IMPLEMENTATION OF SELF-REGULATORY INSTRUCTION BASED ON GUIDED INQUIRY APPROACH TO PROMOTE STUDENTS' ACHIEVEMENT IN SOLUBILITY EQUILIBRIUM AND ACIDS AND BASES, MOTIVATION, AND LEARNING STRATEGIES

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

CANSEL KADIOĞLU

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
SECONDARY SCIENCE AND MATHEMATICS EDUCATION

JUNE 2014

Approval of the thesis:

IMPLEMENTATION OF SELF-REGULATORY INSTRUCTION BASED ON GUIDED INQUIRY APPROACH TO PROMOTE STUDENTS' ACHIEVEMENT IN SOLUBILITY EQUILIBRIUM AND ACIDS AND BASES, MOTIVATION, AND LEARNING STRATEGIES

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ABSTRACT

IMPLEMENTATION OF SELF-REGULATORY INSTRUCTION BASED ON GUIDED INQUIRY APPROACH TO PROMOTE STUDENTS' ACHIEVEMENT IN SOLUBILITY EQUILIBRIUM AND ACIDS AND BASES, MOTIVATION, AND LEARNING STRATEGIES

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June 2014, 307 pages

The current study explored how the self-regulatory instruction (SRI) based on guided inquiry approach affect 11th grade students' achievement in Solubility Equilibrium and Acids and Bases, motivation, and learning strategies compared to traditionally-designed chemistry instruction. In addition, the self-regulatory processes in which students engaged and the development of these processes over the course of the study were examined. Eleven dependent variables related to the three dimensions of SRL (motivation, cognition, and metacognition) were studied under two categories. Motivational variables included mastery-approach goal orientation, mastery-avoidance goal orientation, performance-approach goal orientation, performance-avoidance goal orientation, chemistry self-efficacy for cognitive skills, and self-efficacy for chemistry laboratory. On the other hand, cognitive variables involved achievement in Solubility Equilibrium and Acids and Bases, and rehearsal, elaboration, organization and metacognitive self-regulation strategies.

Mixed Methods Design was employed: Nonrandomized Control Group Pretest-Posttest Design as a Type of Quasi Experimental Design was utilized as a

Quantitative Method and Case Study was utilized as a Qualitative Method. Totally 78 students participated in the study: 38 students in the experimental group and 40 students in the control group. Quantitative data were collected using Solubility Equilibrium and Acids and Bases Test, Goal Orientation Scale, High School Chemistry Self-Efficacy Scale, and Cognitive and Metacognitive Strategies Scale. The instruments were administered as pre-tests before the intervention and as post-tests after the intervention. Additionally, four students from each classroom were selected as focal students using maximum variation sampling method. Interviews, journals, and think aloud protocols were used as qualitative instruments. Two separate mixed Multivariate Analyses of Variance were run to analyze the quantitative data: one for motivational variables and another for cognitive variables as dependent variables.

In terms of motivational variables, results of quantitative and qualitative analyses revealed that SRI supported development of students' self-efficacy beliefs; especially their self-efficacy beliefs for chemistry laboratory. Regarding cognitive variables, an improvement in students' achievement was observed in favor of experimental group; however, its effect was less compared to self-efficacy beliefs. Although, quantitative analyses did not yield any significant difference among groups in terms of the use of cognitive and metacognitive strategies, analyses of think aloud protocols revealed that students in the experimental group used more cognitive and metacognitive strategies and in turn showed higher academic performance compared to the students in the control group.

Keywords: Self-regulatory Instruction, Guided-inquiry Approach, Chemistry Education, Motivation to Learn Chemistry, Self-Efficacy, Goal Orientations, Learning Strategies

ÖZ

ÖĞRENCİLERİN ÇÖZÜNÜRLÜK DENGESİ VE ASİTLER VE BAZLAR BAŞARISINI, MOTİVASYONUNU VE ÖĞRENME STRATEJİLERİNİ DESTEKLEMEK İÇİN ÖĞRETMEN REHBERLİ SORGULAYICI ARAŞTIRMA YAKLAŞIMINA DAYALI ÖZDÜZENLEYİCİ ÖĞRENME YÖNTEMİNİN UYGULANMASI

