teaching were not well developed and overlapped with national standards. However, regarding her about the goals or purposes of science teaching and beliefs about science teaching and learning, what she stated in the interviews and performed in the classes overlapped well. To sum up, Carla's science teaching orientations corresponded with her teaching practice.

In another study, Boesdorfer (2015) analyzed her dissertation data from a different perspective. In this study her purpose was to elicit the relationship between science teaching orientations and teachers' use of representations in their classes. She used the data collected from two in-service teachers by observations, interviews and written documents in the unit of electronic structure and periodic table which was an abstract topic for students. Results of the study showed that two teachers held different science teaching orientations and their use of representations were different, too. Moreover, their orientations were compatible with their use of representations which indicated that teachers' orientations directed their use of representations in their classes. For instance, one of the teachers, Louise, saw herself as coach which meant "demonstrating for students” to her, regularly solved problems in the classes and while doing this she did not give chance to the students much and solve the problems on the board by herself, which meant she was “demonstrating for students.”

Different from the above mentioned studies, science teaching orientations of teachers were examined by Faikhamta (2013) and Demirdöğen and Uzuntiryaki-Kondakçı (2016) in the context of PCK-based NOS instruction. In his study Faikhamta (2013) studied with 25 in-service teachers who are also Master of Education students in Science Education department. Participants enrolled to PCK-based NOS instruction aimed to enhance science teachers’ understandings of NOS and its teaching. Data were collected through pre- and post-questionnaires, weekly electronic journal entries of participants, course assignments, and field notes. Results of the study indicated that while at the beginning of the study participants had naive ideas on NOS and their goals for NOS instruction aligned with project-based science and science process skills. At the end of the course, in-service science teachers enhanced their understanding of NOS and orientations to teaching NOS.

Different from Faikhamta (2013), Demirdöğen and Uzuntiryaki-Kondakçı (2016) studied with 30 pre-service chemistry teachers in the context of a course designed to develop their PCK for NOS. Their aim was to investigate the change in pre-service chemistry teachers’ science teaching orientations during intervention designed to develop their PCK for NOS. The NOS instruction was designed to address the aspects of NOS to make the NOS explicit for participant. PCK for NOS instruction was designed to address components of PCK by using activities regarding NOS aspects. Researchers analyzed data and examined the results under four headings which were the change in NOS understandings and science teaching orientations, translation of change in orientation into instructional planning and other PCK components. Results indicated that at the end of the course most of the pre-service teachers’ beliefs about the NOS changed into informed ideas from naive or transitional ideas. Moreover, their science teaching orientations changed into more reform-based orientations. Pre-service teachers began to use at least one NOS aspect in their lesson plans as an objective. When the interactions between science teaching orientations and the other PCK components was taken into consideration, results of the study showed that pre-service teachers' reform-based orientations corresponded with their with knowledge of instructional strategy and assessment more than their knowledge of student understanding.

In her recent paper, Kind (2016) studied on the two components of science teaching orientations proposed by Friedrichsen et al. (2011) that are beliefs about the NOS and beliefs about science teaching and learning in order to clarify science teaching orientations and provide empirical data to the orientation literature. First, she revealed the orientations pre-service teachers hold and then searched for the alignment between their beliefs about the NOS and science teaching orientations. She studied with 237 pre-service teachers and collected data via content-specific vignettes and questionnaire. Vignettes included content specific scenarios taken place in chemistry, physics or biology classes and preceded with 3 questions one of which was "What is your definition for science?" First, she analyzed the responses of the participants using the STO conceptualization of Magnusson et al. (1999) regarding the nine categories of science teaching orientations. Then she analyzed the responses of the participants to the open-ended questions and coded them for each participant as naïve, partially informed and informed regarding their beliefs about the NOS. Last, she cross-matched the two data to examine the alignment between STO and beliefs about the NOS. At the end of the data analysis, results from 118 pre-service teachers, who completed all the data collection instruments, indicated that participants who had academic rigor and didactic orientations had naïve views about NOS. Participants who held discovery and guided inquiry orientations showed partially informed NOS views that aligned with their orientations. Last, conceptual change, inquiry, project-based and process orientations compatible with informed NOS views. Looking at these results alignments between orientations and beliefs about the NOS, Kind (2016) concluded that orientations dominated pre-service teachers' ideas about science teaching. Moreover, she proposed instead being a component of science teaching orientations, beliefs about the NOS could be counted as a component of subject matter knowledge.

2.4. Research on interactions between PCK components

In recent years interactions among the components of PCK attracted researchers' attention and found place in the studies. Studies investigating only the interaction between STO and other PCK components were few in the literature. Even in these studies, interaction between STO with the other components of PCK did not examined in depth and the interactions between the other components became prominent. Therefore, all interaction studies were examined in this section even they were lack of the emphasis on interactions related to STO. In this section, first, studies conducted with pre-service teachers and then in-service teachers was given. Finally a study conducted with university professors was presented.

In the study conducted with pre-service teachers, Aydin et al. (2015) examined development of the interactions of pre-service teachers' PCK components during a practicum course. They studied with 3 pre-service teachers and used content representations and semi-structured interviews to collect data both before and after the practicum course. Researchers utilized from Magnusson et al.'s (1999) nine categorization of the science teaching orientations and analyzed orientations by using deductive approach. Interaction among the PCK components were analyzed by using content analysis and constant comparative method. Results of the study showed that preservice teachers' interaction among PCK components were idiosyncratic and developed from fragmented to integrated at the end of the practicum course. Moreover, while interaction between the knowledge of curriculum and other PCK components developed the most; knowledge of assessment showed no interaction between knowledge of instructional strategy although it had interaction between the other components of PCK.

In her study with 8 pre-service science teachers Demirdöğen (2016) used three dimensions of science teaching orientations proposed by Friedrichsen et al. (2011) to examine pre-service teachers' science teaching orientations and the relationship between their STO and other components of PCK. She collected data by using Content Representations, open-ended instrument and semi-structured interviews. She analyzed pre-service teachers' beliefs about the goals or purposes of science teaching by using Robert's (1988, 2007) curriculum emphasis, teaching and learning by using Luft and Roehrig's (2007) and Campbell et al.'s (2014) categorization and the nature of science by Khishfe and Abd el Khalick (2002) categorization. Researcher concluded the results of her study in three assertions. The first assertion was that pre-service teachers' purpose of science teaching informs the PCK component it interacts with. Second pre-service teachers' beliefs about the nature of science was interacted with their PCK only if they are directly related to their purposes of science teaching. Third, beliefs about science teaching and learning generally interacted with knowledge of instructional strategies.

Study of Park and Chen (2012) was an example to interaction studies conducted with in-service teachers. This study revealed the interaction between all five components of PCK by using PCK maps. The aim of the study was to make the PCK more visible and the interactions between the components clearer by using a PCK map which showed the frequency of the interactions among the PCK components. Researchers studied with 4 biology teachers working at the same high schools during the teaching of the topics photosynthesis and heredity and collected data from variety of sources such as observations, interviews, lesson plans, instructional materials and students' works. The data was analyzed by using in-depth analysis of explicit PCK, enumerative approach and constant comparative method to map out the integration of the components of PCK. One assumption of this study was that although the strength of the interactions between the components might be different, authors assumed they are the same during the analysis of the data while constructing the PCK maps. At the end of the data analysis they proposed five properties of the integration among the PCK components. First, the nature of the integration among the components of PCK was idiosyncratic and topic-specific. Second, knowledge of student understanding and knowledge of instructional strategies and representations were the central components in the integration. Third, knowledge of science curriculum and knowledge of assessment of science learning indicated the most limited connection with other components of PCK. Forth, knowledge of assessment of science learning was more frequently connected with knowledge of student understanding and knowledge of instructional strategies and representations than it is connected with the other components of PCK and the last one is that didactic orientations toward teaching science inhibited the connection of knowledge of instructional strategies and representations with the other components of PCK and directed it.

Another study conducted with in-service teachers was the study of Aydin and Boz (2013). In this study researchers studied with two experienced in-service chemistry teachers to examine the nature of the interaction among the components of PCK. In this study card-sorting activity was used to reveal participants' science teaching orientations regarding the categorization of Magnusson et al. (1999). Other data collection sources were the interviews, observations and content representation. Analysis of the data depended on the approach proposed by Park and Chen (2012); however, while in Park and Chen's (2012) study the strength of the interactions were not considered and coded as though they are similar, in this study the strength of the interactions were considered by using a rubric that ranged from 1 to 3 depending on the nature of the interactions between the components. Results of the study revealed that similar with the study of Park and Chen (2012) the integrations among PCK components were idiosyncratic and topic-specific. As the overarching component of PCK, science teaching orientations shaped instructional decisions of the teachers. While some interactions were simple (e.g. knowledge of curriculum informs knowledge of instructional strategy) other interactions were more complicated (e.g. prerequisite knowledge as sub-component of knowledge of learner and knowledge of curriculum together informs knowledge of learners' difficulties and it informs knowledge of instructional strategy). Moreover, frequency of some integrations (e.g. integration between knowledge of learner and knowledge of instructional strategy) were more than the others (e.g. integration between knowledge of curriculum and knowledge of assessment). Furthermore, as a result of this study some parts of the integrations were named as understand, decision-making, enactment, and reflection.

Similarly, Henze et al. (2008) conducted their study with nine experienced teachers working at five different schools. The teachers were in their first few years of teaching the new syllabus on Public Understanding of Science (PUSc) and they were followed for three years to detect if their PCK developed or not considering the topic Models of the Solar System and the Universe. Analysis of the data indicated two types of PCK which are Type A and Type B PCK. While Type A PCK was defined as oriented towards model content, Type B was defined as oriented towards model content, model production, and thinking about the nature of models. Results indicated that while some components (e.g. knowledge of instructional strategy) of PCK in Type A became more complex, the interaction between the components were static. In Type B, besides the development of the components of PCK, the interaction between these components were dynamic and consistent.

Different from above mentioned studies conducted with prospective and in-service teachers, Padilla and van Driel (2011) studied with 6 university professors about quantum chemistry. In order to represent their PCK and the integration between components of PCK they conducted interviews with professors and analyzed the interview data considering the Magnusson et al.'s (1999) PCK model. The results showed that university professors mostly held didactic teaching orientations which lead them to problem solving in their instructional approach therefore, it was concluded in this study that there was a relationship between professors' science teaching orientations and knowledge of instructional strategies. Another relationship was found between knowledge of curriculum and knowledge of student understanding. Knowledge of assessment was the component which was reported as taken the least attention in this study, even though it showed some relations to science teaching orientations, knowledge of curriculum and students' understandings.

CHAPTER 3

METHODOLOGY

In this chapter, research design and participants of the study, sources and procedure of data collection, data analysis, and validity and reliability issues were explained in details.

As mentioned in the introduction chapter, the purpose of this study was twofold. The first one was to investigate experienced in-service chemistry teachers PCK and the second one was to examine the interaction between their science teaching orientations and other components of PCK regarding mixtures unit. In order to fulfill this purposes, the below research questions were formed.

3.1. Research Questions

i) What knowledge do experienced in-service chemistry teachers have regarding their pedagogical content knowledge while teaching mixtures unit?

ii) How do the science teaching orientations of experienced in-service chemistry teachers interact with the other components of pedagogical content knowledge?

3.2. Research Design

Qualitative research design were used in this study. Qualitative research in education can be used while researcher wants to get detailed information about implementation (Patton, 1987). The emphasis of qualitative research is on *qualitas* rather than *quantitas* (Erickson, 2003) which means that quality of what is being investigated is more important than its quantity. For this purpose most of the PCK studies are designed as qualitative research in order to get deep and detailed information about the phenomenon.

Creswell (1998) defined five types of methodologies under the umbrella of qualitative research which are: narrative qualitative study; ethnography, phenomenology, grounded theory, and case study. The qualitative design that is going to be used for this study will be case study. Although many different kinds of qualitative research exist, they have similar general characteristics (Fraenkel & Wallen, 2006). The first one is that data of the qualitative research is collected in the natural settings and the researcher has a key role. The second one is that words are more important than numbers in qualitative research and the last one is that the process is as important as the product.

Bogdan and Biklen (1998) defined case study as "a detailed examination of one setting, or a single subject, a single depository of documents, or one particular event" (p. 54). Patton (1987) stated the importance of case studies as "the depth and detail of qualitative methods typically derive from a small number of case studies" (p. 19). Moreover, he stated that case studies are the most useful qualitative methods that give importance to personal differences.

Case of the study may be just one individual or a classroom or a school so it is important to define the case or the object of the study before starting the research (Stake, 1995). The cases of this study are two in-service teachers teaching in different public schools.

3.3. Participants

Participants of the study were selected by purposive sampling which is a highly used sampling method in qualitative studies to enable researchers interact with the information-rich cases (Fraenkel & Wallen, 2006). Considering the purpose of this study, participants must be experienced chemistry teachers who were teaching at 10^{th} grade. I intended to study teachers who were working at the same high school. I visited many teachers to select the participants and talked to them about the study. However, while some of the teachers were not agreed to participate in the study, some of them were not teaching at 10^{th} grade. At the end, two experienced chemistry teachers, a woman, Mrs. Akman and a man, Mr. Kuzu, who were meeting the criteria of being a participant in this study, were selected as the participants. The high schools they were working were different but both of them were highly regarded public high schools in Turkey who had successful students. Both teachers had B.S. degree in chemistry education and only worked as chemistry teachers throughout their work life. Summary of the information about the participant teachers is given in Table 2.

Table 2. Information about the participant teachers

Participant	**Teaching Experience**	**Bachelor's Degree**	**Master/PhD**	**School type**	**Professional development trainings**
Mr. Kuzu	32 years	Chemistry education	-	Public	Introduction of the new curriculum Using smart board
Mrs. Akman	27 years	Chemistry education	-	Public	Introduction of the new curriculum Using smart board

3.4. Topics Selection

In this study, mixtures unit was chosen to conduct the study. One of the reasons to choose the mixtures unit as the subject matter was the convenience of it. When I consider the sequence of the pilot study and the actual study, mixtures unit was the best topic to study because chemistry curriculum was changed for 10^{th} grade at the end of 2013-2014 2^{nd} semester and the new curriculum started to be implemented at the beginning of the 2014-2015 1st semester. While I was conducting pilot study mixtures unit was covered at the 2nd semester and then after the curriculum change it was started to be covered at the 1st semester when I started to collect actual data of my study. Old and new content of the mixtures unit can be seen in the curriculum released by National Ministry of Education (NME) (NME, 2011; NME, 2013). The other reason to select the mixtures unit was that it is one of the fundamental topics in chemistry which includes three main sub-topics that are "homogeneous mixtures" also known as solutions, "heterogeneous mixtures" and "separation of mixtures" in the 10th grade chemistry curriculum. The basis of solution chemistry and liquid solutions which are advanced chemistry topic implemented in 11th grade, stays behind the mixtures unit. Moreover, its relation to real life situations also increases the importance of the unit in order to develop scientifically literate students (AAAS, 1993). The unit includes so many sub-microscopic concepts that it has an abstract nature which makes it difficult for student to understand and as a result hold misconceptions about it (Çalık, Ayas, & Coll, 2007; Ebenezer & Erickson 1996). Therefore, in order to increase student understanding about the topic, we need to get better understanding of its implementation by the teachers during the instruction. To sum up, reasons for studying mixtures unit in this study were that first its convenience and second fundamental and important place in chemistry.

3.5. Context of the study

In qualitative research it is important for researcher to collect the data in the natural settings of the participants to describe and interpret the phenomenon being studied in a proper way (Lincoln & Guba, 1985). In this study the context was the chemistry teachers' classroom in which they teach. The number of the students in the observed classrooms were 25-30 students. All classrooms have smart boards and internet connection. Both Mr. Kuzu and Mrs. Akman were teaching in public schools but they were different schools. Before starting the study, my intent was to study with teacher working in the same schools, in order to eliminate the differences between the contexts. However, it was not possible, due to the fact that participating the study is based on voluntariness and any two teachers working in the same high schools were not volunteer to participate in the study. Therefore, I had to study teachers from different schools. I tried to choose schools which were highly regarded high schools in Ankara which have successful students who enrolled to these schools by getting high scores in the nationwide examinations in the middle school. Students also get high scores in the nationwide examinations like Higher Education Examination (HEE) and Undergraduate Placement Examination (UPE). The most important difference between these two schools was that they are in different regions of Ankara. Mr. Kuzu's school was near the city center of Ankara and had 704 students, Mrs. Akman's school was far away from the city center and had 668 students. Also Mr. Kuzu's school had more successful students than Mrs. Akman's school according to the data obtained from NME.

3.6. Data Collection and Data Collection Sources

In qualitative research to make realistic conclusions and report these conclusions in an unbiased way, the researcher needs to collect data from variety of sources (Erickson, 2003). Creswell (1998) reported that getting information from different sources is important to get deeper information. In this study, interviews, observations field notes and classroom documents were used to collect data. First of all, in Figure 10 information about the timeline of the data collection was given and then detailed information about the data collection sources was provided.

3.6.1. Interviews

Interviews are used to gather in depth information about participants' attitudes, beliefs and thoughts to provide detailed information about what they actually think (Fraenkel & Wallen, 2006). According to Patton (2002) the purpose of interviewing is to learn "what is in and on someone else's mind" (p.341). As a researcher we cannot learn everything by observing; therefore, to get information from the participant's perspective "we have to ask people questions about those things" (p. 341).

In this study during the data collection process five different type of interviews were conducted with the participants. (See Figure 10) The interviews are about teachers' background information, science teaching orientations, other PCK components, mixtures unit and weekly interviews, respectively. All interview sections were recorded using digital audio recorder. Detailed information about the interviews is given below.

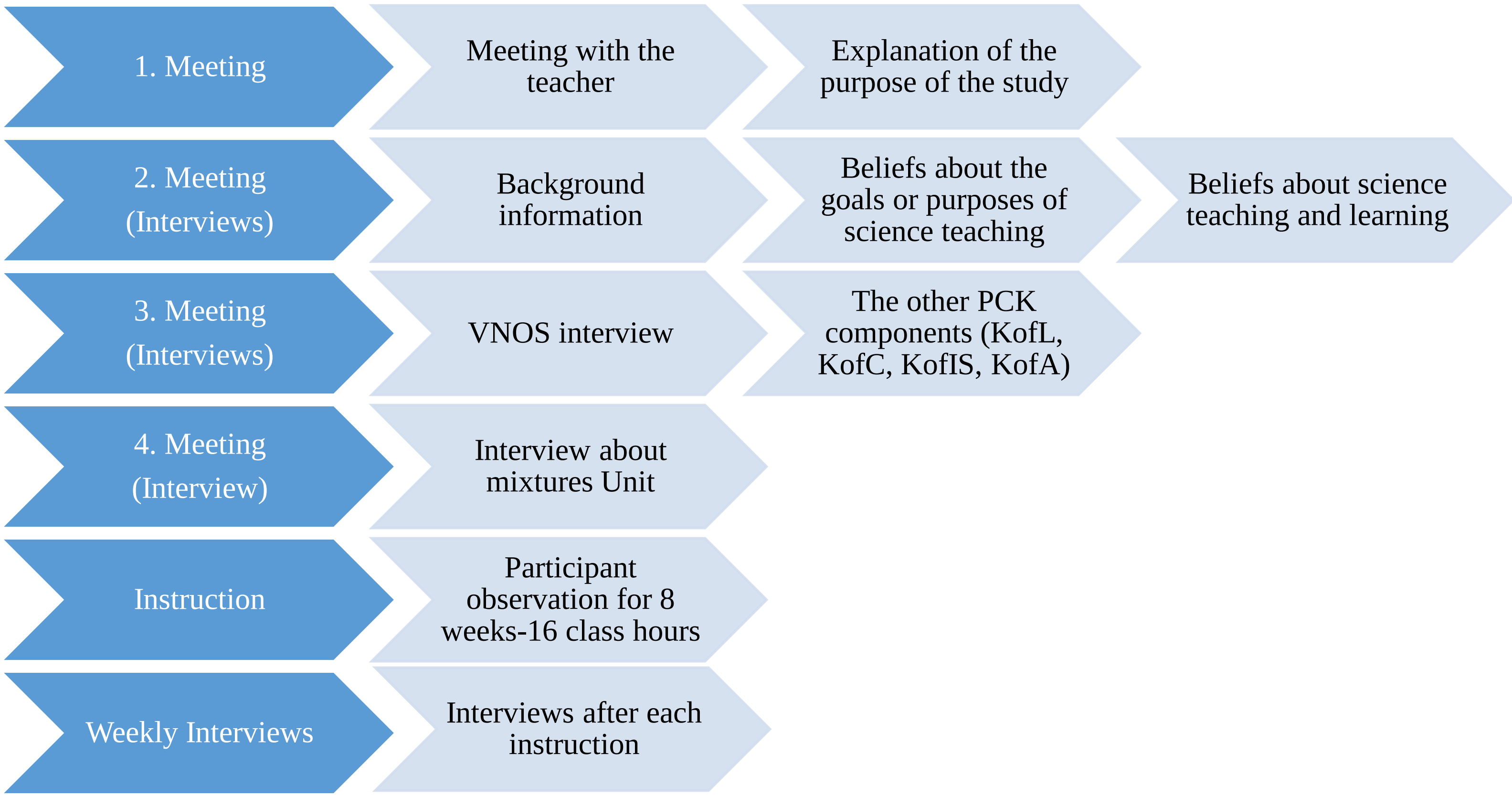

Figure 10. Timeline of the data collection

3.6.1.1. Background Information

Interview about background information of teachers was conducted to get detailed information about teachers' education levels, teaching and learning experiences, and ideas of being a teacher. (See Appendix A for the interview questions). At the first meeting with the teachers, the purpose of the study was explained and at the second meeting, interview about background information was conducted. The interviews was lasted approximately in 30 minutes.

3.6.1.2. Science Teaching Orientations

Science teaching orientations was examined under 3 sub-components that are beliefs about the goals or purposes of science teaching, teaching and learning science and the nature of science. While interviews about beliefs about the goals or purposes of science teaching and beliefs about science teaching and learning were conducted together at the second meeting right after the background information interview; the nature of science interview was conducted at the third meeting with the teachers.

The purpose of the interviews conducted at the second meeting was to elicit and elaborate on teachers' beliefs about the purposes or goals for teaching chemistry and beliefs about science teaching and learning. Interview questions (see Appendix B) were constructed based on the questions and suggestions from the literature (Friedrichsen et al., 2011; Friedrichsen, Lankford, Brown, Pareja, Volkmann, and Abell, 2007; Friedrichsen, 2002; Boesdorfer, 2012; Luft and Roehrig; 2007). For instance, to elicit their beliefs about the goals or purposes of science teaching, participants were asked questions like "What are the purpose of teaching chemistry in high schools? Why is it important for students to learn chemistry topics stated in the high school curriculum? ...etc." Besides, to elicit participants' beliefs about science teaching and learning, they were asked questions like "How do you define your role as a teacher? How do you maximize student learning in your classroom? …etc."

For both participant the interview was started with the questions on beliefs about the purposes or goals for teaching chemistry and the duration of the interview was approximately 45 minutes, and then a break was given for lunch. After the lunch the interview was continued with the questions related to the beliefs about science teaching and learning and the duration of this interview was approximately 70 minutes.

The interview about the last sub-component of science teaching orientations, beliefs about the nature of science, was conducted at the third meeting and it was lasted in approximately 45 minutes. Views of the Nature of Science Questionnaire Form C (VNOS-C) developed by Lederman, Abd-El-Khalick, Bell, and Schwartz (2002) was used for the purpose of determining teachers' beliefs about the nature of science. (See Appendix C for the VNOS-C Questionnaire). VNOS-C questionnaire includes 10 open ended questions referring particular NOS aspects. In this study seven aspects of NOS which are (a) tentative nature of science, (b) empirical nature of science (c) inferential nature of science (d) creative and imaginative nature of science (e) sociocultural nature of science (f) subjective nature of science and (g) differences of theory and law were elicited. In Table 3 VNOS-C questions and related NOS aspects are given.

Table 3. VNOS-C questions and related NOS aspects

Question Number	**The NOS aspects related question refers to**
1	General ideas about science, Empirical NOS
2	General structure and aim of experiments
3	Role of experiments in development of science
4	Tentative NOS
5	Theory and Law

Table 3. (continued)

6	Inferential NOS
7	Imaginative and creative NOS, empirical NOS
8	Subjective NOS
9	Sociocultural NOS, imaginative and creative NOS
10	Imaginative and Creative NOS

3.6.1.3. Other PCK Components

Interview about other PCK components (Figure 10) was conducted at the third meeting with the teachers, right after the VNOS-C interview. It lasted approximately in 50 minutes. The purpose of the interview was to find out participants' general ideas about an instruction regarding components of PCK, except science teaching orientations component. Questions were prepared based on Loughran, Berry, and Mulhall 2006 and NME, 2013. (See Appendix D for the interview questions) Interview questions were composed of four parts that are aimed to elicit participants' ideas about knowledge of learner, knowledge of curriculum, knowledge of instructional strategy, knowledge of assessment during their instruction. Examples of the interview questions were "What do you generally do to elicit student misconceptions?" "Are you considering the sequence in the chemistry curriculum during your instruction?" "Which instructional strategies do you use in your instruction?" "How do you use the results of your assessment?" for each component, respectively.

3.6.1.4. Mixtures Unit

Interview about mixtures unit was conducted a few days before starting to teach mixtures unit and the interview was lasted approximately in 60 minutes. The questions aimed to elicit participants' plans to teach the mixtures unit considering PCK components. Examples to what I wanted to learn by this interview was participants' awareness of the misconceptions and curriculum goals unit, and which activities they planned to use, and when they planned to assess students' understanding specific to mixtures unit. For this aim I prepared interview questions specific to mixtures unit regarding PCK components (See Appendix E for the interview questions). For instance, in the interview, participants were asked questions like "Which concept do the students need to know to learn mixtures unit?" to understand their knowledge of learner and "What are the goals and objectives stated in the curriculum regarding mixtures unit?" to understand their knowledge of curriculum and "Which activities are you planning to use during the teaching of this unit?" to understand their knowledge of instructional strategies, and last "When are you planning to assess students' understanding of this unit?" to understand their knowledge of assessment regarding mixtures unit.