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Bu çalışmada öğretmen rehberli sorgulayıcı araştırma yaklaşımına dayalı özdüzenleyici öğrenme metodunun 11. sınıf öğrencilerinin Çözünürlük Dengesi ve Asitler ve Bazlar başarısı, motivasyonu ve öğrenme stratejileri üzerindeki etkisi geleneksel yaklaşıma göre tasarlanmış kimya dersi ile karşılaştırılarak araştırılmıştır. Ayrıca, öğrencilerin kullandıkları özdüzenleme süreçleri ve bu süreçlerin çalışma boyunca gelişimi incelenmiştir. Özdüzenleyici öğrenmenin üç boyutu (motivasyon, biliş, ve üstbiliş) ile ilişkili 11 bağımlı değişken iki kategori altında çalışılmıştır. Motivasyon değişkenleri öğrenme-yaklaşma hedef yönelimi, öğrenme-kaçınma hedef yönelimi, performans-yaklaşma hedef yönelimi, performans-kaçınma hedef yönelimi, bilişsel beceriler için kimya öz-yeterlik ve kimya laboratuvarı için öz-yeterlik değişkenlerini içermektedir. Diğer taraftan, bilişsel değişkenler kimya başarısı ve tekrarlama, ayrıntılandırma, örgütleme ve bilişüstü öz-düzenleme stratejilerinden oluşmaktadır.

Bu çalışmada farklı kaynaklardan elde edilen verilerin karşılaştırılması amacıyla Karma Yöntem Araştırması kullanılmıştır. Nicel araştırma tekniği olarak Yarı-Deneysel Desen olan Rasgele Olmayan Kontrol Gruplu Öntest-Sontest Deseni ve nitel araştırma tekniği olarak Durum Çalışması tekniği kullanılmıştır. Çalışmaya toplam 78 öğrenci katılmıştır: deney grubunda 38 öğrenci ve kontrol grubunda 40 öğrenci vardır. Nicel verilerin toplanmasında Hedef Yönelimi Ölçeği, Lise Kimya Öz-Yeterlik Ölçeği, Duyuşsal ve Üstduyuşsal Stratejiler Ölçeği ile Çözünürlük Dengesi ve Asitler ve Bazlar Testi kullanılmıştır. Ölçme araçları çalışmadan önce öntest ve çalışmadan sonra sontest olarak uygulanmıştır. Nicel verilerin analizinde bilişsel değişkenler ve motivasyon değişkenleri için ayrı ayrı Karma MANOVA analizi yapılmıştır. Ayrıca, her iki gruptan dört öğrenci maksimum çeşitlilik örnekleme yöntemi kullanılarak odak öğrenci olarak seçilmiştir. Nitel veri toplama aracı olarak öğrenme günlükleri, yüksek sesle düşünme protokolleri, gözlem formları ve görüşme tekniği kullanılmıştır.

Motivasyon değişkenleri açısından, nicel ve nitel analiz sonuçları incelendiğinde, özdüzenleyici öğrenme metodunun özellikle kimya laboratuvarı için öz-yeterlik değişkeni açısından öğrencilerin öz-yeterlik inançlarının gelişimini desteklediği bulunmuştur. Bilişsel değişkenlerden öğrencilerin kimya başarısında deney grubu lehine bir artış gözlenmiştir. Fakat bu etki, öz-yeterlik değişkeni ile karşılaştırıldığında daha düşük kalmaktadır. Her ne kadar nicel verilerin analizi bilişsel ve üst bilişsel strateji kullanımı açısından anlamlı fark ortaya koymasa da, yüksek sesle düşünme protokolleri deney grubundaki öğrencilerin bilişsel ve üst bilişsel stratejileri daha sık kullandıklarını ve bunun sonucunda kontrol gruptaki öğrencilere kıyasla daha yüksek akademik başarı gösterdiklerini ortaya koymuştur.

Anahtar Kelimeler: Özdüzenleyici Öğrenme Metodu, Öğretmen Rehberli Sorgulayıcı Araştırma Yaklaşımı, Kimya Eğitimi, Kimya Öğrenmeye İlişkin Motivasyon, Öz-yeterlik, Hedef yönelimleri, Öğrenme Stratejileri

ACKNOWLEDGEMENTS

First of all, I would like to express my gratitude to my supervisor, Assoc. Prof. Dr. Esen Uzuntiryaki Kondakçı, for her support throughout my PhD. I would like to thank her for being a role-model to me in my journey to become a faculty member. I always appreciate her guidance and encouragement during my hard times.

I would also like to thank to my committee members, Prof. Dr. Ömer Geban, Assoc. Prof. Dr. Yezdan Boz, Assist. Prof. Dr. Yeşim Çapa Aydın, and Assist. Prof. Dr. İ. Elif Yetkin Özdemir, for their assistance and recommendations.

I wish to express my thanks to all members of the Department of SSME for their extensive support at those times when things got really hard; for their understanding and sincere support. I feel very lucky to have worked with them.

I am also very thankful to the teacher and the students participating in this study. The cooperative teacher deserves special thanks for her considerable effort in this study.

I would like to acknowledge The Scientific and Technological Research Council of Turkey (TUBITAK) for the program coded as 2211 and Faculty Development Program (OYP) for the financial support throughout my PhD.

I am an extremely lucky person to have wonderful friends around me who encouraged me to apply for the PhD program and supported me throughout the program whenever I needed help. Sharing all those years with you was a great chance for me: Dr. Gülsüm Gül Cömert, Dr. Ayla Çetin Dindar, Dr. Ebru Kaya, Dr. Zübeyde Demet Kırbulut, Dr. Esma Emmioğlu, Dr. Oktay Bektaş, Dr. Hanife Can Şen, Dr. Buket Bezgin Çarbaş, Kübra Eryurt, Fatma Nur Akın, Dr. Uğur Taşdelen, Dr. Verda Kocabaş, Dr. Burcu Şenler, Dr. Burçin Acar Şeşen, Sevim Sevgi, Fazilet Boynueğrioğlu, Amy Newman, Çiçek Coşkun, Yasemin Çetin Kaya, Ahmet İlçi, and Mustafa Şat.

Writing an academic work in a second language was the most challenging part of this journey. Luckily, I had the opportunity to work on my thesis at the Academic Writing Center (AWC) at METU. Writing my thesis turned to an enjoyable activity. Thanks to its coordinators (Ms. Deniz Saydam and Ms. Cahide Çavuşoğlu) and tutors for their invaluable help and feedback, increasing my self-efficacy in writing, and helping me become a more independent writer. Without their help and encouragement, it would have been so difficult to finish this work.

Last but not least, I am very thankful to my parents who have always given priority to and invested in our education. I would like to express my special thanks to my mother for her patience at my stressful times. I am also very thankful to my sisters and brother for their support.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

LLL	: Lifelong Learning
SRL	: Self-Regulated Learning
SCT	: Social Cognitive Theory
SRI	: Self-Regulatory Instruction
TDCI	: Traditional Designed Chemistry Instruction
EG	: Experimental group
CG	: Control group
DV	: Dependent variable
IV	: Independent variable
MoNE	: Ministry of National Education
SEABT	: Solubility Equilibrium and Acids and Bases Test
GOS	: Goal Orientation Scale
HCSS	: High School Chemistry Self-Efficacy Scale
MSLQ	: Motivated Strategies for Learning Questionnaire
CMSS	: Cognitive and Metacognitive Strategies Scale
CSCS	: Chemistry Self-Efficacy for Cognitive Skills
SCL	: Self-Efficacy for Chemistry Laboratory
MANOVA	: Multivariate Analysis of Variance
CFA	: Confirmatory Factor Analysis
RMSEA	: Root-Mean-Sqaure Error of Approximation
SRMR	: Standardized Root Mean Square Residual
TLI	: Tucker-Lewis Index
CFI	: Comparative Fit Index
GFI	: Goodness of Fit Index
NFI	: Normed Fit Index

NNFI : Non-Normed Fit Index

CHAPTER 1

INTRODUCTION

"*When planning for a year, plant corn. When planning for a decade, plant trees. When planning for life, train and educate people.*" Chinese proverb: Guanzi (c. 645BC)

The development of society and economy depends on the improvements in technology which is supported by the scientific innovations. The accelerating growth in technology requires new skills day after day. Considering this, Eropean Union (EU Council, 2002) and Turkish government (National Agency, 2013) embrace Lifelong Learning (LLL) as a key concept for economic advancement. LLL includes education programs at school and after school for all members of the society in order to help them develop knowledge and skills (EU Council, 2002). As a consequence, guiding individuals to take control and responsibility of their own learning processes (i.e. helping them become independent lifelong learners) has turned out to be an important topic among educational researchers and policy makers. As the Chineese preverb above foresaw centuries ago, education does not end with graduation; instead, indivuduals need new skills after school, and learning continues during the whole life span. Accordingly, we should plan our curriculum in a way to support development of learning skills as well as content knowledge/conceptual understanding. To put it in another way, *learning how to learn* has become an important goal of education so that individuals could adapt their skills to new conditions and accomplish their learning needs throughout their lives.

Researchers have proposed different theories to describe how individuals become independent learners, i.e. masters of their own learning. Most of those investigations are conducted based on the Social Cognitive Theory proposed by Bandura (1986). It explains human functioning through reciprocal interactions between personal (e.g., student’s self-efficacy beliefs), environmental (e.g., feedback from the teacher), and behavioral (e.g., attention towards the instruction) factors. The Social Cognitive Theory emphasizes the agency of the learner, which means that individuals have control over their thoughts, feelings, and actions as a result of their self beliefs. With respect to this view, the learner makes his/her own choices and continues his/her learning regarding these choices in order to achieve his/her goals.