3.6.1.5. Weekly Interviews

In a week, teachers have two hours chemistry classes to the 10^{th} grades. The classes may be two consecutive hours in a day or one hour each in two different days depending on the teachers' schedule. Weekly interviews was conducted after the last instruction of that week to elaborate the salient teaching and learning activities of the instruction that I took as field notes. The interviews was lasted in at most 20 minutes depending on the intensity of the teaching and learning activities covered on that week. Most of the time, teachers' ideas about the reasons of those activities were asked to them. For instance, if the teacher used a demonstration in the instruction, the reason of using that demonstration and whether it was successfully used or not was asked during the interview. If the teacher emphasized a misconception in the instruction, in the interview we talked about that misconception and the reason of emphasizing it. Examples to some of the questions used in the weekly interviews was like "Why did you use that demonstration in the instruction?" or "What was your purpose of emphasizing that misconception?" or "What do you think about the student's response to the question…?"

3.6.2. Participant Observation

Interaction and activities of people can be described in a more accurate and reliable way by observing them. The strength of observational data is that it is collected when the action is happening, in other words in the field (Patton, 2002). In this study, observations were used during the instruction of in-service teachers. Non-participant observations were used during the observation process that researcher was a complete observer (Fraenkel & Wallen, 2006) and were not involved in the teaching process. To make students and in-service teachers get used to the presence of the researcher in the teaching environment, the researcher began to attend classes two weeks before starting to collect data to accommodate them for her presence. Recording videos in the classrooms was not permitted by the school management, in order not to cause loss of concentration on either teachers or the students. Therefore, during each instruction, by the permission of the school management and the teachers, a digital audio recorder was used to record the conversations in the classroom, in order not miss the important points. The recorder was turned on near the teacher's desk during the class hours.

During the observations field notes were taken. Field notes are the own description of the researcher to give what is observed (Patton, 2002). They are important sources of data about what was observed, as researcher cannot trust to future recall. Any information can be noted as soon as possible during the observation, if observer thinks that it is worth to note. Besides the subject of the observation, notes can be taken about anything in the observing area such as physical setting, activities taking place in the observing area or any descriptive information.

Baxter and Lederman (1999) suggested that when the aim is to assess teachers' PCK, observations become important data collection sources for better understanding. Therefore, in this study the researcher, also she was the observer, took notes about all the activities occurring in the class related to PCK, especially the ones that would not be clearly understandable only by listening the audio records of the instruction. Sub-component of PCK (see Figure 11) and related actions for instance, the teaching activities and the methods teachers use, their interaction with the students, writings on the board... etc. were noted especially to use in the weekly interviews. For example, when the teacher drew a graph on the board, I noted it as field note. When the teacher showed a demonstration, or when s/he showed a model I noted the materials used and how the demonstration or model was showed in order not to forget them, because understanding what was written on the board or what was happening in the classroom would be difficult by just using the audio recordings of the instruction.

Component	Sub-components
Science Teaching Orientations	•Beliefs about the Goals or Purposes of Science Teaching •Beliefs about Science Teaching and Learning •Beliefs about the Nature of Science
Knowledge of Learner	•Prerequisite Knowledge •Misconceptions •Difficulties
Knowledge of Instructional Strategies	•Subject Specific Strategies •Topic Specific Activities •Topic Specific Representations
Knowledge of Curriculum	•Knowledge of Goals and Objectives •Relating to Other Topics (Vertical --- Horizontal) •Relating to Other Disciplines •Altering the Curriculum
Knowledge of Assessment	•Methods of Assesssment •Dimensions of Science Learning to Assess (what is assessed --- the way of assessment --- the purpose of assessment)

Figure 11. PCK components and sub-components used in this study

3.7. Pilot Study

The pilot study was conducted one semester before starting to collect the data of the actual study. The purposes of the pilot study were to see whether the data collection tools are available for the research, improve their quality and practice before the actual study. Especially I intent to see if the interview questions were clear and understandable for the interviewee and have practice in the classroom environment while observing the instruction and taking field notes. For the pilot study, I studied with a chemistry teacher who has 20 years of teaching experience. Before starting to observe her classes I interviewed her as I planned to do for the actual study. Interviews about background information, science teaching orientations, other PCK components, and mixtures unit were completed before starting to observe her instruction. At the time of the pilot study mixtures unit was covered at the end of the 2nd semester at 10th grade and it would started to be taught in the 1st semester beginning from the following semester because of the curriculum change. Therefore, I observed one of her 10th grade class for 6 class hours; for 3 weeks 2 hours a week at the mixtures unit; however, this unit was covered considering the old curriculum. At the end of each week I conducted weekly interviews with her to elaborate the activities occurred in the class hours. Especially we talked about the instructional practices (e.g. assessment of the student understanding) occurred in the classes and the reasons of choosing to use that articular practice (e.g. distributing a content test to assess student understanding about the topic).

After finishing the pilot study some changes were made especially in the interview questions. For instance; I added extra questions when I felt to go deep into the topic that we discussed with the teacher. For instance, the teacher had some complaints about the new curriculum that I determined to add some questions about comparing the old and new curriculum like “Can you compare the new and the old curriculum? What do you think about the pros and cons of the old and new curriculum?”

3.8. Data Analysis

Before starting to analyze data all audio-recordings of interviews and class observations were transcribed. All the transcribed data were then read and analysis procedure started. Data obtained from interviews, observations and field notes were analyzed by using deductive approach (Patton, 2002).

First, regarding the components of PCK which are STO, KofL, KofC, KofIS and KofA, data were analyzed deductively. In deductive analysis the collected data is analyzed by using an already existing framework (Patton, 2002). In this study, modified version of PCK model proposed by Magnusson et al. (1999) was used as the existing framework (see Figure 11) to analyze the data deductively.

Second, analysis of the interactions between STO and other components of PCK was conducted. Before starting the analysis of interactions a coding scheme was prepared by the researcher utilizing from the literature. Then the analysis regarding interactions were conducted depending on this coding scheme. Detailed information about the data analysis procedure was presented below.

3.8.1. Science Teaching Orientations

Science teaching orientations are composed of three dimensions which are beliefs about the goals or purposes of science teaching, beliefs about science teaching and learning and beliefs about the nature of science. Data analysis of three dimensions was explained in details below.

First dimension, beliefs about the goals or purposes of science teaching was analyzed by using a model called *curriculum emphases* proposed by Roberts in 1982 and defined it as:

> A curriculum emphasis in science education is a coherent set of messages to the student about science (rather than within science). Such messages constitute objectives which go beyond learning the facts, principles, laws, and theories of the subject matter it-self-objectives which provide

> answers to the student question: “Why am I learning this?” (Roberts, 1982, p.245).

Based on this common question, Roberts (1982) examined the curricula implemented in the North America and found seven curriculum emphases in the history of science education claiming that there is something more in science education than teaching science topics. These emphases are; everyday coping, structure of science, science technology and decisions, scientific skill development, correct explanations, self-as-explainer, and solid foundation. Each of these curriculum emphases were defined as below (Roberts, 1995, p. 497).

- Solid foundation: stresses science as cumulative knowledge;
- Correct explanations: science as reliable, valid knowledge;
- Structure of science: how science functions as a discipline;
- Scientific skill development: the ‘science-as-process’ approach;
- Science/technology/decisions: the role scientific knowledge plays in decisions which are socially relevant;
- Personal explanation: understanding one’s own way of explaining events in terms of personal and cultural (including scientific) influences; and
- Everyday applications: using science to understand both technology and everyday occurrences.

Roberts (1982) stated that “no one curriculum emphasis is any more “right” than another, a priori. Each is theoretically as possible as the others” (p. 253).

In Table 4 each of the seven curriculum emphases is described regarding view of science, view of learner, view of teacher and view of society. As an example, curriculum emphasis of everyday coping is based on a view of science as “A meaning system necessary for understanding and therefore, controlling everyday objects and events” view of learner as “Needs to master the best explanations available for comfortable, competent explanation of natural events, and control of mechanical objects and personal affairs” view of teacher as “Someone who regularly explains natural and man-made objects and events by appropriate scientific principles” and view of society as “Autonomous, knowledgeable individuals who can do mechanical things well, who are entrepreneurial, and who look after themselves, are highly valued members of the social order” (Roberts, 1988, p.45). More information about each emphasis with regard to views of science, learner, teacher and society can be found in Table 4. Friedrichsen et al. (2011) suggested that the descriptions of each curriculum emphasis “includes elements of the nature of science, goals of science education, and views of teaching and learning” (p. 371). Therefore, these curriculum emphases can be used to explore teachers’ beliefs regarding their purposes of the curriculum they teach (Friedrichsen et al., 2011; van driel, Bulte & Verloop, 2008). Regarding the views of science, learner, teacher and society given in Table 4, I considered the view of science as the basis and utilized from view of learner and view of teacher to determine teachers’ beliefs about the goals or purposes of science teaching.

Table 4. Four curriculum commonplaces inherent in even curriculum emphases for science education (Roberts, 1988)

Curriculum Emphasis	View of Science	View of Learner	View of Teacher	View of Society
Everyday coping	A meaning system necessary for understanding and therefore controlling everyday objects and events	Needs to master the best explanations available for comfortable, competent explanation of natural events, and control of mechanical objects and personal affairs	Someone who regularly explains natural and man-made objects and events by appropriate scientific principles	Autonomous, knowledgeable individuals who can do mechanical things well, who are entrepreneurial, and who look after themselves, are highly valued members of the social order
Structure of science	A conceptual system for explaining naturally occurring objects and events, which is cumulative and self-correcting	One who needs an accurate understanding of how this powerful conceptual system works	Comfortably analyzes the subject matter as a conceptual system, understands it as such, and sees the view point as important	Society needs elite, philosophically informed scientists who really understand how that conceptual system works
Science, technology, decisions	An expression of the wish to control the environment and ourselves, intimately related to technology and increasingly related to very significant societal issues	Needs to become an intelligent, willing decision maker who understands the scientific basis for technology, and the practical basis for defensible decisions	One who develops both knowledge of and commitment to the complex interrelationships among science, technology, and decisions	Society needs to keep from destroying itself by developing in the general public (and the scientists as well) a sophisticated, operational view of the way decisions are made about science–based societal problems
Scientific skill development	Consists of the outcome of correct usage of certain physical and conceptual processes	An increasingly competent performer with the processes	One who encourages learners to practice at the processes in many different contexts of science subject matter	Society needs people who approach problems with a successful arsenal of scientific tool skills

Table 4. (continued)

Correct explanations	The best meaning system ever developed for getting at the truth about natural objects and events	Someone whose preconceptions need to be replaced and corrected	One responsible for identifying and correcting the errors in student thinking	Society needs true believers in the meaning system most appropriate for natural objects and events
Self as explainer	A conceptual system whose development is influenced by the ideas of the times, the conceptual principles used, and the personal intent to explain	One who needs the intellectual freedom gained by knowing as many of the influences on scientific thought as possible	Someone deeply committed to the concept of liberal education as exposing the grounds for what we know	Society needs members who have had a liberal education - that is, who know where knowledge comes from
Solid foundation	A vast and complex meaning system which takes many years to master in	An individual who wants and needs the whole of a science, eventually	One who is responsible to winnow out the most capable potential scientists	Society needs scientists

Second dimension, beliefs about science teaching and learning was analyzed by using the categorization proposed by Luft and Roehrig (2007). Luft and Roehrig developed Teacher Beliefs Interview (TBI) to capture teacher beliefs about science teaching and learning. Seven interview questions were related to ways of maximizing student learning, the role of the teacher, know when students understand, what to teach and what not to teach, decide when to move on a new topic, the best way learning science, and to know when learning occurs. To analyze the responses to these interview questions related to the beliefs about science teaching and learning science, Luft and Roehrig (2007) defined five categories which were traditional, instructive, transitional, responsive and reform-based. While traditional and instructive responses of teachers reflect teacher-focused beliefs, responsive and reform-based responses reflect student-focused beliefs. Traditional category “focus on information, transmission, structure, or sources” instructive category “focus on providing experiences, teacher-focus, or teacher decision” transitional category “focus on teacher/student relationships, subjective decisions, or affective response” responsive category “focus on collaboration, feedback, or knowledge development” and reform-based category “focus on mediating student knowledge or interactions” (Luft & Roehrig, 2007, p. 54). In Table 5 seven categories and their descriptions regarding each category were given.

Table 5. Teacher beliefs interview category description (Luft & Roehrig, 2007)

Category	**Traditional (Teacher focused)**	**Instructive (Teacher focused)**	**Transitional**	**Responsive (Student focused)**	**Reform-based (Student focused)**
Ways of maximizing student learning	Teacher provides information in a structured environment	Teacher monitors student actions or behaviors during instruction	Teacher creates a classroom environment that involves the student	Teacher designs the classroom environment to enable students to interact with each other and their knowledge	Teacher depends upon student responses to design an environment that allows for individualized learning
Role of the teacher	Focus on information and structure	Focus on providing experiences	Focus on teacher/student relationships or student understanding	Focus on collaboration between teacher and student	Focus on mediating student prior knowledge and the knowledge of the discipline
Know when the students understand	When they receive the information	When they can reiterate or demonstrate what has been presented	When they give an explanation or response that is related to the presented information	When they can utilize the presented knowledge	When they can apply knowledge in a novel setting, or construct something novel that is related to the knowledge
What to teach, what not to teach	Decision guided by adopted curriculum or other school factor	Decision based on teacher focus/direction	Decision in which some modification is based on student feedback	Decision based on student feedback and other possible factors	Decision based upon student focus and guiding documents (e.g., standards, research)

Table 5. (continued)

Deciding when to move on a new topic	Directed by teacher	Directed by teacher; based on basic student understanding of facts and concepts	Teacher decision based on limited student feedback or ability of the teacher	Decision based on student feedback that potentially involves revisiting concepts	Decision based upon an on-going evaluation and considers student abilities to demonstrate understanding in different ways. May involve the modification of lessons.
Best way of learning science	From the teacher	By mimicking the teacher	By using procedures/guidelines	By encountering and interpreting phenomena	By eliciting, encountering, and constructing their ideas about phenomena.
Know when learning occurs	Determined by action of students during instruction. Emphasis is on order and attention as related to the student	Determined through measures given by the teacher. Emphasis on the correctness of the student response to the measure.	Determined through subjective conclusions about the student.	Students interact with their peers or the teacher about the topic. Responses are limited or preliminary.	Students initiate significant interactions with one another and/or the teacher about the topic.

Third dimension, beliefs about the nature of science was analyzed by using the categorization widely used in the NOS literature (Khishfe, 2004; Abd-el-Khalick, 2005; Khishfe, & Abd-El-Khalick, 2002; Lederman et al., 2002). In this categorization tentative, empirical, inferential, creative and imaginative, sociocultural, subjective aspects of NOS and differences of theory and law was analyzed under three categories which are (a) naive (b) transitional and (c) informed. Based on Khishfe (2004) if participants have misconceptions or explain the NOS aspect incorrect it is categorized as naive, if participants have deficient explanation or cannot give proper example to the NOS aspect it is coded as transitional and if participants give an appropriate example with sufficient explanation to the aspect of NOS it is coded as informed (Table 6). For instance, in this study, one of the teachers stated that there was a hierarchy between theory and law, and theories might change into law. The ideas of this teacher was coded as naive regarding theory and law aspect of NOS because of his misconception. The other teacher thought that scientific knowledge may change throughout time and gave the atomic theories as an example to his explanation and the ideas of this teacher was coded as having informed view considering the tentativeness aspect of NOS because of his correct answer and example. Both teachers accepted that scientist may interpret the same data in different ways which is correct, however, they either could not defend their ideas or gave clear examples to their claims. These teachers' ideas were coded as transitional regarding the sociocultural aspect of NOS.

Table 6. Description of the categories used to analyzed NOS aspects

Category	**Description**
Naive	Having misconceptions or wrong explanation
Transitional	Deficient explanation or no proper example
Informed	Sufficient explanation with proper example

Other components of PCK, knowledge of learner, knowledge of curriculum, knowledge of instructional strategy, knowledge of assessment was analyzed deductively considering the modified version of Magnusson et al. (1999) PCK model. For this purpose, knowledge of learner was examined under three sub-components; prerequisite knowledge, misconceptions and difficulties of students. Sub-components of knowledge of curriculum were goals and objectives, vertical relations and horizontal relations to other topics, relation to other disciplines and altering the curriculum. Knowledge of instructional strategy was examined under subject specific strategies, topic specific activities and representations. And last component knowledge of assessment was analyzed under methods of assessment and dimensions of science learning to assess which are what to assess, how to assess and the purpose of assessment (Figure 11).

3.8.2. Data analysis for Interactions between Science Teaching Orientations and other PCK Components

To analyze the interactions among sub-components of STO and KofL, KofC, KofIS and KofA a coding scheme (see Table 7) was prepared by using the studies in the literature (Aydin & Boz, 2013; Park & Chen, 2012; Padilla, & Van Driel, 2011). Each sub-component of STO was examined considering their interaction to each sub-component of other PCK components.

Table 7. Coding scheme for interactions between science teaching orientations and other components of PCK

STO	KofL	KofIS	KofC	KofA
Beliefs about the Goals or Purposes of Science Teaching	The teacher considers students' pre-requisite knowledge, learning difficulties and misconceptions related to his/her beliefs about the goals or purposes of science teaching	The teacher uses an instructional strategy which supports him/her to emphasize his/her beliefs about the goals or purposes of science teaching	The teacher benefits from his/her repertoire of curriculum while teaching his/her goals and purposes of science teaching	The teacher assesses students' learning considering his/her goals and purposes of science teaching
Beliefs about Science Teaching and Learning	The teacher considers students' pre-requisite knowledge, learning difficulties and misconceptions related to his/her beliefs about science teaching and learning	The teacher uses an instructional strategy which supports him/her to emphasize his/her beliefs about science teaching and learning	The teacher considers curriculum referring to his/her beliefs about science teaching and learning	The teacher assesses in a way supporting his/her beliefs about science teaching and learning
Beliefs about the Nature of Science	The teacher considers students' pre-requisite knowledge, learning difficulties and misconceptions related to his/her beliefs about the nature of science	The teacher uses an instructional strategy which supports him/her to emphasize his/her beliefs about the nature of science	The teacher considers curriculum related to the nature of science	The teacher makes an assessment supporting his/her beliefs about the nature of science

When analyzing the interactions, both researcher's observations and interviews with the teachers were taken into consideration. In order to be counted as interaction, the action of the teachers must not only be mentioned by the teachers during the interviews as their ideas but also observed by the researcher during the classes. In other words, instead of their ideal beliefs, teachers working beliefs were taken into consideration when determining the interactions between their STO and other components of PCK. For instance, if the teacher thought that using analogies was a good way to increase students' understanding and used it in the class, it was concluded that there was an interaction between teacher's beliefs about science teaching and learning which is sub-component of STO and knowledge of topic specific representations which is sub-component of knowledge of instructional strategies. Another example would be that if teacher had a purpose of elaborating natural events in the instruction and assessed whether students learnt them or not, it was concluded that there was an interaction between the teachers' beliefs about the goals or purposes of science teaching which was sub-component of STO and dimensions of science teacher to assess which was sub-component of knowledge of assessment.

3.9. Validity and Reliability Issues of the Study

Creswell (1998) claimed that validity and reliability issues should be taken into consideration while designing the study, collecting the data and analyzing them. In qualitative studies validity and reliability are defined in different terms than it is in the quantitative studies. When we talk about validity; credibility refers to internal validity and transferability refers to external validity. Besides, dependability is used in place of reliability, (Lincoln & Guba, 1985). Details of the credibility, transferability and dependability of the study were explained below.

3.9.1. Credibility

Merriam (1998) defined credibility as the compatibility of the research findings with what is actually happening in the research area. Lincoln and Guba (1985) suggested several strategies to assure credibility of a study. They are prolonged engagement, persistent observation, triangulation, peer debriefing and negative case analysis, referential adequacy and member checking. In this study prolonged engagement, persistent observations, triangulation, peer debriefing and member checking is used to provide credibility of the study.

Lincoln and Guba (1985) define prolonged engagement as giving sufficient time testing of any kind of misinformation, building trust and learning the culture. Also, they claim persistent observations ensure being open to encounter to the research phenomenon and continuity to follow the development of the phenomenon. The relationship between prolonged engagement and persistent observation is defined by Lincoln and Guba (1985) as “If prolonged engagement provides scope, persistent observation provides depth” (p.304). In this study three weeks before starting the observations I began to attend the schools regularly and spend time with the participant teachers, students and the other teachers in the schools. For the following two months I continued to the observations of the whole mixtures unit for two class hours a week, during two months at the same class and spent time with the teachers out of the class hours at the school, either at the laboratory or teachers room. By this way prolonged engagement and persistent observations were ensured.

Patton (2002) stated that triangulation is a way to strengthen the results of a study by using different sources of data. There are four types of triangulation which are: methods triangulation, triangulation of sources, analyst triangulation, and theory/perspective triangulation (Patton, 2002). In this study triangulation of sources was provided by using different kinds of data sources such as, interviews, observations and field notes to examine the same phenomenon. Analyst triangulation was provided by asking two colleagues to analyze some part of the data by giving them the transcribed documents of the interviews and observations. The colleagues were also studying on PCK. After their analysis we came together to discuss on the incongruent parts until we agreed upon.

Peer debriefing is getting help from a colleagues and asking them to comment on the process of data collection, analysis and interpretation to ensure the credibility of the study (Merriam, 1998). In this study, I always negotiated with two of my colleagues who are also studying on PCK and qualitative research during the whole process of the study, from starting to prepare data collection tools to the interpretation of the data.

Member checking is another way to provide trustworthiness (Merriam, 1998). Member checking was provided by discussing on the emerging findings with the participants throughout the study and at the end of the study. For this purpose I provided the emerged findings to the participants and wanted them to read and comment on them to understand whether they think the same way as I did or not.

3.9.2. Dependability

Dependability refers to replicability of the research findings in quantitative research; however, in qualitative research it cannot be provided for several reasons (Lincoln & Guba, 1985). Instead Lincoln and Guba stated "…rather than demanding that outsiders get the same results, a researcher wishes outsider to concur that, given the data collected the results make sense- they are consistent and dependable" (p. 206). Therefore, they suggested researchers to define investigators position clearly, triangulation and audit trail to ensure that results are dependable. Above the investigators position and triangulation was explained in details. For audit trail Lincoln and Guba, 1985 suggested "In order for an audit to take place, the investigator must describe in detail how data were collected, how categories were derived, and how decisions were made throughout the inquiry" (p.207). For this aim the related parts of the study was explained in every details.

3.9.3. Transferability

Transferability refers to generalizability of the research findings; however, it is not the aim of qualitative research. Instead of generalizing the findings by thick description it is suggested to describe our study in every details to let the other researchers know in which extend their study match with ours (Lincoln & Guba, 1985). In the methodology chapter details of the study were given to ensure thick description of the study.

3.10. Key Words and Databases Searched

The key words used to search for the related studies were PCK, science teaching orientations, orientations towards science teaching, conceptions of science teaching, in-service teachers, pre-service teachers, science education and chemistry education. Although scope of this study was chemistry education with in-service teachers, science education and pre-service teachers were also used for keywords to access more studies, due to the limited number of studies about science teaching orientations. Databases searched for reaching primary sources were Web of Science, Educational Research Information Center (ERIC) and International Dissertation Abstracts. Furthermore, online journals in Turkey (Hacettepe University Journal of Education, Education and Science, Elementary Online, and Educational Science: Theory and Practice) which have online access searched for the aim of reaching the primary sources. Also, for reaching the books related to my study I searched for the libraries of Middle East Technical University and University of Georgia.

3.11. The Role of the Researcher

The role of the researcher is explained by considering the participantness, revealedness, intensiveness and extensiveness as proposed by Patton (2002). Participantness refers to role of the researcher between two ends, the range between full participant to complete observer. In this study I was a complete observer as a researcher. I attended to the classes and sat at the back of the classroom and did not participate in any kind of instructional activity during the class hours. I just took notes and observed the classroom.

In terms of revealedness, both participants were informed about the purpose of the study before starting it. At the first day of my meeting with the participants, I informed them about every detail of the study and they agreed to participate in. Also during the study we sometimes talked about the ongoing process of the study. I began to attend to the class hours two weeks before starting the observations. The teachers introduced me as a PhD student to the students aiming to observe mixtures unit for my dissertation. The students did not become uncomfortable about it as they are used to the pre-service teachers attending their classes for field observation.

In terms of intensiveness and extensiveness I met participants four times to conduct interview before starting the observations and observed their classes for two months. Out of the class hour I spent time with them to build trust between us.

3.12. Ethical Considerations

Before starting the study I applied for Institutional Review board (IRB) permission to conduct a study with in-service chemistry teachers working in the high schools of National Ministry of Education (See Appendix F for the IRB form). All participants were voluntarily involved in the study. They were informed about the purpose of the study and I emphasized that they can quit the study any time they want. Pseudonyms were used for the participants. Only researcher, supervisor and the coders had access to the data.

3.13. Limitations of the Study

Before starting the study participant teachers were informed about the purpose of the study and I emphasized that they did not need to change anything in their instruction because of my existence in the classroom and teach the way as they always did. I always reminded them that the aim of collecting data was not for evaluating them but for understanding their STO and its interaction with the other components of PCK. Nevertheless my existence in the class might affect their teaching and relationship with the students.

During the classroom observations video recording was not used to record the instruction as it was not allowed by the school management. Therefore, the display of the reactions of the teacher and the students cannot be recorded. However, audio recorder was used to record the conversations of the teacher and students during all instruction. Besides, field notes were taken to illustrate the visual representations of the teachers to recall them in the future.

3.14. Time Schedule

Timeline of the study is given in Table 8.

Table 8. Timeline of the study

Date	**Events**
September 2012 – June 2013	Design of the study
August 2013 – February 2014	Development of interview questions and the other documents related to the data collection
March 2014 – May 2014	Piloting the study
June 2014 – August 2014	Data analysis of the pilot study and revising the data collection instruments
September 2014 – October 2014	Selection of the participants and getting the IRB permission
November 2014 – January 2015	Data collection
February 2015 – January 2016	Data analysis
February 2016 – August 2016	Writing results and discussion section

3.15. Assumptions of the Study

- Participants sincerely respond the questions of the researcher.
- The existence of the researcher did not affect any part of the instruction.

- The strength of all interactions between STO and other components of PCK are the same.
- Participants are information rich cases.

CHAPTER 4

RESULTS

In this section, firstly, participants' pedagogical content knowledge was presented under five components which are science teaching orientations, knowledge of learner, knowledge of curriculum, knowledge of instructional strategies and knowledge of assessment. Next, the interactions between science teaching orientations and other PCK components for each participant were described.

4.1. Pedagogical Content Knowledge

4.1.1. Science Teaching Orientations

Science teaching orientations of Mr. Kuzu and Mrs. Akman were examined under three dimensions: beliefs about the goals or purposes of science teaching, beliefs about science teaching and learning, and beliefs about the nature of science. Among these three dimensions, beliefs about the goals or purposes of science teaching, and beliefs about science teaching and learning were examined under two headings, which were ideal and working beliefs. Ideal beliefs were teachers' beliefs that may or may not exist during the instruction but stated as their beliefs by the teachers during the interviews. Working beliefs were teachers' beliefs, indications of which was clearly observed during the instruction which means teachers reflect the signs of these beliefs during the instruction and they are clearly observed by the researcher. While ideal beliefs were obtained from participants' responses to the interview questions conducted at the beginning of the study, working beliefs were obtained from researcher's observations and field notes of the instruction. The last dimension of science teaching orientations, beliefs about the nature of science, was examined only dependent to the participants’ responses to the interview questions because no concrete emphasis to the nature of science was observed by the researcher during the instruction.

4.1.1.1. Beliefs about the Goals or Purposes of Science Teaching

Participants’ beliefs about the goals or purposes of science teaching were analyzed under seven categories which were (a) everyday coping (b) structure of science (c) science technology and decisions (d) scientific skill development (e) correct explanations (f) self as explainer and (g) solid foundation. Mr. Kuzu’s and Mrs. Akman’s ideal and working beliefs about the goals or purposes of science teaching can be seen in Table 9.

Table 9. Participants’ beliefs about the goals or purposes of science teaching

	Beliefs about the Goals or Purposes of Science Teaching	
Participants	**Ideal Beliefs**	**Working Beliefs**
Mr. Kuzu	Everyday coping Solid foundation Science, technology and decisions	Everyday coping Solid foundation Correct explanations
Mrs. Akman	Everyday coping Solid foundation Correct explanations	Everyday coping Solid foundation Correct explanations

Mr. Kuzu’s ideal purposes of science teaching were everyday coping, science technology and decisions, and solid foundation. However, his working purposes were everyday coping, solid foundation, and correct explanations. While everyday coping and solid foundation was common in both Mr. Kuzu’s ideal and real purposes, science, technology and decisions was not detected as a purpose from the analysis of the observations. Yet, correct explanations was manifested as a working purpose of Mr. Kuzu during the instruction. While Mrs. Akman had exactly the same working beliefs about the goals or purposes of science teaching with Mr. Kuzu, there is a difference between their ideal beliefs. The main difference is that while science, technology and decisions manifested as an ideal belief only for Mr. Kuzu, correct explanations manifested as an ideal belief for only Mrs. Akman. Mrs. Akman's ideal and working purposes of science teaching were detected as the same which were everyday coping, solid foundation and correct explanations.

Everyday coping was uncovered as Mr. Kuzu's purpose of science teaching. He thought that not only chemistry but also the other branches of science had the same purpose. He explained his purpose of chemistry teaching as "It is oriented to the same purpose as every other science lesson does. To understand the world much easier and better, to get a better understanding of the events around…" He believed nature and chemistry had a strong relationship and chemistry serves for nature. He explained the relation between chemistry and nature as

> One of the best way to figure out the nature is learning chemistry because it is one of the major branches of science. To understand the nature, live at peace with nature and respect it will be possible with chemistry because chemistry tells the story of nature. Is there anything more awesome than it?

During the instruction, he always emphasized daily life examples related to the topic and gave importance to know the reason of these events. When he was asked the reason of mentioning daily life examples so much, he answered: "Students will learn everything around them by the help of chemistry. They will measure with it; try to understand with it. They will look with more tolerance and see how nature works with great devotion." He gave breathing and digestion as an example to explain what he meant in details.

> For instance, they will see how many chemical reactions are required to breathe which is also directly related to their own life. So they will respect. Moreover, at least they will see the complex reactions required

> for digestion. This is my only reason of mentioning daily life examples so much.

Similar to Mr. Kuzu, Mrs. Akman had a purpose of everyday coping regarding both her ideal and working beliefs. She stated that “Providing chemical literacy is the purpose… Establishing relationship between chemistry and daily life.” She gave importance to elaborate relation between chemistry and the daily life during the instruction. After she taught the chemistry concept, she always gave an example of daily life event and its relation to chemistry. For instance while she was teaching like dissolves like first, she explained what it meant and then gave dry cleaning as a daily life example and its relation to chemistry. Likewise, during the instruction, while she was talking about alcohols as solvents, she gave methyl and ethyl alcohol as examples and said

> Methanol is methyl alcohol. You know it is used in the bootleg alcohol or in cologne. We always have to relate chemistry with daily life. When we hear something about chemistry in the news or TV programs, we have to think on it. Ethyl alcohol and methyl alcohol are often Turkey’s agenda.

When she was asked the reason of giving daily life examples and their relation to chemistry too much she said “the aim of chemistry teaching would be providing chemical literacy. Learning the advantages and disadvantages of chemistry in daily life will lead students to make interpretations on the events they encountered in daily life.”

Mr. Kuzu’s another purpose of teaching chemistry was solid foundation. In general, he thought the purpose of learning chemistry was to understand the world. However, for reasons arising from the educational system in Turkey, preparing students to the exams appeared as his new goal because high school students should succeed especially in the Higher Education Examination (HEE) and Undergraduate Placement Examination (UPE) to attend the university. He explained this situation:

> At the end, they all become dependent to the university entrance examination. You have to teach compulsorily because there is an examination. If you do not want to teach, you should change the examination system. This purpose is not dependent on me. Chemistry questions are asked in the examination, if not I don't have such an aim. Simply, I teach chemistry to make them understand the world.

He believed this purpose was imposed on him as a purpose because he did not have such a purpose if there would not be such an exam students have to succeed in. He believed that students had to be prepared for the next chemistry classes even for the high school or college chemistry courses and stated preparing students to the next chemistry courses as another purpose.

> In the future, they will be studying at the college. Content of the classes at the high school is determined dependent to the content of the classes at the college because they need to be familiar with the classes at the college more or less when they are enrolled to those classes.

He always emphasized his purpose as students being successful at the HEE and UPE and attending to the university. The reason behind this purpose was to have acquire a profession. "Why do we teach? To simplify their (students') life… Ultimately, to acquire any profession, you need to be educated. It has some tools, one is the curricula, and chemistry curriculum is one of these curricula."

Mrs. Akman had also a purpose of solid foundation and it was predominantly seen during both her interview and instruction. Unlike Mr. Kuzu she did not focus on students' success at the next chemistry classes, she only focused on HEE and UPE and wanted her students to be successful at those examinations. She explained her purpose as

> Actually providing chemical literacy is the purpose of chemistry… Establishing relationship between chemistry and daily life. However, I don't think that is the only purpose. There is an examination (HEE and UPE) students have to pass. Therefore, the purpose is to respond the questions correctly in the examination. This is the purpose of the chemistry, to respond the chemistry questions.

For this aim she designed her instruction considering the HEE and UPE and always solved problems about the topic. She always attracted students’ attention to the questions that were asked in the previous HEE and UPE and introduced the type of questions that students might encounter in the next exams.

Correct explanations was the purpose of Mr. Kuzu that was not stated by him during the interviews but observed by the researcher during the instruction. He tried to give the best explanation of the concepts he taught with every single detail during the instruction. If he encountered any misunderstanding or wrong explanations of any concepts from students, he immediately gave the correct explanations of it. Following explanation of Mr. Kuzu could be an example of his giving importance to the correct explanations of the concepts.

> A solution containing undissolved solute is a saturated solution not supersaturated one. Write it down on your notebook. Every solution that is in equilibrium with undissolved solute is a saturated solution. Sometimes I draw a solution that is in equilibrium with undissolved solute and ask the type of the solution. You (students) immediately respond the question as supersaturated solution which is wrong.

While correct explanations was detected as purpose of Mr. Kuzu only in his working beliefs, it was detected as Mrs. Akman’s purpose both in her ideal and working beliefs. She believed that teacher is the one who knows everything and students had to rely on what teacher said. During the interview she stated that “Listening to what teacher says is very important for students. Because teacher has an accumulation and if teacher says something, it means most probably it is true. When students listen to the teacher carefully, they don’t have much difficulty.” Depending on the field notes of the researcher, during the instruction Mrs. Akman always attracted students’ attention to the correct explanations of the concepts and wanted them to learn the concept in a correct way. If she felt that students were in confusion she made an effort to make them understand the concept clearly. For instance, while students were confused about the dissociation and melting, and dissociation and ionization concepts, she elaborated these concepts until she became sure that these concepts were clear in students' minds.

During the interviews, differently from Mrs. Akman's ideal beliefs, science, technology and decisions appeared to be one of Mr. Kuzu's ideal purposes. He explained his purpose of science, technology and decisions as

> Learning science will lead people to know what to do under difficult conditions or what the possibilities are. They will be able to choose the most convenient one among these possibilities by the help of scientific knowledge. They will increase their decision-making ability and decide what to do when they come across to a scientific problem. We (science teachers) are trying to create a better understanding for them (students) to increase their capacity.

He claimed that sometimes students ask the question "why do we need to learn all of these chemistry topics?" He explained the reason of teaching chemistry at the high schools as increasing students' capacity to increase their decision-making ability and added "Students also ask why do they need to learn differential equations. Because of the same reason of learning science: to increase their capacity to make decisions under difficult conditions." When I examined his answers to the interview questions, it looked like he specified science technology and decisions as one of his purpose. However, it was not detected as his working purpose because he did not emphasize any element of science, technology and decisions to be counted as his purpose of science teaching during the instruction.

4.1.1.2. Beliefs about Science Teaching and Learning

Mr. Kuzu's and Mrs. Akman's beliefs about science teaching and learning were examined under seven heading: (a) ways of maximizing student learning (b) the role of the teacher (c) when students understand (d) what to teach what not to teach I when to move on a new topic (f) best way of learning science (g) when learning occurs. Every heading were categorized as traditional, transitional or instructive for each teacher. In this part, ideal and working beliefs about the above-mentioned headings will be examined separately, likewise beliefs about the goals or purposes of science teaching section (Table 10).

Table 10. Participants' beliefs about science teaching and learning

Categories of beliefs about science teaching and learning	Mr. Kuzu		Mrs. Akman	
	Ideal belief	**Working belief**	**Ideal belief**	**Working belief**
Ways of maximizing student learning	Transitional	Traditional	Instructive	Instructive
Role of the teacher	Transitional	Traditional	Traditional	Traditional
Know when the students understand	Transitional	Traditional	Instructive	Instructive
What to teach, what not to teach	Traditional	Traditional	Traditional	Traditional
Deciding when to move on a new topic	Instructive	Instructive	Instructive	Instructive
Best way of learning science	Transitional	Instructive	Instructive	Instructive
Know when learning occurs	Instructive	Instructive	Instructive	Instructive

Mr. Kuzu’s ideal beliefs about science teaching and learning ranged from teacher focused to transitional while his working beliefs were teacher focused, indeed. Mrs. Akman’s ideal and working beliefs about science teaching and learning were both teacher focused.

Mr. Kuzu’s ideal belief about ways of maximizing students learning was transitional while his working belief was traditional. As his ideal belief, he emphasized student learning would be maximized by using different types of activities. He thought if he used different activities that appeal more than one senses of students like using words, visuals, music etc. together, it would help students to learn better. However, in real practice he gave the information in a structured manner to students. First, he gave the definitions of the concepts, and explained them, then wanted students to take notes, and then gave examples to the related concept, and lastly solved problems if there were any about the topic. In this way Mr. Kuzu’s belief about way of maximizing student learning in the classroom was like traditional more than transitional.

Mrs. Akman’s both ideal and working beliefs about ways of maximizing students learning was instructive. She believed that student learning would be maximized by giving them homework and control if they did it. She stated that “Instead of watching me solving 10 questions in the classroom, students themselves solving three questions as homework would be better to increase their learning. Therefore, we (teachers) have to give homework and control if students did it.” During the instruction Mrs. Akman asked questions and waited students to respond them or sometimes wanted students to solve questions or problems and monitor them if they can achieve to solve.

Mr. Kuzu’s belief about the role of the teacher was transitional in ideal; however, it was traditional in real. According to him, the role of the teacher is being guide to the students. He defined teacher’s role like “The role of the teacher should be guide. Students can learn in any case if you show them the way to reach the information." Although Mr. Kuzu thought that the role of the teacher should be guide, I observed his role as a deliverer of the information or teller during the instruction. He gave all the information, solved problems, told students to take notes, and gave examples, in short, he took the lead of the instruction by himself.

Mrs. Akman had traditional view of teacher roles in both her ideal and working beliefs. She stated that teacher is the deliverer of information and therefore, she liked to teach the topics which could be more understandable for students when teacher taught it. She said that

> Chemistry teacher would be a chemistry teacher only if she can teach the quantitative relations to the students. Therefore, I like teaching topics mole, chemical reactions or gases that includes quantitative relations and could be more understandable for students when I explain as a teacher.

During her instruction she behaved as she explained during the interview and took the lead of the class while teaching the mixtures topic and did not give opportunity to students to actively participate in the instruction.

Mr. Kuzu's ideal belief about identifying whether students understood or not was transitional and his working belief was traditional. He knew whether his students understood or not from their affective responses. He gave an example to this situation, as "I understand it even from their eyes. When they look at me distressfully, it means they could not understand." During the instruction when Mr. Kuzu finished what he intended to teach about the topic he only asked students "Do you have any questions?" If students do not ask any questions, he assumed they understand what he taught. However, he did not investigate whether students really understand or they pretended to understand the topic or not. If students ask questions, he gives the response and supposes that they have understood without further investigation of their understanding and continue to the lesson.

Mrs. Akman had instructive beliefs about identifying whether students understood or not in both her ideal and working beliefs. She determined whether students understood or not by asking questions after teaching the topic and monitoring their responses to these questions. During the instruction most of the time she used informal questioning and asked questions to students. Depending or their responses being wrong or correct, she determined if students understood or not.

Mr. Kuzu's and Mrs. Akman's both ideal and working beliefs about determining what to teach and what not to teach was traditional. Mr. Kuzu was strictly bounded to the curriculum goals and objectives and considered them during the instruction. He thought that there was nothing that prohibited him to get out of the curriculum. Still, he regarded the limits of the curriculum because he thought that once he exceeded the limits of the curriculum there was no end. He stated,

> We have a curriculum, goals, and objectives. We have boundaries. Curriculum draws that boundary and you have to obey it. For instance, we are supposed to give percent concentration by mass and ppm about solutions. However, molality and normality is out of the curriculum this year. Nobody can prevent me from giving molality and normality but when I digress, there is no limit. So I have to obey the rules and boundaries of the curriculum.

Likewise Mr. Kuzu, Mrs. Akman stated that she decided what to teach and what not to teach by considering curriculum and she stated that "Curriculum directs us already. I am obeying the sequence stated in the curriculum, not teaching randomly." So indeed Mr. Kuzu and Mrs. Akman followed what the curriculum stated and made their decisions regarding to teach or not to teach a topic in the light of the curriculum objectives.

Mr. Kuzu's and Mrs. Akman's both ideal and working beliefs about the time to move on a new topic was instructive. Mr. Kuzu said, "Student reaction is the best measure for it. I ask questions about what they learnt to decide what to do. If they are able to answer my questions, it means we can move on." Similar to Mr. Kuzu, Mrs. Akman stated that "It depends on the feeling I get from the students. If I feel they got it, I move on." In real practice, I observed exactly what Mr. Kuzu and Mrs. Akman mentioned during the interviews. When they finished the topic, they asked questions to the students and solved problems with students. If students could answer the questions or solve the problems, they moved on to the new topic. If students failed to answer correctly, they solves more problem about the topic until students are able to solve the problem by themselves.

Mr. Kuzu's ideal belief about how students learn science best was transitional while his working belief was instructive. Mr. Kuzu stated that students learnt science better by conducting experiments and doing demonstrations. He explained his ideas as "They learn better by conducting laboratory experiments and demonstrations. It is related to how many senses you appeal to while teaching. The more they conduct experiments, the better they learn." However, Mr. Kuzu did not conduct any laboratory experiments or demonstrations. He chose to show videos of laboratory experiment that did not allow students to use as many senses as Mr. Kuzu stated. In real practice, Mr. Kuzu explained important concepts didactically to students and wanted them to take notes about what he explained. Then he gave examples about the topic and then wanted students to give more examples. He asked questions and solved problems, and after that, he asked a problem to students and wanted them to solve it. Science learning in Mr. Kuzu's class was more like mimicking the teacher and in this way his students' science learning was instructive more than transitional.

Mrs. Akman's both ideal and working beliefs about how students learn science best was instructive. During the interview she stated that she has a motto for the best way of learning and explained her motto as

> Students learn better by listening to the teacher and taking notes. Solving questions and asking the ones they are not able to solve. I have a motto,

> LRSA, Listen, Review, Solve questions and Ask Questions. LRSA, it is my motto, in other words the way to the success.

During the instruction she implemented the things taking place in her motto. She always wanted her students to listen to her very carefully while teaching the topic and review their notes after the instruction. Then she gave questions for students to solve as homework, and in the next lesson she wanted them to ask the questions they are not able to solve to her, and they solve them together.

In determining when learning is occurring in his classroom, Mr. Kuzu was instructive in both his ideal and working beliefs. He gave homework to the students, mostly problems about the topic covered. Students solved the problems and if they did not have questions or anything to ask, he assumed that students learn the topic. He clarified this situation as

> I give them time at the beginning of the lesson. They ask their questions that they have difficulty in understanding and I solve them. If it is needed, I summarize the topic briefly if we have enough time. However, if students have too many questions to ask I postpone answering their questions to the break time. I listen to their questions, answer them one by one until I feel sure they got the point.

Quite similar to Mr. Kuzu, Mrs. Akman had instructive beliefs about determining when learning is occurring in the class both in her ideal and working beliefs. She gave homework to the students and controlled them in the classroom the following day if students did or not. If students had difficulty in doing the homework, they asked their questions at the beginning of the class. If they did not ask any questions Mrs. Akman assumed that students learnt the topic.

4.1.1.3. Beliefs about the Nature of Science

In order to examine participants' beliefs about the nature of science only results of the analysis of their responses to the VNOS-C questionnaire was used. Due to the fact that teachers' did not consider any aspect of NOS during their instruction throughout the teaching of mixtures unit, observations cannot be included to the analysis of teachers' beliefs about the nature of science. At the end of the unit, when participants were asked the reason of not focusing on the NOS Mr. Kuzu responded that

> It would be better if we mention about how scientific knowledge change and develop but we stuck in traditional topics and we tend to emphasize some specific concepts more than the others. Therefore, after a while, we get used to focusing on that particular concepts. Also nature of science is not a subject that is asked in the examinations so that, needless to say, it does not attract students' attention. For this reason they are not interested in the nature of science as a subject.

From these explanations of Mr. Kuzu it is obvious that his ongoing habits and students' indifferent manner to the NOS were the reasons of not focusing on the NOS in his classes. While Mrs. Akman was asked the reason of not emphasizing the NOS in her instruction she responded that

> I don't know, I have never think about it. We needed to have additional time to spend for teaching of NOS but the existing topics are already too intense and loaded. What if we also try to teach the NOS? We can never complete to teach the existing topics. Furthermore, in the nationwide examinations we did not encounter questions about NOS; therefore, I think we don't need to spend time to cover it.

While Mr. Kuzu mentioned about the ongoing habits and nationwide examination as the limiting factor of not emphasizing the NOS in the instruction, Mrs. Akman claimed time limitation as a reason besides nationwide examinations. To summarize, three main assertions manifested from participants' responses as the reason of not emphasizing any of the NOS aspects during their teaching which are time limitation, their ongoing habits, and nationwide examinations not including questions about the NOS.

On the other hand, teachers' responses to the VNOS-C interview was examined by using seven aspects of NOS which are tentative, empirical, inferential, creative and imaginative, sociocultural and subjective NOS, and theory and law under three categories: naive, transitional, and informed view of NOS (Table 11). Detailed explanations about participants' beliefs about the nature of science was given below.

Table 11. Participants' beliefs about the nature of science

NOS Aspects	Mr. Kuzu	Mrs. Akman
Tentative NOS	Informed	Informed
Empirical NOS	Informed	Informed
Inferential NOS	Informed	Naive
Creative and Imaginative	Informed	Informed
Sociocultural NOS	Naive	Naive
Subjective NOS	Transitional	Transitional
Theory & Law	Informed	Naive

4.1.1.3.1. Tentative NOS:

Mr. Kuzu had an informed view of tentativeness aspect of NOS. He believed that scientific knowledge may change in time. He gave the atomic theories as an example of the tentative nature of science. He attributed this change to the increased opportunities with time that lead scientist to reconsider the new evidence. He responds the question "After scientists have developed a scientific theory does the theory ever change?" as

> Sure, it does change. For instance, Dalton's atomic theory, Rutherford's atomic theory etc. changed. It is related to the opportunities the scientists have. Scientist might accept something right within the bounds of possibilities in the past. However, when they deal with the details of it

> today with more broad opportunities and new evidences, it can actually turn out to be different from the previously accepted one. An atomic theory may be valid just for 8 years. For instance, after 8 years Thomson had proposed his atomic theory, his student proposed another theory claiming that his theory has had some drawbacks. Because his students get some new information, reconsider his theory with new information at hand and propose a different theory. Therefore, it is related to the opportunities that scientists have. Sometimes theories may even turn out to be totally wrong after getting some new evidences.

Mr. Kuzu thought that scientific knowledge was tentative, but he also supported to teach the past theories to the students because it was important to know the sources of the new theories to learn them in an effective way.

> It is impossible to teach current theories unless we teach how they developed. We provide students keep current theories in mind better by teaching their history. Besides, we explain how scientists suffer throughout the development of science. Some scientists have difficulties throughout their lives to contribute to the science. Now we see it something ordinary however, at those times they were even decapitated because of their ideas. You cannot teach new theory without teaching the old one. Students cannot understand why they changed. Then it becomes more clear and logical why we teach the events in time sequence.

Mrs. Akman had informed view of tentative nature of science. She believed that scientific knowledge may change throughout time. When she was asked whether scientific knowledge change or not she answered:

> It does change. We teach nucleus as consisting of protons and neutrons but scientists discover 31 different particles. I think many of them will contribute to produce energy in the next century. Now we are talking about what is known but I am sure in the next century many of them will change.

She gave an example to the tentative nature of science as:

> For instance many of the chemistry topics there are some hypotheses, but it does not mean that they will not be changed in the following century. When I started teaching there were 102 elements, then it was changed to 112, and today there are 118. It means it changed. There were A and B groups at the periodic table, they even changed.

4.1.1.3.2. Empirical NOS:

Mr. Kuzu had an informed view of the empirical nature of science. He emphasized the role of observations and experiments and he gave examples and explanations clearly to differentiate science from other disciplines of inquiry. For him science

> Is an involuntarily existing phenomenon revealed by scientific methods even if it is not directly seen but can be supported by experiments? For instance, mathematics is not science; it is the way of humans' thinking or a language created by humans' themselves.

He thought that science was different than other disciplines of inquiry because science is real and it is an observable phenomena that can be supported by experiments. For him the main difference between science and the other disciplines of inquiry was that science was supported by observations and experiments. He explains the difference between religion and science as

> Religion is faith; it may or may not be real. It is only related to the feelings. What you think right may be wrong to the others, because it is *vis a vis*; however, science is not. For instance, the existence of atom is not the subject of faith. You cannot see it, you cannot touch it but you know that it exists by observing, using experiments with light or some materials. Most probably, the main difference between religion and science is this.

Mrs. Akman had also informed view of the empirical nature of science. She thought that experiment means observing the phenomena and observation was required in order to develop scientific knowledge. She gave example to this claim as "basic chemistry laws were even developed by performing experiments. Lavoisier discovered the law of conservation of mass by conducting experiments." When she was asked if there is a difference between science and other disciplines of inquiry she answered that the difference was

> Conducting experiments and observations and determining as a result of them. In religion and philosophy you determine by thinking. They are like

> the products of ideas. However, in science you verify something by testing. Science differentiates from other discipline of inquiry because of its empirical nature. Therefore, scientific knowledge can change, but I don't think religious knowledge can. On the contrary, it is expected to proceed without changing. However, we should be ready for any changes in chemistry.

4.1.1.3.3. Inferential NOS:

Mr. Kuzu had an informed view of the inferential nature of science. He believed that scientists do not need to see the phenomenon directly to make scientific claims. They could make inferences based on their observations and experiments. He explain his idea as

> As a result of their experiments, they assume, no not assume, but infer, they infer from it. For instance today scientists explain Big Bang Theory by supporting it with all the other theories, theories of light, spectrum, photoelectric etc. Scientist do not need to see it exactly to explain it, they support it with experiments or observations. When the atomic theories proposed, did the scientists see the atoms? Even Dalton proposed that the number of atoms will be conserved, if there is conservation of mass. He did not see the atoms but he make inferences depending on his observations and experiments.

In spite of Mr. Kuzu's informed view of inferential nature of science, Mrs. Akman had a naïve view. She believed that scientists proposed atomic models by doing experiments and using measurement devices. She did not mention about the inferences of scientist derived from the observations.

> Mrs. Akman: There is a measurement device. What was that? By using it. I suppose they determine the shape of atoms by performing experiments. How certain are they even if they don't see it?
> Researcher: Yes.
> Mrs. Akman: If we think in this way there will be no chemistry. They have to base on something.
> R: What do they base on?
> Mrs. Akman: Experiments.

4.1.1.3.4. Creative and Imaginative NOS:

Mr. Kuzu had an informed view of creative and imaginative nature of science. He thought that scientists utilize their creativity and imagination throughout their research and they have stronger foresight than the other people. When he was asked if scientist use their creativity and imagination during their investigation he responded:

> Exactly. That is the most important characteristics of the scientists. They have stronger foresight and more creativity than any other person has. Sometimes in my classes I joke “Even scientific dreams are held by a scientist.” He discovered the formula of benzene after having a dream of snake seizing its own tail. But if any other person has this dream, they said what a bad dream I have.”