In order to help students take the responsibilty of their own learning process and become more effective learners, the concept of self-regulated learning (SRL) has become important in the field of educational psychology for nearly three decades. It covers different aspects of learning such as motivation, cognitive strategies, and metacognition (Zimmerman, 1986). Zimmerman (2000) defines SRL as “self-generated thoughts, feelings, and actions that are planned and cyclically adopted to the attainment of personal goals” (p.14). He explains SRL process in three cyclic phases: forethought, performance and self-reflection. In the forethought phase, students prepare themselves for learning using processes such as setting learning goals and strategic planning. Their motivational orientations (self-efficacy beliefs or/and outcome expectations) are also influential in this phase. Next, in the performance phase, students are in action implementing learning strategies which they choose from their repertoire considering the requirements of the task. After that, students assess the effectiveness of their learning process in the self-reflection phase. Although it seems to be the end of learning process, it actually results in students’ setting new goals based on the evaluation of their previous learning experience. This shows that learning is a cyclic process, and in each cycle students are reengaged in the forethought phase followed by the self-reflection phase.

Highly self-regulated learners follow these three phases to become metacognitively, motivationally, and behaviorally active participants in their own learning (i.e. become a highly self-regulated learner). Highly self-regulated learners are those who are aware of the processes that improve their academic performance, monitor these processes by getting feedback from previous learning experiences, and motivate themselves to learn (Zimmerman, 1994). Self-regulatory processes activate students' learning in several ways: Students determine their learning goals, give importance to mastery of the task, are aware of their strengths and weaknesses in learning, select the most appropriate strategies, are responsible for applications of these strategies, observe their progress, accept teacher guidance when necessary, evaluate whether they achieve their goals or not, monitor the learning process and make necessary changes (Zimmerman, 2000).

Determining the level of students' self-regulation and its relation with other academic outcomes has been an interest among scholars. Initial studies indicate a positive correlation between students' SRL skills and their achievement (e.g., Pape & Wang, 2003; Pintrich & DeGroot, 1990; Yumusak, Sungur, & Cakiroglu, 2007; Zimmerman & Martinez-Pons, 1986; Zusho, Pintrich, & Coppalo, 2003). Indeed, self-regulated learners not only improve their academic achievement, they also become aware of what they know and what they do not know. For example, Pape and Wang (2003) found out that although high- and low-achieving students did not differ in terms of the number of strategies they used, high-achieving students reported the use of different kind of strategies from low achievers. However, there are few studies that have focused on the specific ways in which classroom context influences students' SRL. Among these studies, the field of science is less frequently studied (Cleary, Platten & Nelson, 2008; Cleary & Zimmerman, 2004; DiBenedetto &

Zimmerman, 2010; Labuhn, Bögeholz & Hasselhorn, 2008a, 2008b; Sungur, 2004); most of the SRL studies were conducted in different content areas such as mathematics (e.g., Arsal, 2009; Bell & Pape, 2012; Pape, Bell, & Yetkin, 2003; Fuchs et al., 2003; Schunk, 1998; Yetkin-Ozdemir & Pape, 2012), reading (e.g., Housand & Reis, 2008; Souvignier & Mokhlesgerami, 2006), and academic writing (e.g., Graham & Harris, 2012; Harris & Graham, 1999). Paris and Paris (2001) claim that researchers should give importance to classroom implications of the theories explaining SRL. Accordingly, the aim of the present study was to investigate in what ways classroom context in a chemistry course supported students' SRL processes.

Research on how the nature of classroom context influences student learning suggests the following conditions to enhance students' SRL: challenging tasks that require problem solving skills and inquiry of natural phenemona, activities supporting meaningful learning and using critical thinking skills, opportunities to make choices about learning process, active participation in learning process or control on the learning process, discussing the results with other students or collaborating with peers, and reflection on the learning process, supporting students' individual differences and needs, and giving opportunities to pursue their own learning goals (Ames, 1992; Blumenfeld, 1992; Paris & Paris, 2001; Paris & Turner, 1994; Schraw, Crippen, & Hartley, 2006).