Similar to Mr. Kuzu, Mrs. Akman had an informed view of creative and imaginative nature of science, too. She believed in order to be successful, scientists had to use their creativity and if they did so, they can make a discovery. She answered the question of whether scientists use their creativity or not as:

> They have to use, if they were successful they had used though. They think sophisticated, I suppose. For instance, Kekule proposed the ring structure of benzene after he had had a dream. He discovered it in his dream which means he was so into it. Therefore, if scientists devote themselves to discover, they can discover.

4.1.1.3.5. Sociocultural NOS:

Mr. Kuzu had a naive view of social and cultural nature of science. He believed that science should be universal and should not be affected by cultural and social values. He explained his ideas about the sociocultural NOS as

> I believe in both of them. Science is international and universal. Actually, it is the favored one, because science is above all nations and cultures. However, every nation has its own biases and ideas and science may be affected from it. For instance, why science didn’t develop at the cultures under the sway of Islam although these cultures have great impact on science development at the past? Therefore, science is affected by cultural

> values, in this case adversely. It is favored not being affected by cultural values; however, it is.

Mrs. Akman had naive view of sociocultural nature of science, too. She believed that science is universal but also she believed that it is affected from the cultural values. Her views included contradiction in itself.

> Mrs. Akman: I believe science is universal. It is not just the concern of where it is discovered. There is sharing. What is discovered is used by the other countries as well. None of the scientist discovers or produces solutions just for his country. All countries use it. However, scientist may be affected from the conditions in his country. If a country does not support the scientists, science does not develop.
> R: How so?
> Mrs. Akman: It is affected from the financial or political situation of the country. Science cannot be developed if necessary attention is not obtained from the public. Scientists refrain from discovering something or maybe announce what they discover.
> R: This kind of reasons…
> Mrs. Akman: For sure, we cannot even speak up about evolution theory.

4.1.1.3.6. Subjective NOS:

Mr. Kuzu had a transitional view of subjective nature of science. He accepted that scientists may interpret the same data in different ways, because of the reason that they just used some indicators which were not adequate for them to make the same claim. However, while explaining the reason of the subjectivity he did not emphasize that it was because of the fact that backgrounds and accumulations of the scientists were different. When he was asked the reason of scientists' different interpretations on the same data he responded:

> Scientists use the available data and propose a theory. While proposing a theory, they may interpret the available data in different ways and their conclusions may vary, because ultimately they just use a set of indicators. Now it is overrun with the technologies but it is similar to this example: sometimes doctors examine the same person, while one says, he is patient and the other says he is not. It is because of the difference in their interpretations, because doctors don't have the possibility of giving a definite judgement and no possibility of trial. Although they are using the

> same data, they may interpret it in different ways. Whoever defends the data using the correct means will be right.

Likewise Mr. Kuzu, Mrs. Akman had a transitional view of the subjective nature of science. She recognized knowledge or backgrounds of scientists; however, she could not defend her ideas with broad explanation and clear examples. When she was asked how scientists derive different conclusions although they use the same data she answered

> I am not sure but I suppose they have different perspectives. Even in daily life sometimes, you listen the same event from two different persons, and you feel like they are not talking about the same event. I think because of the variety in scientists' knowledge and accumulation, their interpretations vary too. I am not sure but I am just interpreting.

4.1.1.3.7. Theory and Law:

Mr. Kuzu had an informed view about what theory and law were and the differences between them. He defined theory and law and gave an example to them as

> Theory is kind of the explanation of law. Law is the relationship between the observed variables. For instance, under certain conditions, when temperature increases, pressure increases too. It is a law. The explanation of the increase in pressure with increasing pressure is the theory. Theory could have some drawbacks but it is the best possible explanation of the law.

Mr. Kuzu thought that the role of the theories and laws are different in science. He saw theory as the best possible explanation of law. He explained the difference of theory and law from each other by giving law of gravity as an example.

> They are different from each other but also they support each other. As far as I know, you need a theory to explain law of gravity. It is written as F=m.a; but how do you explain it? You have to support it with a theory.

> Therefore, theory is the best logical explanation of law possible at that period.

Mr. Kuzu thought that law and theory did not turn into each other and there was no hierarchy between them.

> There is nothing like theory turns into law or law turns into theory. They are not independent from each other but they also they don't have tendency to turn into each other. It is just theory is used to explain law.

Unlike Mr. Kuzu, Mrs. Akman had naive view about the role of scientific theory and law. She thought that there is a hierarchy between theory and law, and theory may become law if it was supported by experiments. Although she thought that theories and laws may change, her ideas depended on the hierarchy between theory, law and hypothesis. Here is an example dialog between Mrs. Akman and the researcher:

> R: Is there any differences between theory and law?
> Mrs. Akman: For sure, there are differences. If it is supported by experiments it becomes a law, if not supported it stays as a hypothesis. If theories become law it means they are exact. If it stays as a theory, it means scientists still perform experiments on it.
> R: What about law? Do they ever change?
> Mrs. Akman: It is more exact than theory. However, when existing theories are changed and new theories are proposed, if the new theories become laws, they change. They are not articles, even articles are changed, why not laws.

4.1.2. Knowledge of Learner

This component of PCK was examined under three dimensions which are learners' pre-requisite knowledge to learn the topic, learners' difficulties and their misconceptions. Mr. Kuzu's and Mrs. Akman's summary table for knowledge of learner was given in Table 12.

Table 12. Mr. Kuzu's and Mrs. Akman's knowledge of learner for teaching mixtures unit

Knowledge of Learner	Participants	Description	How to detect/ overcome	Time to elicit	Purpose of detecting/ overcoming
Pre-requisite Knowledge	Mr. Kuzu	Students should have pre-requisite knowledge about the topic as they are familiar to the topic from previous years	By asking questions to the students, elaborating the answers by himself	Before starting to the new topic	Remind what students know to make their understanding of the new topic effective and easier
	Mrs. Akman		By asking questions to the students, letting them to elaborate the answers		
Learners' Difficulties	Mr. Kuzu	Students do not have any difficulty about the topic because they are familiar to it from previous years	By giving the explanation	During the teaching of the topic	To make students understanding easier
	Mrs. Akman				
Misconceptions	Mr. Kuzu	Does not expect any misconception Aware of possible misconceptions	By giving the correct explanation	During the teaching of the topic	To eliminate misconceptions
	Mrs. Akman	Expect students to have misconceptions Aware of possible misconceptions			

4.1.2.1. Pre-requisite Knowledge

In the interview about PCK components, Mr. Kuzu stated that "what students know about the topic that is going to be taught is important for effective understanding of the topic. Not only for chemistry but for all subjects." Due to the fact that students are familiar to the "mixtures" unit from their previous years and daily life, Mr. Kuzu thought they have some prerequisite knowledge about the unit. Nevertheless, most of the time he emphasized the prerequisite concepts and explained them again and again when necessary. For instance while teaching *like dissolves like* principle he reminds students what a nonpolar compound was as "Like dissolves like, nonpolar dissolves nonpolar. You have to know what nonpolar compound is from previous years. It is a compound with symmetric molecules that has no positive or negative poles exist." Mr. Kuzu usually asks questions to detect students' prerequisite knowledge before starting a new topic to remind students the knowledge they should know to understand the new concept. Before starting to teach the solubility concept he asked students the definition of solubility and the following conversation happened:

> Mr. Kuzu: What do you think solubility is?
> Student 1: Isn't it splitting of a matter into its ions when it is placed in a solvent?
> Mr. Kuzu: It can dissolve as a molecule as well.
> S1: Yes it can. It is splitting of a matter into its particles when it is placed in a solvent.
> Mr. Kuzu: First of all let's remember 9th grade. What kind of interactions are there between the molecules?
> S2: Ionic and covalent.
> Mr. Kuzu: I am not talking about chemical bonds. Let's see how much you remember. Ionic and covalent bonds are chemical bonds, put them away. Between the molecules there are London forces, dipole-dipole forces… (and so continues)

Even if Mr. Kuzu asked questions to detect students' prerequisite knowledge most of the time he himself explained all the necessary information after getting the responses of the students as it could be seen from the above dialogue. He did not let students to elaborate what he asked and took the control immediately.

Similarly, before starting the boiling point concept he explained vapor pressure in every detail to the students and then he said "Why did I explain vapor pressure? To explain boiling point better because I teach boiling point depending on vapor pressure."

When Mrs. Akman's interview about PCK components was examined it was seen that Mrs. Akman thought prerequisite knowledge was important for students to understand the new topic more easily because if they know something about the topic it would be easier for teacher to construct new knowledge on it. Like Mr. Kuzu, Mrs. Akman stated that students had to know something about mixtures unit because they are familiar to the topic from previous years. She mentioned that "Until from primary school they have heard about mixtures concept. They can give examples to mixtures and know the differences between homogenous and heterogeneous mixtures. However, they don't have to know how dissolving occurs yet."

Mrs. Akman's purpose and time of using prerequisite knowledge was the same with Mr. Kuzu. She used prerequisite knowledge of students before starting a new topic to remind it to the students to make their understanding of the new topic easy. However, unlike Mr. Kuzu she always elicited students' prerequisite knowledge by asking questions and waiting for an answer from them. For instance, before starting to teach like dissolves like she tried to remind students the chemical bonds and polarity by asking the following questions and waiting for students' answers until they find the correct one. She started the discussion environment by saying "Ok let's remember the chemical interactions. What are the chemical bonds? Bonds that are between the atoms of a molecule?" or "We always repeat like dissolves like. So, which characteristics of these two molecules are similar? Do you have any idea?" and then students began to discuss and tried to find the correct answer for a while.

4.1.1.2. Learners' Difficulties

In the interview about PCK components Mr. Kuzu stated that he realized students may have difficulties about the topic if he spent too much time due to students' questions or if students explicitly mentioned that they did understand. When he was asked the possible difficulties of students about "mixtures" he answers that it was an easy topic to understand but students may have difficulties about understanding how solubility occurs due to lack of knowledge about the intermolecular forces from the previous year.

Mr. Kuzu generally gave the correct explanations of the possible difficulty directly during teaching of the topic even though students did not reveal any indications of having difficulty. He mentioned that he gave the correct explanations of the possible difficulty to draw students' attention in case they might have that difficulty. For instance while he was teaching saturated solutions he provided the following information "…then the rate of dissolving decreases, precipitation increases and finally they become equal to each other but we cannot see it because it occurs in the sub-atomic level. We see it something stable" in case students had difficulty to understand that the rates of dissolution and precipitation are equal to each other in saturated solutions because of its sub-atomic nature.

Sometimes Mr. Kuzu gave the correct explanations of the difficulty directly after students asked question about the topic. For instance when he was teaching heat change in solutions he draw the graph in Figure 12 on the board and the following dialog passed between a student and Mr. Kuzu:

> Mr. Kuzu: X, Y, Z, L could be solid or liquid. They cannot be in gaseous state. Dissolving rate of all increase with increasing temperature.
> Student: I don't understand why they cannot be in gaseous state?
> Mr. Kuzu: Because dissolving of all gases is exothermic. If we show it in equation heat will be written on the left side of the equation. *(writes the equation… $X_{(s)}$ + heat $\rightarrow X_{(aq)}$)* What does it mean? It means the reaction is endothermic. It absorbs energy from environment while dissolving and

> the environment gets cold. What if it is a gas? *(writes the equation… $X_{(g)}$ → $X_{(aq)}$ + heat)* It is exothermic. It means it releases energy to the environment.

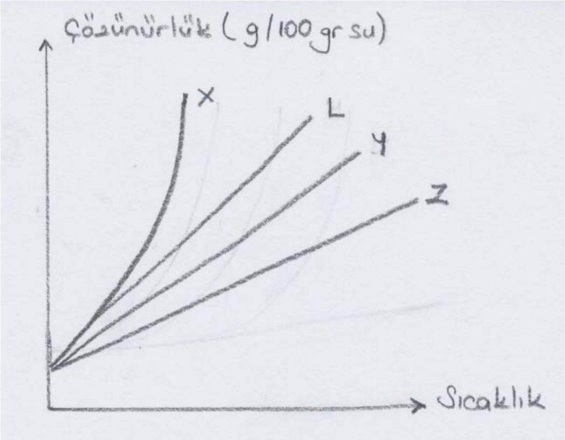

Figure 12. Solubility-Temperature graph for various chemicals drawn by Mr. Kuzu

Mr. Kuzu also used letters like X, Y, Z, L instead of using real chemicals. He needed to use real chemicals in order not to lead students to a misunderstanding about chemistry.

Similar to Mr. Kuzu, Mrs. Akman did not think that students had difficulty in understanding mixtures unit because they were familiar to this unit from their middle school. She also mentioned about the possible difficulty of students to draw their attention in case they had difficulty by giving the correct explanations directly during the teaching of the topic. For instance, while teaching the types of solutions she warned students about the possible difficulty of classifying the solutions as

> A solution could be saturated, unsaturated or supersaturated. Don't confuse it with the classification of diluted and concentrated. It does not mean that if a solution is saturated it is also concentrated or if it is

> unsaturated it is also diluted. They are different classifications and don't have to be comparable to each other.

4.1.1.3. Misconceptions

In the interview about PCK components Mr. Kuzu stated that he did not expect students to have misconceptions but they might have deficient knowledge in "mixtures" unit. Even though he thought that students did not have misconceptions in mixtures unit, he emphasized some misconceptions during instruction to eliminate them. While teaching unsaturated-saturated and supersaturated solutions he emphasized the difference between saturated and supersaturated solutions as

> A solution containing undissolved solute is a saturated solution not supersaturated one. Write it down on your notebook. Every solution that is in equilibrium with undissolved solute is a saturated solution. Sometimes I draw a solution that is in equilibrium with undissolved solute and ask the type of the solution. You (students) immediately respond the question as supersaturated solution which is wrong.

To eliminate the possible misconception of "a solution containing undissolved solute that is in equilibrium with dissolved solute means supersaturated solution." When he was asked the reason of emphasizing those misconceptions he told that "because I remember students may have these misconceptions from my experience with former students in my previous years of teaching."

The misconceptions were usually emphasized during the teaching of the topic. Mr. Kuzu did not implement anything to detect students' possible misconceptions about the topic. Most of the time he explained the correct way of the misconceptions directly by himself, but sometimes he asked questions about the misconceptions to the students and waited until he got the correct answer and then explained the correct way of the misconception.

> Mr. Kuzu: Not all but aqueous solutions of many acids bases and salts are conductive. How much do they conduct?

Student1: very much.
Student 2: it depends on their degree of ionization
Mr. Kuzu: This is the correct answer. It does not conduct (electricity) well if it dissolves highly. It conducts well if it ionizes highly.

Sometimes during teaching of the topic, he mentioned about the possible misconceptions spontaneously even if the misconception was not directly but indirectly related to the topic. For instance while he was teaching the difference between ionization and dissociation he gave dissociation of ethyl alcohol in water as an example and mentioned about a misconception about acids and bases indirectly related to the dissociation of ethyl alcohol in water.

> Let's have a look at ethyl alcohol, C2H5OH, it dissolves in water, but not ionizes. There is OH in its structure but for sure not every substance that contains OH is base. Even though we label alcohols as neutral substances they have slightly acidic properties; however, when they dissociates in water they maintain their molecular integrity.

Differently from Mr. Kuzu, Mrs. Akman was aware of students' possible misconceptions and stated that students might have misconceptions about differentiating melting and dissociation, and ionization and dissociation. During the interview about mixtures unit she said that "Most of the time I hear them saying "sugar melts in the tea" but in this unit they will learn that it does not melt but dissociates." She eliminated students' possible misconception by asking questions to understand what students know about the topic and then explain the correct answer. The following dialogue is an example to the situation of trying to eliminate the possible misconception "Ionization and dissociation are the same thing."

Mrs. Akman: What if I say dissociation and ionization? Are they the same or different concepts and why?
Student: They are different.
Mrs. Akman: Can you prove it?
Student: A matter can dissociates and give ions to the solvent, however, another matter can dissociate but can't give ions to the solvent.

> Mrs. Akman: That's true. So we can say that… (and repeat exactly what the student said)

Sometimes she detected misconceptions, as a result of students' responses during informal questioning. For example, she asked students to give examples to the solutes and solvents that can dissolve in each other and a student answered it as "Ice dissociates in water" and then she began to elaborate the response of the student and mention about the differences between melting and dissociation.

4.1.3. Knowledge of Curriculum

This component of PCK was examined under five dimensions which are knowledge of goals and objectives of chemistry curriculum, relating the mixtures topic to other topics vertically and horizontally, relating the mixtures topic to other disciplines and altering the curriculum. Mr. Kuzu's and Mrs. Akman's knowledge of curriculum considering the sub-components was given in Table 13.

4.1.3.1. Knowledge of Goals and Objectives

Mr. Kuzu knew all the goals and objectives stated in the curriculum because when the new curriculum was released, he examined it in every detail. He attributed his well-informed knowledge of goals and objectives to writing books for HEE and UPE. "I know every single detail, I have to, because I am writing books about them. During the interview about PCK components and mixtures Mr. Kuzu gave examples to the objectives without getting help from the curriculum because he knew all the goals, objectives, suggestions and limitations. "This unit is composed of basically from 3 parts: homogenous mixtures, heterogeneous mixtures and separation methods. We will start with classifying the mixtures and then learn every detail of the homogenous mixtures… " During the instruction he covered each objective one by one and did not eliminate any objective. When he was asked the reason of his precision

Table 13. Mr. Kuzu's and Mrs. Akman's knowledge of curriculum for teaching mixtures unit

Knowledge of Curriculum	**Participants**	**Description**	**How to use**	**Time to use**	**Purpose**
Goals and objectives	Mr. Kuzu	Rely on his knowledge because he examined the curriculum in every detail	Mention about all the objectives without ignoring any point	During planning and teaching	To teach the topic as it is stated in the curriculum
	Mrs. Akman	Does not rely on her knowledge because of the frequent curriculum change	Mention about the objectives at the minimum basis		
Vertical relations	Mr. Kuzu	Give importance to relate the new topic to the previous and next grades	By asking questions or reminding the previous topics	During teaching	To increase students' understanding of the new topic
	Mrs. Akman				
Horizontal relations	Mr. Kuzu	Effective relations	By asking questions or reminding the previous topics	During teaching	To increase students' understanding of the new topic
	Mrs. Akman	Superficial relations			
Relation to other disciplines	Mr. Kuzu	-			
	Mrs. Akman				
Altering the curriculum	Mr. Kuzu	Add some topics that are not stated in the curriculum	Use the topics that are not stated in the curriculum while teaching the new topic	During teaching	To make the topic clearer for students
	Mrs. Akman				To help students understand better and solve questions easily

about mentioning all the objectives he said "You may have your own objectives as a teacher but there are also curriculum objectives and sub-objectives. If you get out of these objectives there is no limit. Therefore, you have to give curriculum objectives without digressing."

Mr. Kuzu did not ignore any objectives stated in the curriculum about mixtures, however, he sometimes mentioned about topics or concepts that were not covered in the mixtures curriculum even if he told that he strictly bounded to the curriculum objectives. He explained the aim of emphasizing those topics or concepts as to make the curriculum objectives clearer for students. He stated that he covered the topics and concepts that were not stated as objectives in the mixtures curriculum because he wanted "to make objectives of the mixtures unit more understandable to students, but not to teach the other topics."

Unlike Mr. Kuzu, Mrs. Akman did not rely on her knowledge about the goals and objectives because of the change in the curriculum. She stated that

> Due to change in curriculum I don't feel competent on my knowledge of curriculum. I only know the unit I am going to teach but not the rest. I am now studying on mixtures unit, but I have no idea about what students are expected to learn, what they should know…etc. about the next units. I am not so much aware of them.

Mrs. Akman added that if curriculum hadn't been changed she wouldn't feel any difficulty on her knowledge of goals and objectives of the curriculum. About mixtures unit she knew the goals and objectives stated in the curriculum because she examined this unit from the curriculum. Quite similar to Mr. Kuzu, Mrs. Akman also did not ignore the objectives stated in the curriculum but added some more besides the stated objectives due to the necessity. She said "As far as I see calculations about concentration is not included to the curriculum. I think chemistry curriculum becomes more verbal and the objectives are more limited in this curriculum than it is in the previous one." Further information about the change in the objectives is given at the Altering the Curriculum part.

4.1.3.2. Relating to the other topics

Relating mixtures unit to the other chemistry topics was given in two sub-topics which are vertical relations and horizontal relations.

4.1.3.2.1. Vertical Relations

Mr. Kuzu gave importance to relate the new topic with the necessary topics at lower and higher grades. He especially used vertical relations with previous grades to remind students what they have already known to increase the effectiveness of students' understanding of the new topic. Before starting to teach solubility concept he asked students "First of all let's remember 9th grade. What kind of interactions are there between the molecules?" to remind the interactions between molecules and similarly before starting the endothermic process of solubility topic, he reminded bond concepts as "… we covered it at 9th grade, a compound has to be more stable than the separated atoms; therefore, it could have lower energy…" to the students.

Usually he related the new topic to the topics that students are not familiar yet but will be in the next grades. For instance when teaching the units of solubility he said "When we define solubility we use 100 cm3 instead of 1L. We will use 1L at 11th grade." He explained the reason of relating the new topic to the next grades' topics "what we are covering at 10th grade will be the pre-knowledge of the topic of next grades. So I want them to be familiar to the concepts of the next grades." The following explanation of Mr. Kuzu to his students is a good example to the situation:

> …an interaction formed between the solute and the solvent. We covered the interactions at 9th grade. When the interaction between solute and solvent is stronger than it is between solute and solute especially when it is an ionic compound… we will see it at 11th grade again. It was in 9th grade, now is at 10th and will be at 11th.

Mrs. Akman also related the new topic to the topics of previous or next grades. The topics she made connections were chemical bonds from 9th grade and enthalpy from 11th grade. She talked about chemical bonds for one class hour before starting to teach like dissolves like because she thought that reminding this topic to students was important for students' understanding of the dissolution clearly and solving the questions about this topic. She reminded students all the intramolecular and intermolecular forces, and their detailed explanations during the instruction.

Mrs. Akman mentioned about the enthalpy topic to help students solve the questions easily. She taught differences between physical change, chemical reaction and nuclear reaction, enthalpy concept, bond enthalpy and enthalpy of a reaction. These topics were not stated in the 10th grade curriculum while teaching of the mixtures unit.

4.1.3.2.2. Horizontal Relations

Mr. Kuzu also emphasized horizontal relations between mixtures and other units of the 10th grade when necessary. Before mixtures unit, Acids-Bases and Salts unit had been covered. Mr. Kuzu related mixtures unit to Acids-Bases and Salts unit while he was teaching conductivity in aqueous solutions as "Not all but aqueous solutions of many acids bases and salts are conductive. How much do they conduct?" and dissolving of solids and liquids as

> Aren't there any solid or liquid substances that release heat when dissolving in water? There are, we have covered it. Sulphuric acid release heat when dissolved in water. Then you don't have to add water into acid but acid into water.

Sometimes Mr. Kuzu related the new topic to the topics placed in the next units. Chemistry is All Around is the last unit of 10th grade and Mr. Kuzu related this unit to the mixtures unit while teaching supersaturated solutions like "… so if you wonder why don't commercial jam precipitate, there are some chemicals in them. We will see those chemicals in the class at the later in this year. They inhibit precipitation of the jam."

Mrs. Akman also related the new topic to the previous ones. It is only observed for twice, relating mixtures unit to Acids-Bases and Salts; however, these relations were made superficially without emphasizing them too much or giving detail. For instance, during the teaching of the conductivity in aqueous solutions, Mrs. Akman related acids-bases and salts to this topic; however, she just mentioned it in a sentence and did not emphasize it in detail. Likewise, while teaching solubility of salts she gave calcium carbonate ($CaCO_3$) as an example to insoluble salts and stated that students should be familiar to this salt from the previous unit.

4.1.3.2.3. Relations to other Disciplines

During the observations of Mr. Kuzu's and Mrs. Akman's classes, they only mentioned a relation to Mathematics. Especially during problem solving about *mixing different solutions* most of the time they mentioned that these problems were related to mathematics, except the content of them was chemistry. For instance while solving problem "What will be the final concentration of 180 grams of 40% sugar solution if we add 120 grams of pure water into it?" Mr. Kuzu stated "These are not the subject of chemistry actually, it is more related to mathematics, it is about ratio and proportion, but curriculum assign a mission to us too" to relate chemistry and mathematics. Similar to Mr. Kuzu, while solving problems about solubility Mrs. Akman stated that "Guys it is not needed to be chemistry, in our daily life we even use ratio and proportion. We also use them in Mathematics. You should be familiar to them."

4.1.3.3. Altering the Curriculum

As mentioned before Mr. Kuzu knew the goals, objectives, limitations and the list of the concepts to be covered that were stated in the curriculum very well.

During the interview about mixtures he said that he would not remove any topic but he would add some to make the concepts clearer for students even though he emphasized that he was strictly bounded to the curriculum. For instance, he said he would explain the concepts of vapor pressure and concentration, although they were not stated in the curriculum, as to make the new topic clearer for students and to be pre-knowledge for 11th grade units.

While teaching factors effecting solubility he mentioned about types of solute and solvent, pressure and temperature effect in details. Then he said "Let's write the forth factor. It is common ion effect. You don't have to concern too much but I still want to mention about it." He mentioned about common ion effect although it was not stated in the curriculum goals. Likewise, even though problem solving about solubility was not stated in the curriculum goals he solved problems in the class mentioning "Now we are going to solve one or two problems about solubility even if it is not stated in the curriculum." He explained the reason of emphasizing these topics although they are not stated in the curriculum as

> Before the curriculum change common ion effect and problems about solubility are stated in the curriculum goals, but in the new curriculum they are not. I still mention about them briefly to make the students aware of them in case they encounter with them.

The most important change in the curriculum was made by Mr. Kuzu during the teaching of the like dissolves like principle. He wanted a student to answer a question about the principle and student said that she did not know what polar and nonpolar meant. Then the following dialogue occurred:

> Mr. Kuzu: Can you answer the next question with its reason?
> Student: According to like dissolves like principle, polar solvents dissolve polar solutes and nonpolar solvents dissolves nonpolar solutes. Which of the following pair is not expected to dissolve in each other? I don't know what polar and nonpolar means.
> Mr. Kuzu: How so you don't know. At 9th grade you must have learnt them.
> Student: We did but I did not understand them.

> Mr. Kuzu: Now I can summarize them briefly but remind me next lesson and we will talk about it again in details.

Then he summarized briefly about polar and nonpolar compounds and next lesson he started from strong and weak chemical attractions which was placed in the 9th grade curriculum and covered polar-nonpolar compounds throughout the lesson. When he was asked the reason of covering polar and nonpolar compounds again for whole lesson in details although it is 9th grade's topic he said that

> They did not remember what polar and nonpolar means, we have to repeat this topic. Because in solubility topic we will frequently use these terms and if they don't know what polar and nonpolar are, they cannot understand solubility. Then I have to remind them the previous topic."

Mr. Kuzu also gave brief information about vapor pressure before starting to teach boiling point even though it was stated not to mention about vapor pressure as ""Properties of a solution such as freezing/boiling point and osmotic pressure is different than it is in the solvent and as concentration increases, the difference increases" should be stated. (Don't mention about decrease in vapor pressure.)" After explaining vapor pressure in the class Mr. Kuzu said that

> Why did I explain vapor pressure? To explain boiling point better because I teach boiling point depending on vapor pressure. First we summarize vapor pressure although curriculum limit us (teachers) to mention about it but we don't refer to how much it changes quantitatively depending on the mole fraction. We just mention it can change depending on the quantity of the solute dissolved.

He explained the reason of explaining vapor pressure although it is indicated not to be in the curriculum he said

> There is contradiction in the curriculum. It is stated not to mention about vapor pressure but then we have to teach boiling point. How can I teach boiling point without teaching vapor pressure? Although curriculum limits me I am constrained to teach vapor pressure to increase students' understanding."

As it was mentioned at the Knowledge of Goals and Objectives part, Mrs. Akman did not feel competent about her knowledge of goals and objectives. She did not ignore any objectives stated in the curriculum, besides added some more objectives to them during the instruction. When she was asked whether she strictly bounded to the curriculum or not, she said she did not and explained the reason of it as

> It is because of the necessity. Curriculum does not give importance to and cover some topics in detail. However, students have to solve problems about those topics. Therefore, I need to cover them in detail to help students understand better. If they understand better they will be able to solve problems.

As an example to this situation Mrs. Akman wanted students to memorize names and the components of some common alloys like steel, bronze, brass...etc.

Another example for changing the curriculum to help students understand better and solve questions easily was the bonding topic. Similar to Mr. Kuzu, Mrs. Akman made some changes in the curriculum during the instruction, and taught bonding concept to the students for a class hour before starting to teach like dissolves like even though bonding concept was taught at the 9th grade. While Mr. Kuzu taught this topic because of students' request, Mrs. Akman taught it as she thought it was necessary to remind this topic to solve problems. Just like the same reason, to help students to solve problems easily about solubility Mrs. Akman taught enthalpy briefly to the students because she thought that they needed to know this concept to solve questions even though enthalpy is the unit of 11th grade. She stated that

> If student will understand the enthalpy change when a solute dissociates in a solvent, they will easily solve the questions about enthalpy of solutions. Because even though it is not stated in the 10th grade curriculum, sometimes we encounter with the questions about enthalpy of solutions in the textbooks."

4.1.4. Knowledge of Instructional Strategies

Teachers' knowledge of instructional strategies were examined under two dimensions which are knowledge of subject specific strategies and topic specific strategies. Knowledge of topic specific strategies included two sub-dimensions: knowledge of topic specific activities and representations. Mr. Kuzu's and Mrs. Akman's knowledge of instructional strategies considering its sub-components was given in Table 14.

4.1.4.1. Subject Specific Strategies

Mr. Kuzu and Mrs. Akman did not use any subject-specific strategy during their instruction. They always used traditional didactic teaching method.

4.1.4.2. Topic Specific Strategies

4.1.4.2.1. Activities

Mr. Kuzu thought that laboratory activities are important for better understanding of students. He stated that "They learn better by conducting laboratory experiments and demonstrations." However, during the instruction he never used laboratory experiments and demonstrations. When he was asked the reason of not using laboratory experiments he stated that "It is because of the lack of opportunities, materials and also the loaded curriculum that we don't have much time to spend for laboratory experiments." Although Mr. Kuzu could not allow time for laboratory experiments, he showed videos of already conducted experiments to students. He said that it was not time consuming and students have a chance to see the results of the experiment even though they did not conduct it.

Table 14. Mr. Kuzu's and Mrs. Akman's knowledge of instructional strategies for teaching mixtures unit

Knowledge of Instructional Strategies	**Participants**	**Description**	**How to use**	**Purpose**
Subject Specific Strategies	Mr. Kuzu	Participants did not use any subject specific strategies		
	Mrs. Akman			
Topic Specific Activities	Mr. Kuzu	Simulations	Show the simulation and explain it to the students by himself	To show students what is happening at the sub-microscopic level
	Mrs. Akman	Demonstrations	Do the demonstration by the help of a student and explain it by asking questions to the students	Enable students to experience the practice of the theoretical information they covered in the class
Topic Specific Representations	Mr. Kuzu	Analogies Symbolic representations like graphs, molecular representations, schemas	Superficial and randomly use of analogies Use of symbolic representations without adding students to the process	To make the topic more understandable to the students
	Mrs. Akman	Analogies Symbolic representations like graphs, models and tables		

Mr. Kuzu often used simulations to emphasize sub-microscopic level of chemistry. While teaching dissolving, first of all he reminded students types of intermolecular forces then defined dissolving and then talked about how dissolution occurs verbally. Then he showed a video from Network of Education and Informatics (NEI) which includes simulations about dissolving of table salt. After the class, when he was asked the reason of showing the simulation about dissolving he responded

> to show students what is happening in sub-microscopic level. We talk about it, explain it but simulations lead them to see the motion of particles while dissolving. What is happening there actually, how the particles split and how they are surrounded by water molecules…"

Different from Mr. Kuzu, Mrs. Akman did four demonstrations in the classes during the teaching of mixtures unit. She thought that using laboratory activities is important in chemistry teaching; however, due to the crowded classes and limited class hours it was difficult to handle laboratory hours. She stated that "

> We have to sacrifice from one of them. Doing laboratory experiments is beneficial for students only if they know the theoretical information about the topic. However, if we do experiments we don't have time to teach the theoretical information. Nevertheless I am trying to do at least demonstrations in the class.

During the instruction, she did demonstrations to enable students experience the theoretical information they covered in the class. For instance, after teaching diluted and concentrated solutions, by the help of a student she prepared a dilute and concentrated solution of potassium permanganate ($KMnO_4$) and showed them to the students. Then by the help of another student she prepared copper (I) nitrate ($CuNO_3$) solution and showed students that this solution was electrolyte by using the electricity provided from this salt water circuit to light up a light bulb. During performing these demonstrations, she gave students the instructions and the students did what teacher said. She also did some more basic demonstrations throughout the mixtures unit.

4.1.4.2.2. Representations

Mr. Kuzu used analogies frequently. He tried to resemble chemistry concepts to the concept that students are familiar from daily life and he thought that it increases students' understanding and time of remembrance of the chemistry concept. While he was teaching boiling he use the following analogy to emphasize the effect of atmospheric pressure on boiling. "

> Surrounding atmospheric pressure prevent the movement of the liquid. The liquid has to overcome this pressure. At least it has to generate an equal force. It is like when a country tries to invade neighbor country that has forces in the border, first of all it should store guns, weapons, soldiers, tanks up to the border of the neighbor country. When the invader country become sure to win the neighbor country it attacks. Liquid does the same thing.

Although Mr. Kuzu used analogies too often, most of the analogies he used were superficial and randomly used. He did not emphasize the important points of the analogies or the similarities and the differences between the concepts analogies. For instance,

> If the interaction between the solute and the solvent is stronger than the interaction between solute-solute and solvent-solvent, dissolving occurs. Suppose that we will create a new class by mixing your class and the next class. There is an interaction and friendship among the students of your class, and there is among the students of the next class. If we cannot create this interaction after we mix the classes there will be disagreements and the new class will split. Therefore, the new combination will be formed only if it is stronger than the pieces form it."

Mr. Kuzu widely used symbolic representations like graphs, molecular representations and schemas. While he was teaching the topic he drew symbolic representations on board if there is about the topic and then continue teaching the concepts by using these representations. Especially while teaching the solubility concepts he draw solubility-pressure and solubility-temperature graphs as it is seen below Figure 13. He stated that "graphs are the best way of showing the relations between the concepts."

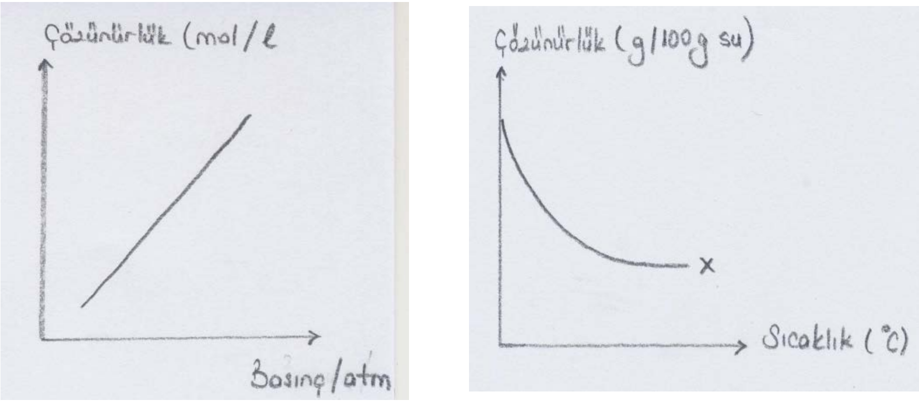

Figure 13. Solubility-pressure and solubility-temperature graph

Sometimes he draw molecular representations on board to show the concepts in microscopic level. When he was talking about the interaction between the solute and the solvent he draw the following figure:

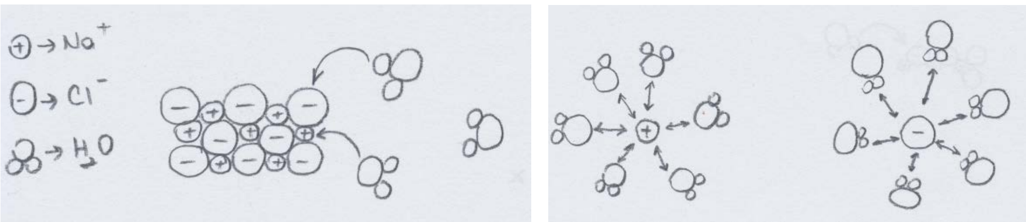

Figure 14. Solute-solvent interactions drawn by Mr. Kuzu

Likewise Mr. Kuzu, Mrs. Akman frequently used representations. Most of the time she used representations like analogies, graphs, models and tables**.**

However, different from Mr. Kuzu she never draw molecular representations on board.

To teach saturated, unsaturated and supersaturated solutions, she drew an analogy between these solutions and eating. She resembled unsaturated solution to eating little, saturated to being full and supersaturated vomiting after being replete.

> If you eat as much as you can, it means you are saturated; if you eat less than you can eat, it means you are unsaturated; if you are greedy and eat much more than you can eat, you are supersaturated. Supersaturated solutions are unstable and the excess of the solute precipitates with any reaction. Likewise if you eat much more than your limits you throw up the excess of food.

She stated that using analogies to teach a concept would provide better understanding of the topic to the students. However, the analogy she used to increase students' understanding had some limitations. She did not emphasize among which concepts she draw the analogy. It was not clear which chemistry concept was resembled to eating, and which one was familiar to precipitate. Likewise, she did not mention the limitations of the analogy either.

Mrs. Akman showed graphs to the students whenever necessary and explained how to use them during the instruction. She especially used solubility-temperature graphs and explained how to interpret them. For instance, she showed the following graph **(**Figure 15**)** showing the solubility vs. temperature graphs of some common salts. She stated that students should know solubility-temperature graphs and how to interpret them to understand solubility better and solve the questions related to these graphs easily.

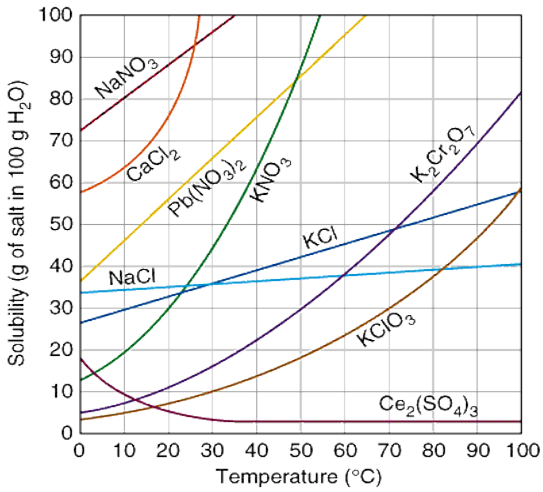

Figure 15. Solubility vs. temperature graphs of some common salts used by Mrs. Akman

Different from Mr. Kuzu, Mrs. Akman sometimes used molecular models while she was teaching students the solvents and reminding polarity of the molecules before teaching like dissolves like. While she was giving benzene as an example to organic solutes, she wanted students to see the cyclic structure of benzene and used the molecular models. Before teaching like dissolves like, Mrs. Akman reminded student the intramolecular, intermolecular forces, polar and non-polar molecules that were covered at 9^{th} grade for one class hour. During this instruction she used molecular models to show students different polar and non-polar molecules. She formed different molecules by herself and then showed these molecules to the students. She did not let students to play with the molecular models to form the molecules they wanted to form. She thought that students could understand even they see and when she was asked the purpose of using molecular models to teach the polarity topic she answered as "I think they will understand polarity better if they see the sub-microscopic structure of the molecules."

4.1.5. Knowledge of Assessment

Knowledge of assessment was examined under two components which are methods of assessment and dimensions of science learning to assess. Dimensions of science learning to assess is examined under three sub-components as what is assessed, the way of assessment and the purpose of assessment. All these components and sub-components are not explained under separate topics but integrated to each other since they are too much related to each other. Mr. Kuzu's and Mrs. Akman's knowledge of assessment considering methods of assessment and dimensions of science learning to assess was given in Table 15.

Table 15. Mr. Kuzu’s and Mrs. Akman’s knowledge of assessment

Participant	Method of Assessment	What to assess	How to assess	Purpose of assessment
Mr. Kuzu	Informal questioning	Prior knowledge	By asking questions	To detect what students know related to the new knowledge
	Direct observation	Chemistry content	By observing students’ performance on responding questions	To detect how much students learn To summarize the topic To complete the deficiencies about the topic To show students type of questions could be asked about this topic in the exams
	Homework	Chemistry content	By delivering them quiz questions to solve at home	To detect how much students learn and deficiencies about the content
	Term project	Chemistry content	By assigning students a topic to search and report	To grade students To make students’ understanding of the topic easier
	Examination	Chemistry content	By giving students written exams	To grade students

Table 15. (continued)

Mrs. Akman	Informal questioning	Prior knowledge	By asking questions	To detect what students know related to the new knowledge
		Chemistry content	By observing students' performance on responding questions of the teacher	To detect how much students learn To complete the deficiencies about the topic
	Direct observation	Chemistry content	By observing students' performance on presenting a chemistry content in classroom	To summarize the topic To complete the deficiencies about the topic
			By observing students' performance on solving questions in the class	To detect how much students learn To show students type of questions could be asked about this topic in the exams
	Homework	Chemistry content	By delivering them quiz questions as a sheet or assigning test questions from books to solve at home	To detect how much students learn and deficiencies about the content
	Examination	Chemistry content	By giving students written exams	To grade students

Mr. Kuzu widely used informal questioning in order to detect what students knew related to the new topic. For instance, following dialogue is an example to the informal questioning used by Mr. Kuzu before starting to introduce ethanol as a solvent to detect students' prior knowledge.

> Mr. Kuzu: What kind of interactions are there between ethanol molecules?
> Student: Dipole-dipole
> Mr. Kuzu: That's right. How do we know? Because it is polar. Any other? Have you forgotten about 9^{th} grade? There is one more.
> Student: Induced dipoles
> Mr. Kuzu: No, there is hydrogen bond. Do you remember what hydrogen bond is?
> Student: F, O, N
> Mr. Kuzu: Is there anyone to define hydrogen bond?
> Student: the interaction occurs between the molecules of compounds that is formed when a hydrogen atom bound to a fluorine, oxygen or nitrogen.

Mr. Kuzu gives importance to emphasize daily life in chemistry lessons. He usually asks students if they know any daily life examples about the concept he emphasize. In the lesson, while teaching *detecting whether a mixture is homogenous or heterogeneous by using light* the following dialogue occurred between Mr. Kuzu and a student.

> Mr. Kuzu: ….Because light is dispersed by colloidal particles and we can see it. Is there any example of it in daily life?
> *Silence*
> Mr. Kuzu: we will see it but I just want you to think about it. So when the light passes through and it is not reflected by particles then it is homogenous mixture and when the light disperse it is heterogeneous. Is there any daily life example?
> Student: We can see the sun.

At the end of each topic, Mr. Kuzu regularly solved problems and questions from books with whole class. During these times he observed students' performance on responding questions. He reflected the questions or problems to the smart board to let everyone see the question. Then sometimes he answered the question or solved the problem and sometimes chose a volunteer to respond. When he was asked the reason of this this regular process he claimed:

> When we solve problems about the topic covered, student understand what kind of questions could be asked about this topic in the examinations and also it provide us to review and summarize the topic. It also let me detect how much students learn, find the deficiencies and fill the gaps."

At the end of each topic Mr. Kuzu gave homework to the students and wants them to solve all of the questions related to the topic from their books. He said that the aim of giving homework to the students is to detect how much students learn and deficiencies about the content. After solving the problems students ask the questions that they are not able to solve to the teacher. Therefore, Mr. Kuzu detect if there is any deficiency about the topic, and repeat the topic if needed. He said that by giving homework he also understand how much students learn.

Before starting the mixtures unit Mr. Kuzu made students groups of 2 or 3 and wanted them to prepare term projects about the topics he assigned to the students. The aim of preparing term projects is to grade students and to make their understanding of the topic easier. Although he thought that students should be interviewed about the project they prepare he could not find time for the interview and he only graded their written projects.

> Mr. Kuzu: Which topic have you prepared?
> Student: How does the freezing and boiling point affected depending on the concentration of the solution?
> Mr. Kuzu: colligative properties. What does it mean?
> Student: properties depending on the concentration of the solution.
> Mr. Kuzu: so they depend on the number of particles per unit volume. What are they?
> Student: Vapor pressure, boiling point, freezing point.

During the semester Mr. Kuzu implemented two examinations. The first one was related to the first unit, Acids-Bases and Salts, and the second one was related to both Acids-Bases and Salts and mixtures units. The aim of implementing these examinations was to grade students and he asked 25 multiple choice questions. Even though he thought that open ended questions were better to grade students, he used multiple choice questions because of the fact that they were easy to grade. The questions were similar to the questions Mr. Kuzu emphasized during the classes and most of them were algorithmic problems.

Similar to Mr. Kuzu, Mrs. Akman always asked questions to the students during the teaching of the topic. Especially before starting to teach a topic she asked questions to detect what students knew about the new topic. For instance, before starting to teach solubility he asked students what they knew about like dissolves like and the following dialogue happened:

> Mrs. Akman: There is a principle in chemistry, like dissolves like. Let's elaborate it, what does it mean? Do you have any idea?
> Student 1: polar solutes dissolves in polar solvents.
> Mrs. Akman: What does polar mean?
> Student 2: Molecule that has two poles.
> Mrs. Akman: How do you understand that a molecule has two poles?
> (and so on…)

Unlike Mr. Kuzu, Mrs. Akman had two more purposes to use informal questioning during the instruction which are detecting how much students learn and completing the deficiencies about the topic. She assessed students by observing their performance based on students' responses to the questions she asked. An example to this situation is as follow:

> Mrs. Akman: Can you say anything that you remember related to this topic?
> Student 1: mixtures can be grouped as homogenous and heterogeneous mixtures.
> Mrs. Akman: Can you give an example?
> Student 1: Sugar solution
> Mrs. Akman: This is for…?
> Student 1: For homogenous
> Mrs. Akman: For heterogeneous?
> Student 1: Ayran.

> Mrs. Akman: And you, what can you say about this topic?
> Student 2: There is a type of solution called saturated.
> Mrs. Akman: How do you understand that a solution is saturated? What does saturated mean?
> (and so on…)

If a student gave wrong answer to the question, she directed the question to another student. If students failed to find the correct answer, she gave the correct answer and explained it.

Quite similar to Mr. Kuzu, Mrs. Akman also detected what student learnt by observing their performance on solving questions in the class. Most of the time these questions were similar to the questions that were asked in the previous HEE and UPE so that she had opportunity to show students kind of questions could be asked in HEE and UPE about this topic. However, different from Mr. Kuzu she assigned chemistry topics related to the unit to the students who were volunteered to present that topic in the classroom. For instance, a student prepared a presentation related to the types of solutions and presented it in the classroom for 20 minutes. During the presentations, Mrs. Akman sometimes interrupted the presentation and elaborated the concepts which she thought were important. When she was asked the purpose of these presentations, she answered

> It would be good for students to hear the chemistry concepts from one of their friends. They may ask their questions easily to their friends if they did not understand. Besides student presentations are kind of a summary of the topic."

Mrs. Akman frequently gave homework to the students. The content of the homework was always the same, solving questions about the topic lastly covered. She either delivered students quiz questions as a sheet or assigned them test questions from books to solve at home. She controlled whether students did the homework at due date and wanted students to ask her the questions that they were not able to solve. She stated that by this way she can detect how much students learn and elicit the deficiencies about the topic if there was.

And lastly she implemented two written examinations throughout the semester. The first examination was only related to the first unit which was Acids-Bases and Salts. The second one was related to both Acids-Bases and Salts and mixtures unit and the ratio of the questions were 30% and 70% for the topic, respectively. She used multiple choice and essay type questions and the ratio of the questions were 40% and 60%, respectively. The questions of the examinations were similar to the questions teacher solved in the instruction. Most of them were includes to mathematical calculations and conceptual questions were rarely used. Open-ended questions were more likely to assess students' knowledge and comprehension skills instead of upper level skills and includes writing the definition of concepts or classification of the concepts which needs memorization. Lastly, Mrs. Akman used the scores of the examinations to grade the students.

4.2. Interaction between STO and Other Components of PCK

In this section, interactions between sub-components of participants' science teaching orientations (STO) and other components of PCK, which are KofL, KofC, KofIS and KofA, were examined one by one. As mentioned in the data analysis section in order to be assumed as an interaction, an action must be both mentioned by the teacher during the interviews and observed by the researcher during the classes. Furthermore, instead of their ideal beliefs, working beliefs of the teachers were considered while determining the interactions between their STO and other components of PCK. In Table 16 it can be seen whether there is an interaction among sub-components of Mr. Kuzu's and Mrs. Akman's PCK. As mentioned earlier, no sign of NOS was observed during the instruction of the teachers; therefore, NOS was not included in this section.

4.2.1. STO vs. KofL

In this part, interactions among sub-components of Mr. Kuzu's and Mrs. Akman's science teaching orientations and knowledge of learner were explained in details. In Table 17 Mr. Kuzu's and in Table 18 Mrs. Akman's interactions among sub-components of their science teaching orientations and knowledge of learner were given all together. For Mr. Kuzu all sub-components of STO and KofL were found to have an interaction among each other. For Mrs. Akman except for beliefs about the goals or purposes of science teaching vs. difficulties and beliefs about science teaching and learning vs. misconceptions, and beliefs about science teaching and learning vs. students' prerequisite knowledge, there were interactions between the components.

Table 16. Interactions among sub-components of PCK for Mr. Kuzu and Mrs. Akman ("+" indicates there is an interaction "-" indicates there is no interaction)

Components of PCK	***Sub-components of PCK***	**STO**			
		Goals or purposes		*Teaching and learning*	
		Mr. Kuzu	*Mrs. Akman*	*Mr. Kuzu*	*Mrs. Akman*
KofL	*Pre-requisite knowledge*	+	+	+	-
	Difficulties	+	-	+	+
	Misconceptions	+	+	+	-
KofC	*Goals and Objectives*	+	+	+	-
	Relating to other topics or disciplines	-	-	-	-
	Altering the Curriculum	+	+	+	-
KofIS	*Subject specific strategies*	+	+	+	+
	Topic specific activities	-	-	+	+
	Topic specific representations	-	+	+	+
KofA	*What is assessed*	+	+	-	-
	The way of assessment	+	+	+	+
	The purpose of assessment	+	+	-	-

Table 17. Interaction between Mr. Kuzu’s science teaching orientations and knowledge of learner

	KNOWLEDGE OF LEARNER		
STO	**Pre-requisite Knowledge**	**Difficulties**	**Misconceptions**
Goals or purposes	**STO:** Everyday coping **KofL:** Always asking what students know about everyday life examples related to the unit.	**STO:** Solid foundation **KofL:** Students who choose science major involuntarily could be unsuccessful because next chemistry classes are tough.	**STO:** Solid foundation and Correct explanations **KofL:** Even if it is not detected in the class, correct explanations of the misconception is stated by the teacher, just in case somebody has it.
Teaching and learning	**STO:** Teacher Focused **KofL:** If previous units are covered in the class, students have to have pre-requisite knowledge about the new unit.	**STO:** Teacher Focused **KofL:** The unit is covered in the middle school, so they don’t have any difficulty at this unit.	**STO:** Teacher Focused **KofL:** Even if it was not detected in the class, correct explanations of the misconception was stated by the teacher, just in case somebody has it.