In fact, the characteristics of classroom context supporting SRL overlap with the features of inquiry approach. Sinatra and Taasoobshirazi (2011) emphasize the importance of use of SRL processes in science classrooms and define problem solving, inquiry, and critical thinking skills as the key elements in SRL. Similarly, Schraw et al. (2006) suggest inquiry as an instructional strategy to support cognitive, metacognitive, and motivational processes in science classes. As a result, among other teaching/learning approaches, inquiry-oriented instruction was implemented in the current study in order to promote students' SRL. Inquiry is an important skill; a way of thinking for scientists, a way of teaching science, and a way of exploring natural phenemona and learning for students. Teachers ask open-ended (authentic) questions about the natural phenomena and students engage in scientific activities to answer these questions. The classroom environment that provides students authentic and challenging tasks help them take control gradually in different forms such as choosing the content to learn, designing method, and reporting results. In guided inquiry approach, by asking open-ended questions, teachers provide feedback to students and help them reflect on the learning process. Guided inquiry, therefore, is an important teaching approach for the shift of control from environment (teachers) to individuals (students). The development of SRL skills also follows a parallel sequence: develops with social influences (models) and shifts to self-source (self-efficacy beliefs) (Zimmerman, 2000). In turn, students are expected to have more control on their own learning processes and become more independent learners. Inquiry oriented instruction also improves students' ability to ask higher order questions (Hofstein, Navon, Kipnis, & Mamlok-Naaman, 2005) which will improve metacognitive thinking - a key element to develop SRL in science classrooms (Schraw et al., 2006).

In summary, in the current study, the following principles are considered in order to help students develop self-regulatory skills based on guided inquiry approach (Carin, Bass, & Contant, 2005; Colburn, 2004; Georghiades, 2004; Paris & Winograd, 1999; Schraw et al., 2006): Students are exposed to open-ended (authentic) questions to explain natural phenomena, set challenging at the same time attainable goals for their own learning (a mastery goal orientation), use strategic planning to monitor different resources and time, give priority to evidence in classroom discussions, have opportunity to choose some classroom activities or assignments, have control on their learning while designing the experiments, collecting data and reporting results, reflect on the learning process through discussions or writing journals, evaluate what they know and what they do not know, use self-assessment of learning outcomes to monitor their progress, and become aware of effective learning strategies and compare them with the strategies of others. Teachers guide students by asking open-ended questions rather than giving the concepts and principles directly, and can promote development of their SRL skills by modeling them and providing feedback. Classroom activities include small group discussions and whole classroom discussions. Students share their opinions initially in small groups and then with the entire class. Critical discourse with others helps students reflect on what they know and how they know.

Considering the discussion above, the main purpose of the present study was to investigate the effect of self-regulatory instruction (SRI) based on guided inquiry approach on 11th grade students' achievement in Solubility Equilibrium and Acids and Bases, use of learning strategies, and perceived motivation in Solubility Equilibrium and Acids and Bases Units over time compared to traditionally-designed chemistry instruction. In addition to this quantitative analysis, the self-regulatory processes students engaged in and the development of these processes over the course of the study were explored using qualitative methodology.

1.1 The Main Problems

This study addresses the following research questions:

1. What is the effect of SRI based on guided inquiry approach on 11^{th} grade students' achievement in Solubility Equilibrium and Acids and Bases Units, motivation, and learning strategies over time?
2. How do students who were taught with SRI based on guided inquiry approach and who received traditionally-designed chemistry instruction utilize the self-regulatory processes in the Solubility Equilibrium and Acids and Bases Units over time?

1.1.1 The Sub-Problems

The sub-problems for the first main problem defined above are as follows:

1. Is there any significant difference between experimental group taught by SRI based on guided inquiry approach and control group receiving traditionally-designed chemistry instruction in terms of students' achievement in Solubility Equilibrium and Acids and Base Units and the use of learning strategies?
2. Do the means of students' achievement in Solubility Equilibrium and Acids and Bases Units and the use of learning strategies measured at different time periods (pretest and posttest) change over time?
3. Is there any significant interaction between the grouping variable (experimental group taught by SRI based on guided inquiry approach versus control group receiving traditionally-designed chemistry instruction) and test occasions (pretest and posttest) in terms of students' achievement in Solubility Equilibrium and Acids and Bases Units and the use of learning strategies?
4. Is there any significant difference between experimental group taught by SRI based on guided inquiry approach and control group receiving traditionally-designed chemistry instruction in terms of students' perceived motivation (goal orietations and self-efficacy beliefs)?
5. Do the means of students' perceived motivation (goal orietations and self-efficacy beliefs) scores measured at different time periods (pretest and posttest) change over time?
6. Is there any significant interaction between the grouping variable (experimental group taught by SRI based on guided inquiry approach versus control group receiving traditionally-designed chemistry instruction) and test occasions (pretest and posttest) in terms of students' perceived motivation (goal orietations and self-efficacy beliefs)?