Table 18. Interaction between Mrs. Akman's science teaching orientations and knowledge of learner

	KNOWLEDGE OF LEARNER		
STO	**Pre-requisite Knowledge**	**Difficulties**	**Misconceptions**
Goals or purposes	**STO:** Everyday coping **KofL:** Always asking what students know about everyday life examples related to the unit.	-	**STO:** Solid foundation and Correct explanations **KofL:** When detected in the class, correct explanations of the misconception is stated by the teacher warning them to be careful about the misconception in the examinations.
Teaching and learning	**-**	**STO:** Teacher Focused **KofL:** The unit is covered in the middle school, so they don't have any difficulty at this unit.	-

Beliefs about the Goals or Purposes of Science Teaching vs. Prerequisite Knowledge

Both Mr. Kuzu and Mrs. Akman had everyday coping purposes of science teaching which interacted with their knowledge of students' prerequisite knowledge. Mr. Kuzu and Mrs. Akman always gave importance to emphasize chemistry behind daily life events and they asked students what they knew about everyday life examples related to the topic. For instance, before asking the reason of afterglow appearing after sunset Mr. Kuzu asked students "Do you know any examples of colloids from your everyday life?" His intend was to teach the colloids; however, he preferred to start the topic by asking questions about students' prior knowledge about an everyday life event related to the colloids. In the weekly interviews, when he was asked the reason of considering what students know about daily life examples of the unit and emphasizing daily life examples too much he respond

> Why am I elaborating daily life examples? Because they [students] experience them during their daily life. If we cover them in this unit, they can easily explain the reason of these events to themselves and learn where to use it if necessary."

Similar to Mr. Kuzu, Mrs. Akman emphasized a daily life event by using students' prior knowledge to answer a student's question about solubility. The following dialogue is an example to this situation:

> Student 1: Mrs. Akman, can we say that nonpolar molecules never dissociate in polar molecules or do they dissociate even so little?
> Mrs. Akman: Is water polar or nonpolar?
> Student 1: Polar.
> Mrs. Akman: What about oxygen?
> Students: Nonpolar.
> Mrs. Akman: Do you know any daily life event in which oxygen dissociates in water?
> Student 2: Fish can live in water.
> Mrs. Akman: yes, fish can live in water by using the dissolved oxygen in water. So we can say that nonpolar molecules can sometimes dissociate in water, but it is too little that we assume they cannot.

From this dialogue it was seen that Mrs. Akman used students' prior knowledge about a daily life event to answer their questions about chemistry. While the student was asking whether nonpolar molecules can dissociate in water which is a polar molecule, Mrs. Akman tried to carry students to the daily life example of nonpolar oxygen gas molecules (O2) dissolving in polar water molecules in lakes or seas so that fish can survive in water. So that these examples of teacher-student dialogues can be given as an example to the interaction between their beliefs about the goals or purposes of science teaching and prerequisite knowledge of students.

Beliefs about the Goals or Purposes of Science Teaching vs. Difficulties

Mr. Kuzu had solid foundation purposes and it interacted with his knowledge of students' learning difficulties. Mr. Kuzu had a purpose of preparing students to the next chemistry classes and HEE and UPE in order for them to acquire a profession. Therefore, when students had difficulty in understanding a chemistry topic or solving a problem he warned them about the loaded and tough curriculum of chemistry in the next classes and he believes "Students who choose science major involuntarily could be unsuccessful because next chemistry classes are tough." While teaching solubility topic, one of the students had difficulty in solving the problem about solubility. Then the teacher suddenly began to talk about chemistry classes at 11th grade science major. He said

> While choosing major at the end of this year, consider which profession suits you. Choose major considering what you want to be in 5 or 10 years. My concern is that science major at 11th grade is not an easy major…. Only volunteers should choose science major because it is a tough, long, and a tiring major. All atomic theories that you [students] have difficulty in understanding at 9th grade will be covered at 11th grade.

By this explanation, he tried to warn students for the difficulties of the next chemistry classes which may lead them to fail in the examinations. Thus there is an interaction between Mr. Kuzu's beliefs about the goals or purposes of science teaching and knowledge of students learning difficulties.

For Mrs. Akman interaction between beliefs about the goals or purposes of science teaching and students' learning difficulties was not detected.

Beliefs about the Goals or Purposes of Science Teaching vs. Misconceptions

Mr. Kuzu had solid foundation and correct explanations purposes that interacted with his knowledge of students' misconceptions. Mr. Kuzu was aware of students' possible misconceptions related to mixtures unit; however, during the interview about PCK components he said he did not expect students to have misconceptions about this unit as this unit is mostly related to events that they encounter in their daily life. "I don't expect them [students] to have misconceptions about this unit because they are familiar to the important concepts of this unit from their everyday life. They know almost all of them." It was interesting that even though he did not expect students to have misconceptions, he gave importance to eliminate possible misconceptions of students and emphasize the correct explanations of the misconceptions. Whether or not detected in the class, the correct explanations of the misconception was stated by the teacher, just in case somebody has it.

> A solution containing undissolved solute is a saturated solution not supersaturated one. Write it down on your notebook. Every solution that is in equilibrium with undissolved solute is a saturated solution. Sometimes I draw a solution that is in equilibrium with undissolved solute and ask the type of the solution. Students immediately respond the question as supersaturated solution which is wrong.

When the reason of explaining the correct form of possible misconceptions was asked to him, he responded that "If students have these misconceptions, they will be eliminated when I explain the correct answer. So that they can respond the questions correctly if they encounter these kind of questions in the nationwide examinations." From this explanation, it was understood that he explained the correct form of the misconceptions to support students in their examinations. As a result Mr. Kuzu's correct explanations and solid foundation purposes interacted with his knowledge of students' misconceptions.

So similar to Mr. Kuzu, Mrs. Akman's two of the beliefs about the goals or purposes of science teaching which were solid foundation and correct explanations interacted with his knowledge of students' misconceptions in the same way. She gave great importance to the HEE and UPE that she always emphasized questions that students may encounter in those exams. She also warned students about the possible misconceptions they might encounter in those exams compatible with her solid foundation belief. If she feel that students hold these misconceptions, she explain the correct form of the misconceptions in order to help her students in the examinations. The following dialogue is an example to this situation happened one of her instruction:

> Mrs. Akman: Can we say that all solutions are electrolytes?
> Student 1: No some of them may not be.
> Mrs. Akman: Yes they may or may not be. It is frequently asked in the test questions. Be careful! There are exceptions. For instance, sugar dissociates in water but not ionizes; therefore, it not electrolyte. Don't be confused.

Depending on the above examples it can be stated that teachers' beliefs about the goals or purposes of science teaching interacted with their knowledge of students' misconceptions.

Beliefs about Science Teaching and Learning vs. Prerequisite Knowledge

Mr. Kuzu had a teacher-focused teaching and learning beliefs as examined in Beliefs about Science Teaching and Learning part. There was an interaction between his teacher-focused beliefs and knowledge of students' prerequisite knowledge. He assumed that if he covered a topic that was prerequisite to the new unit, students had to have prerequisite knowledge about the new unit as the prerequisite topics had already covered. For instance, while explaining acids and bases as polar solutes he told students "As we have already covered acids and bases unit, you are supposed to know all these stuff, because you have to." Likewise while teaching vapor pressure he asks the definition of vapor pressure to the students, and nobody can define; therewith, he said "As far as remember you wrote it down on your notebook. So why can't you define it." From these examples it can be claimed that Mr. Kuzu's beliefs about science teaching and learning interacted with his knowledge of students' prerequisite knowledge.

For Mrs. Akman no sign of interaction between her beliefs about science teaching and learning and students' prerequisite knowledge was detected during either the interviews or observations.

Beliefs about Science Teaching and Learning vs. Difficulties

Compatible with his teacher focused beliefs, Mr. Kuzu didn't expect students to have so much difficulties about mixtures because he stated "The unit is covered in the middle school, so they [students] don't have much difficulty at this unit." As it was given in the Beliefs about Science Teaching and Learning part Mr. Kuzu supposed that students understood the topic if they did not asked questions about it. For him delivering the information was enough for students understanding of the topic.

Due to the quite similar reasons with Mr. Kuzu and her teacher focused beliefs, Mrs. Akman did not expect her students to have difficulties in the mixtures unit. Thus, as a result of Mr. Kuzu's and Mrs. Akman's actions which were compatible with their teacher focused beliefs, it can be stated that there was an interaction with teachers' beliefs about science teaching and learning and their knowledge of students' learning difficulties.

Beliefs about Science Teaching and Learning vs. Misconceptions

Mr. Kuzu did not have any action to detect whether students have misconceptions during the classes. He believed that because students were familiar to the mixtures unit from their daily life, they did not have any misconceptions. He ignored the view of students and considered his own view regarding misconceptions of students. Even though he did not presume students to have misconceptions in mixtures unit or detected them in the classes, most of the time he himself gave the correct explanations of the misconceptions. For instance, as it was mentioned before, he explained that a solution containing undissolved solute is not a supersaturated but saturated solution even though he did not detect it as a misconception. He always explained the correct form of misconceptions before they were detected or asked by students. His ignoring manner regarding student ideas was compatible with his teacher focused beliefs about science teaching and learning and interacted with his knowledge of students' misconceptions.

For Mrs. Akman interaction between beliefs about science teaching and learning and knowledge of students' misconceptions was not detected.

4.2.2. STO vs. KofC

In this part, interactions among sub-components of Mr. Kuzu's and Mrs. Akman's science teaching orientations and knowledge of curriculum were explained in details. There were interactions among Mr. Kuzu's sub-components of science teaching orientations which are beliefs about the goals or purposes of science teaching, beliefs about science teaching and learning and sub-components of knowledge of curriculum which are knowledge of goals and objectives and altering the curriculum. Table 19 shows these interactions. For Mrs. Akman there were interactions only between her beliefs about the goals or purposes of science teaching, and knowledge of goals and objectives and altering the curriculum. These interactions were provided Table 20.

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Table 19. Interaction between Mr. Kuzu’s science teaching orientations and knowledge of curriculum

STO	KNOWLEDGE OF CURRICULUM Goals and objectives	Relating to other topics *Vertical*	*Horizontal*	Relating to other disciplines	Altering the curriculum
Goals or purposes	**STO:** Solid foundation **KofC:** He warned students about the loaded and difficult chemistry curriculum.		-		**STO:** Solid foundation **KofC:** Even though they are not stated as goals or objectives in the curriculum, he taught some topics.
Teaching and learning	**STO:** Teacher focused **KofC:** Teacher took the leadership because of the loaded curriculum to provide students better understanding.		-		**STO:** Teacher focused **KofC:** Teacher took initiative to alter the curriculum in order to provide better learning of students.

Table 20. Interaction between Mrs. Akman's science teaching orientations and knowledge of curriculum

	KNOWLEDGE OF CURRICULUM				
STO	**Goals and objectives**	**Relating to other topics**		**Relating to other disciplines**	**Altering the curriculum**
		Vertical	***Horizontal***		
Goals or purposes	**STO:** Everyday coping **KofC:** It is good to see that daily life events were emphasized in the curriculum.		-		**STO:** Solid foundation **KofC:** Even though they are not stated as goals or objectives in the curriculum, she taught some topics.
Teaching and learning	-		-		-

Beliefs about the Goals or Purposes of Science Teaching vs. Knowledge of Goals and Objectives

Mr. Kuzu's solid foundation purposes and Mrs. Akman's everyday coping purposes interacted with their knowledge of goals and objectives of curriculum. Most of the time Mr. Kuzu gave information about the future chemistry classes to the students and explained that goals and objectives in those classes are difficult to handle. He warned students to choose science major only if they really wanted to choose it, otherwise he believed that they will be unsuccessful. In one of the classes he mentioned that

> My concern is that science major at 11th grade is not an easy major. It is like all chemistry topics are accumulated at that grade. Topics at older 10th and 11th grades are now covered at new 11th grade curriculum all together.

Mr. Kuzu was aware of all the objectives stated in the curriculum and thus he knew what students would deal with in the next classes. Therefore, he gave information to his students about the next grade classes in order to inform them before they enrolled to the upper classes.

Mrs. Akman had beliefs about the goals or purposes of science teaching compatible with everyday coping. In the interview about PCK components she emphasized that one of the advantages of the new curriculum was to give importance to emphasizing daily life events. She stated that "It is good to see that daily life events were emphasized in the curriculum. By this way consciousness about chemistry tried to be raised in the students." During her instruction, she always emphasized daily life events and gave examples about them to increase students' awareness about the relation between chemistry and daily life. She was aware of the daily life objectives and used them in her instruction. Therefore, it can be concluded that there was an interaction between Mr. Kuzu's and Mrs. Akman's beliefs about the goals or purposes of science teaching and knowledge of goals and objective of the curriculum.

Beliefs about the Goals or Purposes of Science Teaching vs. Altering the Curriculum

Both Mr. Kuzu and Mrs. Akman had solid foundation purposes interacted with altering the curriculum. Even though they are not stated as goals or objectives in the curriculum, Mr. Kuzu taught some chemistry topics like vapor pressure, common ion effect and problems about solubility to the students. When he was asked the reason of solving problems about solubility even though it is not stated in the curriculum he answered

> I usually don't go beyond the limits of the curriculum, I consider the curriculum. But sometimes I teach the concepts that is not given in the curriculum. Because I believe students will use them somewhere in their future life, maybe in the exams maybe at the college classes, I don't know."

The reason of teaching the topics that were not stated in the curriculum was that his solid foundational purposes. Because of his purpose to prepare students to the future chemistry classes, he altered the curriculum to help his students.

Similar to Mr. Kuzu, Mrs. Akman's beliefs about the goals or purposes of science teaching was interacted with altering the curriculum. Compatible with her solid foundation beliefs she wanted her students to be successful in the nationwide examinations. For this purpose, even though they were not stated as goals or objectives in the curriculum, she taught some topics or concepts in case questions about these topics or concepts could be asked in those examinations. She explained the reason of this situation as

> For instance let me give an example from the last unit we covered, Acids-Bases and Salts. In the curriculum importance is not given to the topics related to the acid-base reactions and their relation to mole concepts. However, all of the test books give importance to them and there are questions in the test books about this topic. Therefore, in order to help students respond the questions in the test books, I sometimes extend the limits of the curriculum and explain some other topics.

Regarding the explanations and instruction of Mr. Kuzu and Mrs. Akman it can be stated that their beliefs about the goals or purposes of science teaching interacted with altering the curriculum.

Beliefs about Science Teaching and Learning vs. Knowledge of Goals and Objectives

Mr. Kuzu's beliefs about science teaching and learning was teacher focused. As a teacher he managed the classes as if he was the leader of the class and he attributed this attitude to the loaded and complex curriculum. When he was asked the reason of his teacher-centered instruction and not always recognizing students' ideas during the instruction he claimed

> There are 2 hours for chemistry lesson in a week at 10^{th} grade; however, the curriculum is too loaded, complex and too much verbal. It is impossible to meet all the objectives stated in the curriculum without taking the leadership on, so what you do as a teacher is finding ways to meet the objectives without hearing, seeing and knowing.

From this explanation it is clear that Mr. Kuzu was aware of all objectives stated in the curriculum and he aimed to teach these objectives to his students. However, because of the time limitation his teacher centered beliefs manifested and hence interaction occurred between his beliefs about science teaching and learning and knowledge of goals and objective of the curriculum.

No sign of interaction between Mrs. Akman's beliefs about science teaching and learning and knowledge of goals and objectives was detected during either the interviews or the instruction.

Beliefs about Science Teaching and Learning vs. Altering the Curriculum

Mr. Kuzu had teacher focused beliefs about science teaching and learning. He stated that he considered the limits of the curriculum all the time, however, when he felt that students could understand a topic better at first learning a topic that was not stated in the curriculum, he did not hesitate to teach that topic first. In order to maximize students' understanding, he himself decided to organize the topics in an altered way because he believed in that way students understood better depending on his experiences with students he taught at previous years.

He said that he would not eliminate any topic in the curriculum but he would add some if necessary to maximize learning of students. He gave vapor pressure and boiling point as an example.

> According to the curriculum objectives while vapor pressure is not required to be taught, boiling point is. The effect of salt amount dissolved in water to vapor pressure is not required to be taught but boiling point elevation is. There is a contradiction. How do I teach boiling point without teaching vapor pressure, partial vapor pressure and their relation to the amount of dissolved particles?

While he was asked the reason of teaching vapor pressure to the students even though it is not required to be taught according to the curriculum he responded

> I think it will be hard to understand boiling point elevation unless they learn vapor pressure. According to the curriculum I am supposed to mention boiling point elevation, freezing point depression and osmotic pressure. But if I mention them without mentioning vapor pressure before, it will be something problematic.

In the light of these explanations there was an interaction between Mr. Kuzu's beliefs about science teaching and learning and altering the curriculum.

No sign of interaction between Mrs. Akman's beliefs about science teaching and learning and altering the curriculum was detected during either the interviews or the instruction.

4.2.3. STO vs. KofIS

In this section, interactions among sub-components of science teaching orientations and knowledge of instructional strategies were examined. While Mr.

Kuzu’s beliefs about science teaching and learning had an interaction between both subject and topic specific instructional strategies, beliefs about the goals or purposes of science teaching has an interaction only with subject specific instructional strategies. In Table 21 these interactions can be seen together for Mr. Kuzu. For Mrs. Akman there was an interaction between her beliefs about the goals or purposes of science teaching and using subject specific strategies and topic specific representations. Also there was and interaction between her beliefs about science teaching and learning, and subject and topic specific strategies. These interaction were provided in Table 22.

Table 21. Interaction between Mr. Kuzu's science teaching orientations and knowledge of instructional strategy

	KNOWLEDGE OF INSTRUCTIONAL STRATEGY		
		Topic Specific Strategies	
STO	**Subject Specific Strategies**	***Activities***	***Representations***
Goals or purposes	**STO:** Solid foundation Correct explanations **KofIS:** Traditional Didactic Teaching	-	-
Teaching and learning	**STO:** Teacher focused **KofIS:** Traditional didactic teaching	**STO:** Teacher focused **KofIS:** Not using demonstrations or laboratory activities because of the loaded curriculum.	**STO:** Teacher focused **KofIS:** Using analogies widely to increase students' understanding.

Table 22. Interaction between Mrs. Akman’s science teaching orientations and knowledge of instructional strategy

	KNOWLEDGE OF INSTRUCTIONAL STRATEGY		
		Topic Specific Strategies	
STO	**Subject Specific Strategies**	***Activities***	***Representations***
Goals or purposes	**STO:** Solid foundation Correct explanations **KofIS:** Traditional didactic teaching	-	**STO:** Solid foundation **KofIS:** Showing students how graphs can be used in the questions at the nationwide examinations.
Teaching and learning	**STO:** Teacher focused **KofIS:** Traditional didactic teaching	**STO:** Teacher focused **KofIS:** Using demonstrations to increase students understanding; however, taking the lead in doing demonstrations.	**STO:** Teacher focused **KofIS:** Using especially analogies and graphs without giving role to the students and taking all the responsibility

Beliefs about the Goals or Purposes of Science Teaching vs. Subject Specific Strategies

Both Mr. Kuzu and Mrs. Akman did not use any subject specific strategies during their instruction. They both used didactic teaching not to miss any point about the content and preferred to explain every detail about the topic. They had solid foundation and correct explanations purposes and these purposes interacted with the teaching strategy they preferred to use in their instruction. Thus, in this part, interaction between participants' beliefs about the goals or purposes of science teaching and their didactic teaching approach was examined.

Mr. Kuzu claimed that he used didactic teaching for his students' success in the examinations. From the following explanation interaction between his didactic teaching approach and beliefs about the goals or purposes of science teaching that are solid foundation and correct explanations can be seen. He said

> As a teacher you are expected to be a guide to students and students are expected to be active participants of the lesson. However, in this way students cannot succeed in the exams. They can learn the subject as liberal education but if you don't explain every single detail about the unit, they fail in the exam. Therefore, you don't want them to actively participate in the lesson and you perform didactic teaching personally.

Mrs. Akman had also correct explanations and solid foundation beliefs about the goals or purposes of science teaching. She used didactic teaching in her instruction and stated that she could not give opportunity for students' participation in the instruction because of the crowded classrooms. She explained

> I cannot allow students to participate in the lesson actively. Because classrooms are crowded and if I only them to participate and ask questions or do the demonstrations or solve a question on the blackboard, and they did something wrong, I would miss at least 10 minutes to correct what they did wrong. Therefore, generally I explain everything and solve the questions not to lose time.

Here it was seen that Mrs. Akman taught in a didactic way not to cause any misunderstanding caused by students while teaching and solving questions. As a result, both teachers' beliefs about the goals or purposes of science teaching interacted with their use of didactic teaching method in their instruction.

Beliefs about the Goals or Purposes of Science Teaching vs. Topic Specific Representations

While Mr. Kuzu had no interaction between his beliefs about the goals or purposes of science teaching and topic specific representations, Mrs. Akman had. She gave importance to the nationwide examinations that she always warned her students to be careful about the possible questions that could be asked in those examinations. During the instruction, while she was explaining the use of solubility vs. temperature graphs, she reflected solubility vs. temperature graph of potassium nitrate (KNO_3) (Figure 16) and she stressed what kind of questions could be asked in the HEE and UPE by using these kind of graphs. She stated that

> Look at the graph. You see there are many temperature values in the graph. Let's mark 20^0C in order to write a question. Listen to me carefully, these kind of questions may be asked in the examinations. The solubility of KNO_3 is 30 grams at 20^0C. Can we find the solubility of it at 40^0C by using proportion?

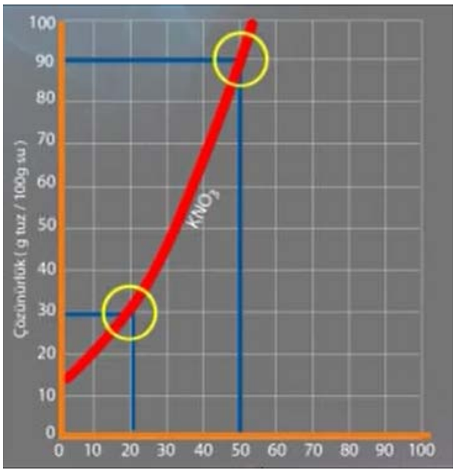

Figure 16. Solubility vs. temperature graph of potassium nitrate (KNO3) used by Mrs. Akman

As a result of her explanations it can be mentioned that there was an interaction between her beliefs about the goals or purposes of science teaching and her knowledge of topic specific representations.

Beliefs about Science Teaching and Learning vs. Subject Specific Strategies

Mr. Kuzu and Mrs. Akman used traditional didactic teaching; therefore, they did not use any subject specific teaching method and they had teacher focused beliefs about science teaching and learning. Mr. Kuzu defined his ordinary instruction as

> First I orally give the chemistry concept I want to emphasize. Then I write it on the blackboard and then solve problems about the concept. If there are visuals or videos of the experiments related to the concept, I show them to the students. Teacher is the one who compiles and summarizes the subject to the students.

From his description of his ordinary instruction, it was clear that this instruction had the features of didactic teaching. Thus, his beliefs about science teaching and learning was compatible with his dominant teaching method which was lecturing.

Likewise Mr. Kuzu, Mrs. Akman was the one who directed the instruction in the classroom. She explained the concepts, important points, definitions, gave examples about the topics. She spoke at least 15 minutes uninterrupted in every instruction. She always warned students to listen to her carefully. These actions were compatible with her teacher focused beliefs about science teaching and learning. Considering the explanations, both Mr. Kuzu’s and Mrs. Akman’s beliefs about the goals or purposes of science teaching and learning interacted with their use of teaching methods.

Beliefs about Science Teaching and Learning vs. Topic Specific Activities

Mr. Kuzu had teacher focused teaching and learning beliefs about science. He believed that laboratory experiments were useful to increase students’ understanding of chemistry; however, he did not use them actively in the classes. He explained it as

> Effective instruction is related to how many senses you appeal to as a teacher. The importance of conducting laboratory experiments is coming from this principle. If we are talking about chemistry or physics, using laboratory is obligatory if possible. However, I show the videos of the already conducted experiments via internet. In this way students can also learn what they need to learn.

The reason of using videos of experiments instead conducting them in the laboratory was not to waste too much time in the classes and he explain this situation as

> There are many videos of experiments conducted by large companies that you can reach quickly online without wasting time….. It takes too much time to conduct an experiment with your students in the laboratory. If you do, it means you fall behind the schedule.

From these explanations, it was obvious that Mr. Kuzu thought using laboratory activities to increase students’ understanding was important. However, he claimed that due to time limitation he could not conduct experiments in the laboratory with students. His teacher focused beliefs lead him to show the videos of the experiments via internet and he tended to give the same value to watching the videos of the experiments and doing the experiments on students' own.

As mentioned in the Topic Specific Activities part, Mrs. Akman used demonstrations during the instruction when necessary. She had teacher focused beliefs about science teaching and learning and her use of demonstrations in the class was compatible with her beliefs. For instance, when she wanted to use demonstrations she generally prepared the materials with the help of a student, and then did the demonstration in front of the class. She did not let students to participate in these activities. She attributed the reason of not letting students to participate in the activities to the crowded classroom. While doing the demonstrations she explained the theoretical information about it, did the demonstration and asked questions about it to the classroom. To summarize, she directed the demonstration. Therefore, depending on the information given above it was stated that there was an interaction between both Mr. Kuzu's and Mrs. Akman's beliefs science about teaching and learning and their use of topic specific activities.

Beliefs about Science Teaching and Learning vs. Topic Specific Representations

Mr. Kuzu widely used representations especially analogies, and symbolic representations like graphs, molecular representations and schemas to increase students' understanding of chemistry. However, he used them without involving students to the process or without completely considering whether they understood or not. For instance, he used analogies superficially not considering the possibility of causing misconceptions because of the deficient explanation, or he draw graphs by himself on the board and explain how to use these graphs. However, he did not consider if students learnt and could draw similar graphs or not. He always taught the topic by himself and suppose students learnt it. Therefore; there is an interaction between his use of topic specific representations and beliefs about science teaching and learning. In one of the interviews conducted after the instruction, the following dialogue between the researcher and Mr. Kuzu occurred:

> "R: You often use analogies during your instruction. What is your purpose of using analogies during your instruction?
> Mr. Kuzu: So that they [students] can understand better. Establishing similarities with what they are familiar will lead them to understand clearly.
> R: What about the graphs? Most of the time you draw the graphs related to the topic on the board.
> Mr. Kuzu: It is because I want them to learn the relations between the related axes.
> R: Do you think it is beneficial for their learning?
> Mr. Kuzu: Sure. If they listen carefully, they can easily learn.

His explanation elicited that he believed students can learn if they listen to what the teacher taught.

Considering Mrs. Akman's teacher focused beliefs about science teaching and learning, there appeared to be an interaction between her beliefs about science teaching and learning and topic specific representations. She widely used especially analogies and graphs during the instruction. However, the way of using these topic specific representation was teacher-focused similar to her beliefs about science teaching and learning. She draw the analogies by herself and did not consider whether students understand it or not like Mr. Kuzu did. Likewise, she used graphs and explained students how to interpret them. However, she did not include students to the process and did all the work by herself. As a result of the information given above, there was an interaction between teachers' beliefs about science teaching and learning and their use of topic specific representations.

4.2.4. STO vs. KofA

In this section, interactions between sub-components of Mr. Kuzu's and Mrs. Akman's science teaching orientations and knowledge of assessment were examined. The interactions were exactly the same for both of the teachers. There was an interaction between their beliefs about the goals or purposes of science teaching and what is assessed, the way of assessment and the purpose of assessment. Beliefs about science teaching and learning was only interacted with the way of assessment. In this part methods of assessment was not considered as a separate component because it was so much related to the way of assessment; therefore, it was given as nested to the way of assessment. All interactions were given in Table 23 for Mr. Kuzu and in Table 24 for Mrs. Akman.

Table 23. Interaction between Mr. Kuzu’s science teaching orientations and knowledge of assessment

	KNOWLEDGE OF ASSESSMENT		
STO	***What is assessed***	***The way of assessment***	***The purpose of assessment***
Goals or purposes	**STO:** Correct explanations Everyday coping **KofA:** Chemistry content Daily life applications	**STO:** Solid foundation **KofA:** Multiple choice tests during the class hours and multiple choice tests as homework.	**STO:** Correct explanations Solid foundation **KofA:** Showing students what kind of questions can be asked in the HEE and UPE about this topic and completing the deficiencies about the topic
Teaching and learning	-	**STO:** Teacher focused **KofA:** Informal questioning directed by the teacher.	**-**

Table 24. Interaction between Mrs. Akman's science teaching orientations and knowledge of assessment

	KNOWLEDGE OF ASSESSMENT		
STO	***What is assessed***	***The way of assessment***	***The purpose of assessment***
Goals or purposes	**STO:** Correct explanations Everyday coping **KofA:** Chemistry content Daily life applications	**STO:** Solid foundation **KofA:** Multiple choice tests during the class hours and multiple choice tests as homework.	**STO:** Correct explanations Solid foundation **KofA:** Showing students what kind of questions can be asked in the HEE and UPE about this topic and completing the deficiencies about the topic
Teaching and learning	-	**STO:** Teacher focused **KofA:** Informal questioning directed by the teacher and solving questions prepared by the teacher in the classroom	**-**

Beliefs about the Goals or Purposes of Science Teaching vs. what is assessed

Mr. Kuzu's and Mrs. Akman's two of the beliefs about the goals or purposes of science teaching, correct explanations and everyday coping, had an interaction with assessing students' knowledge of chemistry content and daily life applications of chemistry. As mentioned at the Knowledge of Assessment Part, during the instruction Mr. Kuzu always asked what could be the daily life applications of the topics and wanted students to learn about them. If students did not have much idea about the daily life examples, he explained them to the students. He also gave importance to the correct explanations of the questions. When he asked questions to the students he always repeated the correct answers and wanted students to learn the best possible explanation of the question. Most of the time, while solving problems in the class, he solved the problems first, and then wanted students to solve the other problems as he showed. Therefore, it can be said that there is an interaction between what he assessed and his beliefs about the goals or purposes of science teaching.

Mrs. Akman did almost the same things what Mr. Kuzu did. She gave importance to emphasize the daily life applications of chemistry topics. For this purpose, she asked examples of daily life events related to the chemistry topic or questions about the reasons of these events to the students to understand how much students know about them. Sometimes she used daily life events to stress chemistry topic. For instance she asked "If I give an example from daily life, let's say there is 20 % discount in all of the products in a store. Does it mean that I will get 20 TL off, if I buy a shirt?" to emphasize how percent is used in mathematics. Some of the students responded "yes" and some of them "no". Then she explained the correct answer and then switched to chemistry to teach mass percent concentration as "It is exactly the same in chemistry. If you want to prepare a 20% sugar solution you have to use 20 grams of sugar and 80 grams of water." Besides everyday coping purposes, this could also be an example for Mrs. Akman's correct explanations purposes about science teaching and learning. Even though she got answers from students, she did not let students to defend their ideas and did the correct explanations of the question by herself. Besides, while solving problems in the classroom with students, she only got answers from students and solve the problem by herself on the board.

Beliefs about the Goals or Purposes of Science Teaching vs. the Way of Assessment

Mr. Kuzu's and Mrs. Akman's one of the beliefs about the goals or purposes of science teaching, solid foundation, had an interaction with the way of their assessment. They used multiple choice questions in the classroom to show students how the chemistry concept could be asked in a question, because they wanted their students to learn the type of questions that could be asked in the HEE and UPE in order to make students familiar to those questions. Also, they gave multiple choice tests as homework to the students. Mr. Kuzu used multiple choice questions "because in the nationwide examinations the type of the questions is multiple choice and I want them [students] to see how the chemistry content we cover in the classroom can be asked as a question." Likewise, Mrs. Akman used multiple choice questions for the same purpose compatible with her solid foundation purposes. For instance, she always reminded students the type of questions that would potentially be asked in the HEE and UPE. Her reminder "Be careful. In previous years, questions with graphs were widely used in the examinations. Like this one (pointing out a question with graph). Who wants to solve this question?" was an example to this situation. Regarding these explanations teachers' beliefs about the goals or purposes of science teaching was interacted with the way they assessed their students' understanding.

Beliefs about the Goals or Purposes of Science Teaching vs. the Purpose of Assessment

Mr. Kuzu's and Mrs. Akman's two of the beliefs about the goals or purposes of science teaching which were correct explanations and solid foundation interacted with their purposes of assessment given in the Table 15. Mr. Kuzu stated that

> When we solve problems about the topic covered, students understand what kind of questions can be asked in the HEE and UPE about this topic and also it provides us to review and summarize the topic. It also let me detect how much students learn, find the deficiencies and fill the gaps.

In this explanation, it was seen that Mr. Kuzu gave importance to find the missing parts of students' understandings and filled the gaps compatible with his correct explanations purpose because it was important for him to give the best possible explanations about the topic. As always he did, even the question is multiple choice or open-ended, first Mr. Kuzu answered the questions or solved the problems and then wanted students to answer the next questions. Especially while answering the multiple choice questions he explained the questions in details and wanted students to learn the correct explanations of the answers compatible with his beliefs about correct explanations. In his explanation, it was also seen that he had purpose of teaching the type of questions that could be asked at HEE and UPE to his students. During the instruction, Mr. Kuzu always emphasized and reminded students how chemistry content could be asked in questions at the HEE and UPE when he was covering the topic which was compatible with his purpose of solid foundation.

Similar to Mr. Kuzu, Mrs. Akman stated that

> It would be better for students to be familiar to the questions that will potentially be asked in the exams. Therefore, I give importance to solve those kind of questions in the classroom and give questions as homework for them to solve at home.

When she delivered multiple choice tests to the students as homework, she controlled them to be sure that students did it, and wanted students to ask the questions to herself that they had difficulty in solving or understanding. If students asked the questions she explained the correct answer to eliminate any kind of misunderstanding and completing the deficiencies about the topic. In the light of the explanations above, it can be stated that both Mr. Kuzu's and Mrs.

Akman's beliefs about the goals or purposes of science teaching interacted with their purposes of assessing students' understanding.

Beliefs about Science Teaching and Learning vs. the Way of Assessment

Both Mr. Kuzu and Mrs. Akman had teacher focused beliefs about science teaching and learning according to the way they assessed students. As mentioned at the previous sections, they directed all types of assessments implemented in the classes. During the solving of multiple choice questions in the class, first Mr. Kuzu solved some questions and then he wanted students to solve questions as he had solved. Also, during the informal questioning sessions, he repeated the responds of the students even though they were correct in order not to leave any missing point.

Mrs. Akman did almost the same thing while assessing students. Most of the time she asked questions to students and got the answers in just one sentence and then she began to explain the correct answer in details. When solving problems she got the answer from the students but solved the problem by herself and did not let students to solve or explain the answer of the problem. In brief teachers always took the lead of the class even when assessing their students. Therefore, their beliefs about science teaching and learning interacted with the way they assess their students.

CHAPTER 5

CONCLUSION, DISCUSSION, & IMPLICATIONS

In this chapter, first of all, conclusions were made depending on the results of this study under four topics: conclusions related to science teaching orientations, other four components of PCK, interactions of beliefs about the goals or purposes of science teaching with other components of PCK and interactions of beliefs about science teaching and learning with the other components of PCK. Second the discussed of the study were provided considering the topics presented in the conclusions part. Third, implications for pre- and in-service teacher education and recommendations for science education research were presented.

5.1. Conclusions

In this part, conclusions derived from the results of the study were provided. They were given under four specific topics: (a) conclusions related to science teaching orientations of the participants, (b) conclusions related to the other four components of PCK which are knowledge of learner, knowledge of curriculum, knowledge of instructional strategy and knowledge of assessment, (c) conclusions related to the interaction of beliefs about the goals or purposes of science teaching with other components of PCK, and (d) conclusions related to the interaction of beliefs about science teaching and learning with other components of PCK.

5.1.1. Conclusions related to the science teaching orientations

In this part, conclusion related to the sub-components of science teaching orientations, which are beliefs about the goals or purposes of science teaching, beliefs about science teaching and learning and beliefs about the nature of science, was provided.

1. STO interacted with all components of PCK. However, sub-components played in the interactions were different for the participants.
2. Teachers might hold different beliefs as ideal and working, regarding beliefs about the goals or purposes of science teaching and beliefs about science teaching and learning.
3. Teachers' working beliefs about the goals or purposes of science teaching were the same for all participants and they were everyday coping, solid foundation and correct explanations.
4. Nationwide examinations were important factors to develop solid foundation beliefs about the goals or purposes of science teaching.
5. Teachers' working beliefs about science teaching and learning were all teacher-focused.
6. None of the participant emphasized the aspects of the nature of science during the instruction, even though they have informed views on that aspect due to the fact that nationwide examinations not including questions about the NOS, time limitation, and teachers' ongoing habits.

5.1.2. Conclusions related to the other four components of PCK

In this part, conclusions related to participants' other four components of PCK, which are knowledge of learner, knowledge of curriculum, knowledge of instructional strategy and knowledge of assessment, was provided.

1. Teachers believed that students didn't have difficulties or misconceptions about mixtures unit as they were familiar to this unit from their daily life.
2. Teachers expected students to have adequate prerequisite knowledge on mixtures unit depending on students' previous classes at middle school.
3. Dealing with any other occupation besides teaching (e.g. writing books in this case) lead participants to have developed knowledge of curriculum.

4. Didactic teaching method was preferred by both of the teachers. The indications of didactic teaching was seen during the instruction in use of each activity and representation.
5. Nationwide examinations had great effect on teachers' knowledge of assessment.

5.1.3. Conclusions related to the interaction of beliefs about the goals or purposes of science teaching with the other components of PCK

In this part, conclusions related to the interaction of teachers' beliefs about the goals or purposes of science teaching with the other components of PCK was provided.

1. When correct explanations and solid foundation purposes were interacted together with the same PCK component, solid foundation purpose appeared to be the reason of having correct explanations purpose.
2. Beliefs about the goals or purposes of science teaching interacted with knowledge of learner and knowledge of assessment the most and knowledge of curriculum the least.
3. All interactions between beliefs about the goals or purposes of science teaching and the other four components of PCK have the same features for two teachers, expect for the interactions with the knowledge of curriculum.
4. Teaching strategy teachers preferred to use during the instruction was interacted with beliefs about the goals or purposes of science teaching regarding solid foundation and correct explanations.
5. Topic specific teaching strategies did not usually interact with beliefs about the goals or purposes of science teaching (Expect for topic specific representations interaction with solid foundation).
6. Teachers altered the curriculum only if they believed this alteration would lead students to get better scores in the examinations, which was

compatible with their solid foundation beliefs about the goals or purposes of science teaching.

5.1.4. Conclusions related to the interaction of beliefs about science teaching and learning with the other components of PCK

In this part, conclusions related to the interaction of teachers' beliefs about science teaching and learning with the other components of PCK was provided.

1. Beliefs about science teaching and learning mostly interacted with knowledge of instructional strategies. The interactions were examined in regarding all the sub-components of knowledge of instructional strategies.
2. Knowledge of assessment was the component of PCK that interacted the least with beliefs about science teaching and learning.
3. Considering knowledge of assessment, beliefs about science teaching and learning only interacted with the way of assessment.
4. There was an interaction between beliefs about science teaching and learning and knowledge of curriculum for the participant who was more knowledgeable about the curriculum.

5.2. Discussions

In this part, results of this study were compared and contrasted with the other studies in the literature considering the sequence in the conclusion part. First, results about science teaching orientations will be discussed. Second the results about other components of PCK, and last results about the interaction between STO and the other four components of PCK will be discussed. As a reminder, the purpose of this study was to investigate in-service chemistry teachers PCK and the interaction between their science teaching orientations and other components of PCK regarding mixtures unit.

5.2.1. Discussions of the results for science teaching orientations

In this study, science teaching orientations interacted with all the other components of PCK; knowledge of learner, knowledge of curriculum, knowledge of instructional strategy, and knowledge of assessment. Science teaching orientations was seen as the overarching component among the five components of PCK, which influences all the other components (Aydin & Boz, 2013; Grossman, 1990; Magnusson et al., 1999). Considering its overarching feature it is not surprising to see its interaction with the other components. However, regarding the two participants of the study, sub-components of PCK that played role in the interactions with STO were different. Even though the frequency or the quality of the interactions were not considered as it is beyond the scope of this study, depending on the existence or nonexistence of the interactions it can be stated that the interactions were different because every teacher represents the topic in different ways (Aydin & Boz, 2013). Interaction between PCK components was found to be varied by other researchers (Aydin & Boz, 2013; Park & Chen, 2012).

Considering science teaching orientations, results obtained from the interviews and observations for a teacher might differ. One participant of the study, Mr. Kuzu, did not perform in his classes compatible with his beliefs about the goals or purposes of science teaching and science teaching and learning. There was a mismatch between his beliefs and practice. Jones and Carter (2007) suggested that insufficient time may be the reason of inconsistency between what teachers believe and how they perform. When they could not find adequate time to teach how they want, their science teaching orientations may be effected from these time constraint (Friedrichsen & Dana, 2005). Similarly, participants of this study frequently complained about limited number of weekly hours of chemistry classes and time constraint. In order to handle discrepancy between teachers stated and reflected beliefs, results from teachers statements were coded as ideal beliefs and results from the observations of the teaching practices were coded as working beliefs. The same situation occurred in the study of Samuleowicz and

Bain (1992) and Aydin (2012) and they used the dual coding of the same belief sets as ideal and working beliefs to handle the mismatch between belief and practice.

Friedrichsen et al. (2011) proposed to examine science teaching orientations under three belief sets in order not to label a teacher's orientation in a single category as Magnusson et al. (1999) did, because it would not reflect a whole belief set of a teacher. In this study, teachers' orientations were examined under three components proposed by Friedrichsen et al. (2011). Teachers' working beliefs about the goals or purposes of science teaching were the same for all participants and they were everyday coping, solid foundation and correct explanations. As it is seen from this result, a teacher can hold multiple purposes for science teaching (Friedrichsen & Dana, 2005; Volkmann et al., 2005). The same categorization of beliefs about the goals or purposes of science teaching was also provided by Demirdöğen (2016) for pre-service teachers. In that study, everyday coping was presented as purpose by all participants. While correct explanations was presented as a purpose by participants in a certain degree, solid foundation was not the purpose of any participant. Most probably the reason of the difference between pre- and in-service teachers' purposes regarding solid foundation may be the nationwide examinations. In-service teachers spend time with high school students who will take the nationwide examinations and may be college students in a short time. They share the feelings of high school students regarding the nationwide examinations and college courses. Therefore, they determine solid foundation as their purposes while pre-service teachers not, as they do not encounter with high school students and their college purposes as much as in-service teachers.

Besides solid foundation, everyday coping and correct explanations were revealed as the purposes of experienced in-service teachers for teaching science. Considering everyday coping, teachers started to deal with chemistry in daily life starting from their college years. Especially in pre-service teacher education programs relation between chemistry and daily life is frequently emphasized. Daily life events and their reasons are discussed widely regarding the chemistry behind them. So that teachers learn to emphasize the daily life applications of chemistry to their students beginning from their pre-service teacher education years. Moreover, in recent years chemistry curriculum (NME, 2013) includes many goals related to the daily life applications of chemistry and students are expected to learn these objectives at the end of the chemistry courses to develop scientifically literate citizens. In almost every topic, there are many objectives that emphasize the relation between daily life and chemistry. Therefore, teachers are expected to know and implement daily life applications of chemistry widely in their instruction.

The other purpose of experienced in-service teachers was correct explanations. Teacher gave importance to provide the best possible explanations of the concepts to the students in order to avoid any misunderstanding. The main idea behind the correct explanations purpose was “Learn it because it’s correct” (Roberts, 1988, p. 37). The reason behind this purpose may be teachers’ confidence on their subject matter knowledge. As it is the case in this study, experienced teachers so much trust on their subject matter knowledge that they believe students should learn chemistry the way they teach, because it is always true.

Nationwide examinations like Higher Education Examination (HEE) and Undergraduate Placement Examination (UPE) are important factors for participants of this study to develop solid foundation purposes regarding beliefs about the goals or purposes of science teaching. These exams have substantial role in the educational system of Turkey that effects both students and the teachers. Moreover, other studies reported the effect of exam-based educational system on science teaching orientations of teachers not only in Turkey (Aydin, 2012; Aydin et al., 2014) but also in the other countries of the world like India

(Nargund-Joshi et al., 2011) and China (Zhang, Krajcik, Sutherland, Wang, Wu, & Qiang, 2003).

When we turn into the second component of science teaching orientations, participants' beliefs about science teaching and learning, we can see that they hold teacher-focused beliefs instead of student-focused ones. Flether and Luft (2011) argued that "the teachers' beliefs about teaching initially shift to a contemporary focus while participating in their teacher preparation program, but ultimately return to a didactic orientation by their first year in the classroom" (p. 1124-1125). Moreover, didactic orientation which was labeled as teacher-focused orientation by Friedrichsen et al. (2011) "is observed most frequently in teachers across all phases" (Kind, 2016, p.6). Considering what Fletcher and Luft (2011) and Kind (2016) stated and the participants of this study who were experienced teachers teaching for many years, their strongly teacher-focused beliefs could become more understandable.

The last component of science teaching orientations was beliefs about the nature of science. Unfortunately, none of the participant emphasized the nature of science in their instruction. They asserted three main reasons for not emphasizing NOS aspects in their instruction: time limitation, their ongoing habits, and nationwide examinations not including questions about the NOS. Time limitation was mentioned as a limiting factor for teachers that inhibit them including NOS to their instruction by Southerland, Johnston, and Sowell (2006). Even these teachers were experienced and had well-developed NOS views it is not adequate for them to manifest these views in their classroom practice (Lederman & Druger, 1985). As the reason of not this situation, Lederman (2007) proposed that teachers did not see NOS instruction as important as the traditional subject matter instruction. Moreover, NOS instruction did not have an instructional outcome as the traditional subject matter instruction had, which lead teachers not to focus on NOS aspects in their instruction. For these reasons in-service teachers NOS views were not automatically manifested in their instruction.

5.2.2. Discussions related to the other four components of PCK

Teachers believed that students didn’t have difficulties or misconceptions about mixtures unit as they were familiar to this unit from their daily life. Teachers assumed that what students learn from their daily life experience were correct and did not consider that students might develop misconceptions or some incorrect conceptions as a result of their daily life experiences (Friedrichsen et al., 2009). Encountering a chemistry concept often in their daily life, did not lead students learn and explain that concept in a scientifically correct way (Taber, 2002). Likewise, teachers believed that students should have adequate pre-requisite knowledge for learning mixtures unit, because this unit was covered in the middle school. In short, teachers did not consider what the students in their classes really know. The reason of this situation might be that teachers’ teacher-focused beliefs limit their perspective to see things from a more broad approach. Teachers who developed teacher-focused beliefs did not consider ideas of students and focused on their own ideas during the teaching of the topic (Luft & Roehrig, 2007). For instance, if the teacher believe that knowledge transmits from teacher to student, s/he does not focus on student-student interaction in the classes even though students tend to learn in this way. Consequently, they could not think from student perspective as their highly teacher-focused beliefs control their decisions.

Didactic teaching method was preferred by both of the teachers. The indications of didactic teaching was seen during the instruction in use of each activity and representation. Teachers explained the reason of using didactic teaching method as time constraints and loaded curriculum. As there were many topics to be covered in a limited time teachers preferred to take the lead of the instruction and did not give chance to students to participate in the classes. Teachers explained the concepts, solved the problems, answered students’ questions, do the activities…etc. while students were just taking notes and listen to the teacher. The same reasons were mentioned by Aydin (2012) so that most probably time limitation and loaded curriculum were the common problems of in-service teachers and they tried to handle these problems by using didactic teaching approach.

Finally, nationwide examinations had great effect on teachers' knowledge of assessment. They preferred to solve problems during their instruction to get students adopt to the questions of HEE and UPE. Most of the time they preferred to use multiple choice questions for the same purpose. Nationwide examinations effect not only their knowledge of assessment but also their some other instructional decisions; however, the most important effect was seen on their knowledge of assessment. Teachers teaching in the countries that have exam-based educational systems were highly affected from those exams in their choices of assessment (Aydin, 2012; Nargund-Joshi et al., 2011).

5.2.3. Discussions related to the interaction of beliefs about the goals or purposes of science teaching with the other components of PCK

The first result to be discussed is that when teachers' solid foundation and correct explanations purposes were interacted together with the same PCK component, solid foundational purposes appeared to be the reason of having correct explanations purposes. Roberts (1988) considered these two purposes as *default emphases* which are situated in traditional science curricula and their purpose did not mentioned explicitly but instead implicitly. The message behind correct explanations purpose is "Learn it because it's correct" (Roberts, 1988, p. 37) and the message behind solid foundation purposes is that getting ready for the next classes and years. The role of the teacher who has correct explanations purpose was explained as by Roberts (1988) as "One responsible for identifying and correcting the errors in student thinking" (p. 45). When these explanations were combined with the results of this study, teachers' purpose of preparing their students to the nationwide examinations and for this aim explaining every single detail about the topic makes sense. They wanted their students to learn the topic without any missing point, to make them being successful in the examinations.

Therefore, their solid foundation purposes dominates correct explanations purposes.

Participants' beliefs about the goals or purposes of science teaching of interacted with knowledge of learner and knowledge of assessment the most, and knowledge of curriculum the least in this study. Similar to these results, Padilla and van Driel (2011) reported that teacher-focused orientations like didactic and academic rigor are generally linked to knowledge of learner and knowledge of instructional strategies. Moreover, knowledge of learner and knowledge of instructional strategies were elicited as the components that had the most interaction with the other components of PCK (Park & Chen, 2012; Aydin & Boz, 2013), while knowledge of curriculum and knowledge of assessment interacted the least (Park & Chen, 2012). In this study, knowledge of assessment demonstrated a contradiction with previous studies as being the mostly interacted component to the beliefs about the goals or purposes of science teaching besides knowledge of learner. When the interactions between knowledge of assessment and beliefs about the goals or purposes of science teaching were examined deeply, it was seen that solid foundation and correct explanations purposes dominated teachers' knowledge of assessment. As explained in the previous paragraph, when solid foundation and correct explanations were interacted together with the same PCK component, solid foundation behaves as it was also the reason of having correct explanations as purpose. Teachers were strongly connected to the solid foundational purposes that, they considered this purpose in any kind of instructional practices including assessing their students so that interaction between knowledge of assessment and beliefs about the goals or purposes of science teaching increases. When we focused on knowledge of curriculum, we can see that previous studies reported its weak interaction with the other components of PCK (Park & Chen, 2012; Aydin & Boz, 2013). Depending on the results of present study, we may infer that the reason of the weak interaction between knowledge of curriculum and other components of PCK is teachers' beliefs about the goals or purposes of science teaching, which is one the sub-component of the overarching science teaching orientations component (Magnusson et al., 1999). Teachers' knowledge of curriculum was controlled by their beliefs about the goals or purposes of science teaching. Participants of this study had everyday coping, solid foundation and correct explanations beliefs. Especially their solid foundation purposes direct their knowledge of curriculum that, they focused more on students' preparation to the nationwide examinations or next year chemistry classes. For this aim they sometimes avoided or altered the objectives stated in the curriculum to make them suitable to their own solid foundational purposes even though they are aware of that objectives. Hence, the interaction between their beliefs about the goals or purposes of science teaching and knowledge of curriculum showed low interaction.

Park and Chen (2012) and Veal and Kubasko (2003) claimed that teaching approach that teachers used were highly effected from their science teaching orientations. In this study, teaching strategy teachers preferred to use during the instruction interacted with beliefs about the goals or purposes of science teaching regarding solid foundation and correct explanations. Teachers did not use any subject specific topic strategy and they used traditional didactic teaching throughout the teaching of mixtures unit. They explained the reason of using didactic teaching as to give students all the important information in order not to miss any single point. So that students learn all the information they give and their chance to be successful in nationwide examinations would increase. From these explanations it was clear that their solid foundational and correct explanations purposes affect their use of teaching strategies. Although topic specific teaching strategies were not usually interacted with beliefs about the goals or purposes of science teaching only topic specific representations interacted with solid foundation purposes which was related to the teachers purpose of students having success in the nationwide examinations. As Friedrichsen et al. (2009) suggested high stake tests had limiting role of teachers' preference of instructional strategies they use in their instruction.

Teachers of this study altered the curriculum only if they believed this alteration would lead students to get better scores in the examinations, which was compatible with their solid foundation beliefs about the goals or purposes of science teaching. When the teachers felt that they need to change the sequence of the topics, they did not hesitate to do it especially if the student learning will be effected in a positive way from this change. As proposed by Lee and Luft (2008), experienced teachers give importance to organize the curriculum subjects depending on the students need and feel themselves flexible in case of changeable situations in the classes.