1.2 The Null Hypotheses

Each of the subproblems for the first main problem is tested with the following hypotheses:

$H_0$1: There is no statistically significant mean difference between experimental group taught by SRI based on guided inquiry approach and control group receiving traditionally-designed chemistry instruction in terms of students' achievement in Solubility Equilibrium and Acids and Base Units and the use of learning strategies.

$H_0$2: There is no statistically significant mean difference in students' achievement in Solubility Equilibrium and Acids and Base Units, and the use of learning strategies measured at two different time periods (pretest and posttest).

$H_0$3: There is no statistically significant interaction between the grouping variable (experimental group taught by SRI based on guided inquiry approach versus control group receiving traditionally-designed chemistry instruction) and test occasions (pretest and posttest) in terms of students' achievement in Solubility Equilibrium and Acids and Base Units, and the use of learning strategies.

$H_0$4: There is no statistically significant mean difference between experimental group taught by SRI based on guided inquiry approach and control group receiving traditionally-designed chemistry instruction in terms of students' perceived motivation (goal orientations and self-efficacy beliefs).

$H_0$5: There is no statistically significant mean difference in students' perceived motivation (goal orietations and self-efficacy beliefs) scores measured at two different time periods (pretest and posttest).

$H_0$6: There is no statistically significant interaction between the grouping variable (experimental group taught by SRI based on guided inquiry approach versus control group took traditionally designed chemistry instruction) and test occasions (pretest and posttest) in terms of students' perceived motivation (goal orietations and self-efficacy beliefs).

1.3 Definition of Important Terms

The constitutive and operational definitions of important terms are given below:

Self-regulation: Based on Social Cognitive Theory self-regulation is defined as "self-generated thoughts, feelings, and actions that are planned and cyclically adopted to the attainment of personal goals" (Zimmerman, 2000, p.14). It is composed of three main dimensions: motivation, strategy use, and metacognition. How these dimensions are defined and measured in this study is explained below.

Motivation: Pintrich and Schunk (2002) define motivation as "the process whereby goal-directed activity is instigated and sustained" (p.5) and underline that motivation is a process rather than a product, and not directly observed but inferred from students' behaviors. In the present study motivation includes students' goal orientations and self efficacy beliefs for learning and performance.

Goal orientations: Elliot (1999) defines students' goal orientations as the purposes or reasons for achievement. In the current study, it is measured with the Goal Orientations Scale (GOS) developed by Elliot and McGregor (2001) and translated into Turkish by Senler and Sungur (2007). This scale includes mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance dimensions.

Self-efficacy beliefs: Bandura (1997) defines self-efficacy as "beliefs in one's capabilities to organize and execute courses of action required to produce given attainments" (p.3). In the current study, it is measured with Capa-Aydin and Uzuntiryaki (2009)'s High School Chemistry Self-Efficacy Scale (HCSS) with the sub-dimensions of chemistry self-efficacy for cognitive skills and self-efficacy for chemistry laboratory.

Self-regulatory Learning Strategies: SRL strategies refer to “actions directed at acquiring information or skill that involve agency, purpose (goals), and instrumentality self-perceptions by a learner” (Zimmerman & Martinez-Pons, 1986, p.615). In this study, it is measured with the rehearsal, elaboration, and organization sub-dimensions of the Motivated Strategies for Learning Questionnaire (MSLQ). The scale is developed by Pintrich, Smith, Garcia, and McKeachie (1991) and adapted into Turkish culture by Sungur (2004).

Metacognition: Flavell (1979) defines metacognition as “knowledge and cognition about cognitive phenomena” (p.906). The metacognitive self-regulation sub-dimension of the MSLQ was used to assess metacognitive self regulatory activities.

Achievement: Achievement is used as an indicator of students’ success on the units of Solubility Equilibrium and Acids and Bases. It is measured with the Solubility Equilibrium and Acids and Bases Test (SEABT) developed by the researcher.

Self-Regulatory Instruction based on Guided-Inquiry Approach: It is the instruction used in the experimental group, which includes activities predominantly composed of laboratory tasks. This type of instruction provides opportunities for challenging tasks, for some degree of choice in learning tasks and assignments, for reflection on the learning process, and for giving responsibility to students (Paris & Paris, 2001). In the laboratory, students make descriptions, explanations or predictions based on their observations. The teacher decides on the question to be investigated. The students themselves decide on the design of the experiment, the data collection procedure, data organization, and relavant observations. In addition, students engage in small group discussions to come up with conclusions and generalizations based on the collected data and their previous knowledge. Conceptual understanding of the scientific phenemona and thinking on learning process are emphasized in this instruction.

Traditionally-Designed Chemistry Instruction: It defines the teaching approach in the control group. In this method, the teacher continues her regular classroom activities. In the traditionally-designed chemistry class, the teacher directly informs the students about the subject and focuses on algorithmic problems rather than conceptual understanding. While conducting the experiments, the students follow the detailed explanations given in the textbook related with the procedure, apparatus, and relationships among the variables.

1.4 Significance of the Study

The significance of the present study is explained under two sections: significance for research and significance for practice.

1.4.1 Significance for Research

The study is significant as it is one of the early examples of studies incorporating theoretical approaches into classroom practices (e.g., Arsal, 2009; Bell & Pape, 2012; Cleary et al., 2008; Cleary & Zimmerman, 2004; DiBenedetto & Zimmerman, 2010; Fuchs et al., 2003; Graham & Harris, 2012; Harris & Graham, 1999; Housand & Reis, 2008; Labuhn et al., 2008a, 2008b; Pape, Bell, & Yetkin, 2003; Schunk, 1998; Souvignier & Mokhlesgerami, 2006; Sungur, 2004; Yetkin-Ozdemir & Pape, 2012). Most of these studies are conducted in the domains of mathematics, reading comprehension, and writing. However, fewer studies are done in science classrooms (Cleary, Platten & Nelson, 2008; Cleary & Zimmerman, 2004; DiBenedetto & Zimmerman, 2010; Labuhn et al., 2008a, 2008b; Sungur, 2004). Furthermore, most of these these studies were conducted in the context of biology classroom. Following Paris and Paris (2001), in this study self-regulatory instruction was developed and implemented in a regular chemistry curriculum. This study fills a gap in SRL literature and improves its ecologic validity by employing the SRL principles to a less frequently studied context, high school chemistry classroom.

SRL, as a broad and complex phenomenon explaining learning as a process rather than as an outcome, has become a popular topic in educational psychology for nearly three decades. It includes several variables associated with cognitive, metacognitive, and motivational dimensions of learning (Zimmerman, 1986). However, how to measure these variables is a concern in the literature (Winne & Perry, 2000). Most of the earlier studies exploring the the relationship between SRL processes and academic performance are conducted based on questionnaires and one-shot data collection procedure (Pintrich & DeGroot, 1990; Sperling, Howard, Staley, & DuBois, 2004; Yumusak et. al, 2007; Zimmerman & Martinez-Pons, 1986; Zusho et al., 2003). For that reason, they are away from explaining what is going on during the learning process. In order to provide better understanding of this phenomenon, this study was designed based on mixed-method approach: the quantitative data were triangulated with qualitative data as suggested by Winne and Perry (2000). Different data collection instruments such as interviews, think aloud protocols and questionnaires were used. Additionally, journals and observations were employed to keep track of students' progress. In this sense, this study is useful for future researchers since collecting and triangulating the data over an extended period of time enabled the researcher to explore different aspects of learning as a process.

1.4.2 Significance for Practice

The goal of science education is to develop scientifically literate individuals who possess conceptual understanding and scientific thinking skills, and connect these with their daily life experiences. Scientifically literate students can discuss the scientific problems they encounter in everyday life, e.g. whether nuclear power plants should be built or not, how global warming affects our lives, and what are the effects of acid rains on environment (Driver, Leach, Millar, & Scott, 1996; Hogan, 2000; Sandoval, 2005). The National Curriculum of Chemistry Education also aims to encourage students to take part in these on-going and important scientific arguments (MEB, 2011). The public understanding of science is important for different reasons such as economic (development of qualified scientists and technologists), utilitarian (use of technological objects and processes in daily life), and/or democratic (participation in public discussions) etc. purposes (Driver et al., 1996). Among others, the democratic argument is accepted as a primary purpose of science education for every member of the society by science educators and policy makers (Hogan, 2000, Sandoval, 2005). According to Sandoval (2005) participation in decision making processes is crucial for democracy. However, this participation should go beyond just rejecting or accepting without any thinking, rather individuals should analyze scientific claims critically (Hogan, 2000). Taking this debate into account, in the present study self-regulatory instruction was designed based on guided-inquiry approach in which students explored curricular concepts (natural phenomena) using the thinking processes same as scientists. In order to encourage students engage in scientific discussions, the teacher gave them authentic tasks and the students planned scientific activities that were required to accomplish those tasks. The tasks led the students to attend discussions, make conclusions based on diverse information coming from different sources, question the trustworthiness of this information, compare the consistency among different sources, and come up with conclusions in order to help them think scientifically and gain conceptual understanding. In conclusion, instruction based on guided -inquiry approach supports development of democratic citizens by encouraging them to think about daily issues and use scientific methods while thinking.