5.2.4. Discussions related to the interaction of beliefs about science teaching and learning with the other components of PCK

Beliefs about science teaching and learning mostly interacted with knowledge of instructional strategies. The interactions were examined in regarding all the sub-components of knowledge of instructional strategies. Teachers of this study held teacher-centered beliefs about science teaching and learning. As discussed above, Padilla and van Driel (2011) argued teacher-focused orientations have connection with knowledge of instructional strategies the most. Likewise Park and Chen (2012) suggested that teacher-focused science teaching orientations managed teachers' knowledge of instructional strategies and prevented its interaction with the other PCK components. Moreover, in the study of Demirdöğen (2016), beliefs about science teaching and learning was reported to be interacted mostly with teachers' knowledge of instructional strategies.

Knowledge of assessment was the component of PCK that interacted the least with beliefs about science teaching and learning, even though it interacted with beliefs about the goals or purposes of science teaching the most. As it was discussed in the previous topic, studies conducted earlier reported that knowledge of assessment had the least interaction with the other components of PCK (Park & Chen, 2012; Aydin & Boz, 2013; Padilla & van Driel, 2011). Considering the overarching identity of science teaching orientations (Grossman, 1990) and the strong relationship between beliefs about the goals or purposes of science teaching and knowledge of assessment as one of the results of this study, it can be concluded that the reason of its weak interaction with other components of PCK could be teachers' beliefs about science teaching and learning. Their teacher-focused beliefs about science teaching and learning inhibit the interaction of knowledge of assessment with the other components of PCK.

Knowledge of assessment is one of the most important however, less studied component of PCK (Abell, 2007; Padilla & van Driel, 2011). Apart from the fact that beliefs about science teaching and learning interacted knowledge of assessment the least, when we examine the interaction deeply, we can see that only one of its sub-component, the way of assessment indicated an interaction with beliefs about science teaching and learning. Same results presented by Aydin and Boz (2013) that the way of assessment was affected by teachers' orientations. Participants have teacher-focused beliefs about science teaching and learning and most of the time they assessed their students' understanding using informal questioning directed by themselves or by solving questions with students in the classes. They believed that if students fail to give the correct answer to the questions it means they did not understand the topic. Regarding their teacher-focused beliefs about science teaching and learning, dominating the assessment procedure and not giving chance to students in this process would be understandable because their beliefs about science teaching and learning affected the way they assess their students.

5.3. Implications

In this part of the dissertation, implications drawn from the results of the study were presented considering beginning and experienced in-service teachers, pre-service teachers and curriculum developers.

Science teaching orientations is the overarching component of PCK that has influence on each of the other components of teachers' PCK and their teaching practice (Grossman, 1990; Magnusson et al., 1999). Moreover, science teaching orientations is the part of PCK that has the most connection with belief systems of teachers (Boesdorfer & Lorsbach, 2014). This study is one of the first study examining science teaching orientations of in-service chemistry teachers and interaction between science teaching orientations and other components of PCK in details. Within the PCK framework, STO is the neglected component (Friedrichsen et al., 2011). Therefore, to see the place of STO in the PCK framework, it is important to study this component in order to develop the PCK framework.

The participants of this study held content specific purposes and teacher-focused beliefs regarding science teaching and learning which may inhibit them to participate in the reform-based activities in their instruction. As frequently stated beliefs are resistant to change (Kagan, 1992; Nespor; 1987) and they are complex structures (Friedrichsen & Dana, 2005). Hence, in order to change them, first of all, they needed to be made explicit. Especially for experienced teachers who have more resistant beliefs to change than beginning teachers (Luft & Roehrig, 2007), it is important to identify their beliefs to see whether they can keep pace with the reform-based education. For this purpose, first of all what beliefs in-service teachers held should be examined and made explicit. Without knowing what they believe, it is impossible to change their beliefs regarding the reform-based practices.

Professional development activities that have the superior effect on teachers' beliefs (Luft & Roehrig, 2007) would be helpful to elicit and change the science teaching orientations of experienced teachers. For instance, participant teachers of this study used didactic teaching method widely in their instruction. The belief behind the reason of using this method should be made explicit. Then professional development courses to change the habit of using this teaching method should be conducted. For this aim, alternative teaching methods could be introduced to the teachers and they need to get the idea behind the necessity of using alternative teaching methods instead of using didactic teaching methods. Another example for using the reform-based teaching practices could be on assessment procedure. This study indicated that teachers' purposes of science teaching were interacted to their knowledge of assessment the most. The results of this and similar studies should be considered to reveal the reasons of the interaction and possible consequences of this interaction. By introducing alternative assessment techniques to the in-service teachers, the strong interaction with their beliefs about the goals or purposes of science teaching and knowledge of assessment should be directed and more reform-based practices could be placed to their instruction.

Results of this study indicated that in-service chemistry teachers widely used traditional teaching methods and did not emphasize the NOS aspects during their teaching. Beginning from the pre-service teacher education program more importance is given to the subject specific courses and most of the time courses indicating the nature or history of science is neglected. As a result, in-service teachers did not give equal importance to the nature of science and subject specific topics. Therefore, starting from the pre-service teacher education programs and continuing with the professional development courses, importance of emphasizing the nature of science aspects should be emphasized to the teachers to enable them emphasize these aspects in their instruction.

This study showed that in-service chemistry teachers mostly had everyday coping, correct explanations and solid foundation purposes. They did not have purposes like structure of science, science, technology, decisions or scientific skill development…etc. the purposes teachers had were mostly related to teaching the subject matter in a correct way by including everyday life knowledge to the students to enable them to be successful in their future life. Teacher should have more science based purposes to widen the world of students regarding science teaching.

The results of this study showed that in-service chemistry teachers always used traditional instructional and assessment methods in their teacher-centered instruction. They were not open to alternative methods or student-centered instruction. Professional development courses that are designed to lead teachers use alternative methods and student-centered instruction would be helpful for teachers to develop their knowledge and practice about these kind of instruction.

As stated above, beginning teachers' beliefs are more flexible and open to reform than experienced teachers. Conclusions could be drawn from the studies conducted with experienced teachers to see the future of beginning teachers and precautions could be taken before their beliefs become robust, as it is hard to change them when they ones strike. Programs introducing the reform-based practices and their concrete applications would be helpful for beginning teachers to develop more student-centered beliefs in their early years of teaching in case the possibility of developing teacher-centered beliefs.

Considering the results of this study, implication for pre-service teacher education could be drawn. If there are more and complicated interaction between the components of PCK, the PCK of teachers become more developed (Park & Chen, 2012; Aydin et al., 2015). As science teaching orientations dominate the instructional decisions of teachers, activities that lead the development of pre-service teachers' science teaching orientations, and hence their PCK, would be beneficial to be conducted in pre-service teacher education programs. Especially well-designed university courses had great impact to develop pre-service teachers' science teaching orientations (Avraamidou, 2013). Most of the time, science teacher educators focused on subject specific and pedagogical courses. As a result, courses that have effect on pre-service teachers' beliefs could be neglected. Therefore, little change in science teaching orientations of pre-service teachers was observed with the existing courses in the education programs (Brown, Friedrichsen & Abell, 2009). To enhance the use of reform-based science teaching, courses focusing on the belief systems of teachers may be helpful to develop reform based science teaching orientations. Likewise, courses to increase their knowledge on PCK would be beneficial to develop their PCK. If they had the opportunity to learn what PCK is and use it in an effective way with all components integrated to each other, the quality of the instruction will increase.

Another implications of this study was drawn for curriculum developers. It is clear from the results of this study that science teaching orientations of teachers highly effect their classroom practices. The variation in teachers' science teaching orientations affect the way they implement the teaching methods, assessment styles, how they consider student knowledge or even the use of curriculum. To handle the latter, curriculum has some flexible points that teachers can choose the suitable alternative for their students considering their needs. By this way teachers do not always concern about the requirement for being strictly bounded to the curriculum and also they can decide instructional practices considering their students' needs and requests.

5.4. Recommendations

The following recommendations are presented for future research on science education.

- In this study, science teaching orientations and its interaction with the other components of PCK was examined for experienced in-service teachers by using the theoretical definition of Friedrichsen et al. (2011) for science teaching orientations. More studies with pre- and in-service teachers and college educators should be conducted to increase the studies on science teaching orientations which is the neglected component of PCK to see if this theoretical definition is suitable for empirical research.
- The focus of this study was limited to the interaction of science teaching orientations with each single component of PCK. Studies searching for the interference of science teaching orientations in the interactions of other PCK components should be conducted.

- In this study, the quality or complexity of the interactions were not examined. Studies focusing on the quality or complexity of the interactions should be conducted. The increase in interplay between components of PCK, also increase the development of PCK (Park & Chen, 2012). Therefore, to develop teachers' PCK, the quality or the complexity of the interactions should be considered.

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APPENDIX A

MESLEKİ YAŞANTINIZ İLE İLGİLİ SORULAR

Amaç: *Bu görüşme sırasında size geçmişiniz ile ilgili sorular sorulacaktır.*

1. Yaşınız?

2. Eğitiminiz? (Lise, Lisans, Lisansüstü)

3. Ne kadar süredir öğretmenlik yapıyorsunuz?

4. Öğretmenlik yapmaya nasıl karar verdiniz?

5. Şimdiye dek öğretmenlik yaptığınız okullar hangileridir?

6. Geçmişte ve şu an girdiğiniz dersler nelerdir?

7. Okulda kimya öğretimi dışında herhangi bir göreviniz var mı?

8. Sınıflarınızın ortalama mevcudu kaçtır?

9. Bu dönem hangi sınıflara ders veriyorsunuz?

10. Lisede öğrenci olduğunuz zamanları düşünmenizi istiyorum.

   a) Kimyanın hangi konusunu daha çok seviyordunuz? Neden?

   b) Kimya derslerinde en iyi nasıl öğreniyordunuz? (Diğer derslerden farklı olarak kimyaya çalışırken neler yapıyordunuz?)

11. Kimya öğretmeni olarak;

   a) En güçlü yanlarınız nelerdir?

   b) En zayıf yanlarınız nelerdir?

12. Öğretmenliğinizin ilk yıllarında sizi en çok zorlayan şey neydi?

13. Sizce öğretmenliğinizin ilk yılları ile son yılları arasında nasıl farklar var?

APPENDIX B

FEN ÖĞRETİMİ YÖNELİMİ İLE İLGİLİ SORULAR

Fen Öğretimi ve Öğrenimi ile İlgili Sorular

Amaç: *Bu görüşme sırasında size fen öğretimi ve öğrenimi ile ilgili düşüncelerinize yönelik sorular sorulacaktır.*

1. Bir kimya dersine nasıl hazırlanırsınız? Dersten önce ve sonra neler yaparsınız?

2. Kimyanın hangi konusunu öğretmeyi daha çok seviyorsunuz? Neden?

3. Kimyanın hangi konusunu öğretmeyi daha az seviyorsunuz? Neden?

4. Öğretmen olarak rolünüzü nasıl tanımlarsınız? (Sizin tipik bir dersinizi izlesek sizi genellikle ne yaparken görebiliriz?)

5. Öğrencinin rolünü nasıl tanımlarsınız? (Sizin tipik bir dersinizde öğrencilerinizi genellikle ne yaparken görebiliriz?)

6. Kafanızda iyi bir öğrenciyi canlandırın. Onun iyi bir öğrenci olduğunu düşündüren özellikleri nelerdir?

7. Kafanızda iyi olmayan bir öğrenciyi canlandırın. Onun iyi bir öğrenci olmadığını düşündüren özellikleri nelerdir?

8. Öğrencileriniz kimyayı en iyi nasıl öğrenir?

9. Öğrencilerinizin öğrendiğini nasıl anlarsınız?

10. Sınıfınızdaki öğrencilerin öğrenmesini nasıl arttırırsınız?

11. Neyi öğretip neyi öğretmeyeceğinize nasıl karar verirsiniz?

12. Bir konuyu bitirip yeni bir konuya geçebileceğinize nasıl karar verirsiniz?

13. Öğrenci velilerinin öğrencilerin öğrenmesi üzerindeki rolü hakkında ne düşünüyorsunuz?

14. Ezberlemek kimya öğrenmede nasıl bir rol oynar?

15. Kimya eğitiminde laboratuvar kullanımı hakkında ne düşünüyorsunuz?

16. Hizmet içi eğitim/seminer/çalıştay gibi etkinliklere katıldınız mı? Cevabınız evetse bunların öğretiminize etkisi olduğunu düşünüyor musunuz?

17. Öğretmenliğinizi etkileyen örnek aldığınız bir modeliniz var mıydı?

18. İstediğiniz şekilde öğretim yapmanızı engelleyen herhangi bir şey olduğunu düşünüyor musunuz? (yönetim, öğrenciler, okul şartları…vb.)

Fen Öğretiminin Amaç ve Hedefleri

Amaç: *Bu görüşmede size kimya öğretimine yönelik amaçlarınız ile ilgili sorular sorulacaktır.*

1. Sizce lisede kimya öğretilmesinin amacı nedir? (bir kağıda yazılabilir)

2. Bu amaçları nasıl belirlediniz?

3. Öğrencinin kimya konularını öğreniyor olması neden önemli?

4. Öğretim hedefleriniz sınıf düzeyine göre değişir mi?

5. Bu sene 10. sınıflarda hangi konuları öğrettiniz ve öğreteceksiniz? (bir kağıda yazılacak)

6. Bu konuları öğretme amacınız nedir? (her bir konu ayrı ayrı sorulacak)

7. Sizce konuları neden bu sırayla öğretiyorsunuz?

APPENDIX C

BİLİMİN DOĞASI HAKKINDA GÖRÜŞLER ANKETİ

1) Bilim ne demektir? Bilimi (veya fizik, biyoloji gibi bir bilimsel alanı) diğer araştırma alanlarından (örneğin, din ve felsefe) farklı kılan şey nedir?
2) Deney ne demektir?
3) Bilimsel bilginin gelişmesi için deney gerekli midir?
    i) Evetse, niçin? Görüşünüzü destekleyen bir örnek veriniz.
    ii) Hayırsa, niçin? Görüşünüzü desteleyen bir örnek veriniz.
4) Bilim insanları bilimsel bir teori geliştirdikten sonra (örneğin atom teorisi, evrim teorisi) bu teori hiç değişir mi?
    i) Eğer bilimsel teorilerin değişmeyeceğine inanıyorsanız nedenini açıklayınız? Cevabınızı örneklerle destekleyiniz.
    ii) Eğer bilimsel teorilerin değişeceğine inanıyorsanız, (a) teorilerin niçin değiştiğini açıklayınız (b) o zaman niçin teorileri öğrenmek için çaba harcadığımızı açıklayınız. Cevabınızı örneklerle destekleyiniz.
5) Bilimsel teori ve bilimsel kanun arasında fark var mıdır? Bir örnek veriniz.
6) Fen kitapları genellikle atomun; protonlar (pozitif yüklü parçacıklar) ve nötronların (nötr parçacıklar) bulunduğu merkezdeki bir çekirdek ile çekirdek etrafında dolaşan elektronlardan (negatif yüklü parçacıklar) oluştuğunu ifade eder. Bilim insanları atomun yapısı hakkında nasıl bu kadar emin olabilmektedirler? Bilim insanlarının atomun neye benzediğine karar verirken hangi spesifik delilleri kullandıklarını düşünüyorsunuz?
7) Fen kitapları bir türü, genellikle benzer özelliklere sahip organizmaların oluşturduğu ve verimli döller üretmek için birbirleriyle çiftleşen grup olarak tanımlar. Bilim insanları bir türün ne olduğuyla ilgili özellikler hakkında nasıl emin olmaktadırlar? Bilim insanlarının bir türün ne olduğunu belirlemek için hangi spesifik delilleri kullandıklarını düşünüyorsunuz?

8) Yaklaşık 65 milyon yıl önce dinozorların yok olduğuna inanılmaktadır. Bilim insanları tarafından bu yok oluşu açıklamak için oluşturulan hipotezlerden ikisi daha fazla kabul edilmektedir. Bir grup bilim insanı tarafından oluşturulan birinci hipotez; 65 milyon yıl önce kocaman bir meteorun dünyaya çarptığını ve yok oluşa neden olan bir dizi olaya yol açtığını öne sürer. Diğer bir grup bilim insanı tarafından oluşturulan ikinci hipotez ise; büyük ve şiddetli bir volkanik patlamanın bu yok oluşa neden olduğunu öne sürer. Eğer her iki gruptaki bilim insanları aynı verilere ulaşıyor ve aynı verileri kullanıyorlarsa, bu farklı sonuçlar nasıl ortaya çıkmaktadır?

9) Bazı insanlar, bilimin sosyal ve kültürel değerlerden etkilendiğini iddia etmektedir. Yani, bilim sosyal ve politik değerleri, felsefi varsayımları ve üretildiği kültürün akla uygun normlarını yansıtmaktadır. Diğerleri ise, bilimin evrensel olduğunu iddia etmektedir. Yani, bilim ulusal ve kültürel sınırları aşmaktadır ve sosyal, politik ve felsefi değerlerden ve üretildiği kültürün akla uygun normlarından etkilenmemektedir.

   i) Eğer bilimin sosyal ve kültürel değerleri yansıttığına inanıyorsanız, nedenini açıklayınız. Cevabınızı örneklerle destekleyiniz.

   ii) Eğer bilimin evrensel olduğuna inanıyorsanız, nedenini açıklayınız. Cevabınızı örneklerle destekleyiniz.

10) Bilim insanları, ileri sürdükleri sorulara cevap bulmaya çalışırken deneyler ve araştırmalar yapmaktadır. Bilim insanları bu araştırmaları boyunca yaratıcılıklarını ve hayâl güçlerini kullanmakta mıdır?

   i) Cevabınız evetse, araştırmanın hangi aşamasında - planlama ve tasarlama, veri toplama, veri topladıktan sonra - bilim insanlarının hayâl güçlerini ve yaratıcılıklarını kullandıklarını düşünüyorsunuz? Bilim insanlarının neden hayâl güçlerini ve yaratıcılıklarını kullandıklarını açıklayınız. Mümkünse örnekler veriniz.

   ii) Eğer bilim insanlarının hayâl güçlerini ve yaratıcılıklarını kullanmadıklarını düşünüyorsanız, nedenini açıklayınız. Mümkünse örnekler veriniz.

APPENDIX D

PAB BİLEŞENLERİ İLE İLGİLİ SORULAR

Konu Alan Bilgisi ve Öğrenci Bilgisi

1. Konu alan bilginize ne kadar güveniyorsunuz?
2. Konu alan bilginizin çoğunu nereden edindiniz?
3. Sizce her öğrenci aynı şekilde mi öğreniyor?
4. Öğrencileriniz kimyayı öğrenirken zorlanıyorlar mı? Evetse, hangi açılardan zorlanıyorlar? Öğrencilerinizin zorlanıp zorlanmadığını nasıl anlarsınız?
5. Zorluk çeken öğrencilerin öğrenmesini kolaylaştırmak için neler yapıyorsunuz?
6. Öğrencilerinizin yaşadığı zorluklar konudan konuya farklılık gösteriyor mu? Sizce neden böyle bir farklılık oluyor? Öğrencileriniz sizce en zor hangi kimya konusunu öğreniyor? Bu durumu nasıl fark ettiniz, bu zorluğu nasıl aşıyorsunuz?
7. Öğrencilerin önbilgisinin öğrenmelerinde herhangi bir etkisi olacağını düşünüyor musunuz? Neden?
8. Öğrencilerinizin ön bilgisini tespit etmek için neler yapıyorsunuz?
9. Öğrencilerinizin yanlış kavramaları olup olmadığını nasıl tespit edersiniz? Bu yanlış kavramaları gidermek için neler yaparsınız?

Öğretim Yöntemi Bilgisi

1. Derslerinizde hangi öğretim yöntemlerini kullanıyorsunuz? Niçin bu yöntemleri kullanıyorsunuz? Bu yöntemleri kullanmayı nasıl öğrendiniz?
2. Kullandığınız öğretim yöntemleri konudan konuya farklılık gösteriyor mu? Cevabınızın nedenini açıklar mısınız?
3. Bir yöntem tüm öğrencilerin öğrenmesi için etkili olabilir mi?

4. **4.** Yaptığınız herhangi bir aktivitenin etkili olduğunu nasıl anlarsınız? Etkili olmadığını anlarsanız ne yaparsınız?
5. **5.** Her dönem aynı konuyu aynı şekilde mi anlatırsınız? Değişiklik yapıp yapmamaya nasıl karar verirsiniz?

Öğretim Programı Bilgisi

1. Kimya öğretim programına tam olarak hakim misiniz? Programla ilgili bilginize güveniyor musunuz?
2. Sizin için öğretim programının amacı nedir? Kimya öğretim programının olumlu ve olumsuz bulduğunuz yönleri nelerdir?
3. Öğretim programından yardım alıyor musunuz? Neden yardım aldığınızı/almadığınızı açıklar mısınız? Öğretim programından öğretiminizin hangi noktalarında yardım alıyorsunuz? Konudan konuya yardım aldığınız noktalar değişiyor mu?
4. Kimya öğretim programında yapılan değişikleri takip ediyor musunuz? Size göre eski programla yeni programın farklılıkları/benzerlikleri nelerdir?
5. Öğretim programına birebir bağlı kalır mısınız? Yoksa bir değişiklik yapar mısınız? Neden böyle bir değişiklik yaparsınız?

Ölçme Bilgisi

1. Öğrencilerinizi bir konuyu anlayıp anlamadığını ölçerken özellikle dikkat ettiğiniz noktalar var mı?
2. Konu ile ilgili "neyi" ölçeceğinize nasıl karar verirsiniz?
3. Öğrencilerinizin bir konuyu anlayıp anlamadıklarını ne zaman, nasıl ve niçin ölçersiniz?
4. Derslerinizde hangi ölçme-değerlendirme yöntemlerini kullanırsınız? Neden bu yöntemleri kullanmayı tercih ediyorsunuz?
5. Öğrencileri başarılı ya da başarısız olarak yorumlarken nelere dikkat ediyorsunuz?
6. Kullandığınız ölçme-değerlendirme yöntemleri konudan konuya farklılık gösteriyor mu? Cevabınızın nedenini açıklar mısınız?
7. Değerlendirme sonuçlarını nasıl kullanıyorsunuz?

APPENDIX E

KARIŞIMLAR KONUSUNA İLİŞKİN SORULAR

1. Karışımlar ünitesinde neler yapmayı planladığınızla alakalı genel bir bilgi verebilir misiniz?

2. Bu üniteyi kaç gün işlemeyi planladınız? Sizce bu süre yeterli olacak mı?

3. Öğrencilerinizin Karışımlar ünitesinden neler öğrenmesini bekliyorsunuz? (bir kağıda yazılacak)

4. Öğrencilerinizin Karışımlar konusunda bunları öğrenmesi neden önemlidir? (her biri ayrı ayrı sorulacak)

5. Karışımlar konusunu öğrenebilmek için öğrencilerin hangi kavramları bilmesi gerekiyor? Neden?

6. Bu ünitede öğrencilerin henüz öğrenmemesi gereken kısımlar var mı? Neden?

7. Bu konuyu öğretirken ne gibi zorluklarla karşılaşmayı bekliyorsunuz?

8. Öğrencilerin Karışımlar konusunda ne gibi öğrenme zorlukları yaşayacağını düşünüyorsunuz?

9. Öğrencilerin bu konu ile ilgili hangi yanlış kavramaları olacağını bekliyorsunuz?

10. Karışımlar ünitesini öğretmek için hangi öğretim yöntemlerini kullanmayı planlıyorsunuz? Neden bu yöntemleri kullanmayı planlıyorsunuz?

11. Bu üniteyi öğretmek için ne gibi aktiviteler yapmayı planlıyorsunuz?

12. Sizce bu yöntem ve aktiviteler öğrencilerinizin öğrenmesine nasıl yardımcı olacaktır?

13. Öğrencilerinizin Karışımlar konusunu anlayıp anlamadığını nasıl ölçeceksiniz? Bu ölçme yöntemini kullanmaya nasıl karar verdiniz? Bu yöntemin yanında kullanabileceğiniz başka yöntemler de var mıdır?

14. Öğrencilerin Karışımlar ünitesindeki konuları anlayıp anlamadığını ne zaman ölçmeyi planlıyorsunuz?

15. Öğretim programının Karışımlarla ilgili kısmını incelediniz mi? Öğretim programında bu konuda dikkat çeken kısımlar sizce nelerdir? Kullanacağınız/kullanmayacağınız kısımlar nerelerdir?

16. Öğretim programında Karışımlar konusuyla ilgili belirtilen amaç ve hedefler nelerdir? Siz bu amaç ve hedeflere katılıyor musunuz?

17. Öğretim programında Karışımlar konusuyla ilgili yapılan değişiklikler nelerdir? Katılıyor musunuz? Neden?

APPENDIX F

IRB FORM

T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

Sayı : 14588481/605.99/3997621 17/09/2014
Konu: Araştırma İzni
(Betül EKİZ KIRAN)

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi : a) MEB Yenilik ve Eğitim Teknolojileri Genel Müdürlüğünün 2012/13 nolu genelgesi
b) 10/09/2014 tarih ve 4464 sayılı yazınız.

Üniversiteniz doktora öğrencisi Betül EKİZ KIRAN'ın "Kimya Öğretmenlerinin Fen Eğitimi Yönelimi İle Diğer Pedagojik Alan Bilgisi Bileşenleri Arasındaki İlişki" konulu tez önerisi kapsamında 2014-2015 eğitim-öğretim yılında uygulama yapma isteği Müdürlüğümüzce uygun görülmüş ve araştırmanın yapılacağı İlçe Milli Eğitim Müdürlüğüne bilgi verilmiştir.

Anketlerin uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde iki örneğinin (CD ortamında) Müdürlüğümüz Strateji Geliştirme-1 Şube Müdürlüğüne gönderilmesini arz ederim.

Ali GÜNGÖR
Müdür a.
Şube Müdürü

EK:
Mühürlü Anket Örnekleri (5 sayfa)

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CURRICULUM VITAE

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MS	Gazi University, Chemistry Education	2007
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PUBLICATIONS

A. Papers published in journals:

Aydin, S., Demirdogen, B., Tarkin, A., Kutucu, S., Ekiz, B., Akın, F. N., Tuysuz, M., Uzuntiryaki, E. (2013). Providing a set of research-based practices to support preservice teachers’ long-term professional development as learners of science teaching. Science Education, 97(6), 903-935. DOI: 10.1002/sce.21080.

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B. Papers presented in international conferences:

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C. Papers presented in national conferences:

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D. Posters presented in conferences:

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