Guided-inquiry also helps students actively participate in the learning process and gain control on it gradually. This could be achieved by helping students become highly self-regulated learners and by promoting the development of all three dimensions of SRL (cognition, metacognition, and motivation). In the present study, the classroom tasks were designed in a way to help students possess a repertoire of learning strategies (cognition), be aware of the effective strategies considering task demands and monitor/change the strategies with respect to how much they accomplished their goals (metacognition), and sustain effort during learning process even in cases of difficulties and failures (motivation). They would set their own learning goals, make plans and use needed strategies to achieve these goals, monitor the learning process considering how much they achieved their goals and make necessary changes if required, and evaluate how much they succeed their goals. These three components of learning (cognition, metacognition, and motivation) are not separate from each other, rather they are related. Students who possess different cognitive skills should also know when to use them and how to monitor them, and should sustain effort in case of obstacles. In conclusion, effective use of all three components increase the level of students' self-regulation, help them develop effective learning habits, and in turn improve their science/chemistry achievement/performance (Zimmerman, 2000).

SRI instruction based on guided inquiry approach can help the students to appreciate learning does not end after graduation from school, rather continues after school and covers the whole life span, and employ existing skills into changed/different/new situations or develop essential skills in order to accomplish their learning needs. Students taking this instruction can develop study skills and learn to learn in addition to developing conceptual understanding or increasing their achievement. People who have received SRI can pursue their cruiosty, select challenging tasks, and develop new skills throughout their personal or professional lives. This instruction can also encourage using effective time management skills, asking help from collegues or experts, and using different resources for the period of individuals' lives. As a result, students could perceive learning as an ongoing process across the lifespan, take control of it, and achieve personal development.

CHAPTER 2

LITERATURE REVIEW

This second chapter includes review of the related literate in six sections. First, Social Cognitive Theory (SCT) and how SCT describes self-regulated learning (SRL) are given. Second, the components of SRL associated with the present study are examined in detail. Third, Zimmerman's Self-Regulatory Model is explained. Next, the development of SRL is clarified. Following, the applications of self-regulatory instruction in actual classroom settings are discussed. Finally, how the inquiry approach is carried out in science classes to promote self-regulatory skills is described.

2.1 Social Cognitive Theory and Self-Regulated Learning

Commonly, getting higher grades in a course or higher scores in nationwide exams are accepted as a sign for higher achievement or enhanced learning among students, teachers and parents. Although there is an emphasis on constructivist approach to teaching and learning in chemistry curriculum of national education (MEB, 2011), still teachers in high schools in Turkey tend to practice traditional teaching which is based on behavioristic theory. This theory defines learning in terms of stimulus –response relationship. Specifically, the teacher provides an appropriate stimulus (teaching material used in the classroom), and the students passively get it from the environment and consequently show the desired behavior (response). As a result, the source of the knowledge is external to the students in behavioristic approach. The teacher is active during the instruction, while the students are assumed to be passive and get the necessary information when the teacher presents it. In general, school success is assessed in terms of content knowledge, and, consequently, extrinsic motivation like getting high scores on the exams is common among students. The main limitation of behaviorism is that it merely focuses on whether a desired behavior occurs or not and ignores the cognitive processes that occur during learning.

The main problem which students commonly encounter is that they do not possess a high achievement level even though they spend an excessive amount of time in front of their desks. What makes their study time more efficient? How can students increase the effectiveness of their study? What makes a student learn better? Researchers search for answers to these and similar questions and propose several theories to explain students' learning process. For nearly three decades ago, the term SRL became popular to explain the active role of students in their learning process. Among different learning theories, the SCT guides a great body of self-regulatory research including this present study.

SCT explains influence of personal, environmental, and behavioral factors on individuals' learning via Bandura (1986)'s Triadic Reciprocal Determinism Model. Figure 2.1 displays the reciprocal interactions among personal (e.g., student's self-efficacy beliefs), environmental (e.g., feedback from the teacher), and behavioral (e.g., attention towards the instruction) determinants. As an example to the bi-directional relationship between personal and behavioral factors, learners with high level of self-efficacy beliefs (personal factor) tend to select more challenging tasks, use different cognitive strategies, and persist in case of failure (behavioral factor) (Linnenbrink & Pintrich, 2003). On the other hand, experience of success after high effort (behavioral factor) results with an increase in students' self-efficacy beliefs (Schunk & Zimmerman, 1997). For the bi-directional relationship between personal and environmental factors; when students perceive that classroom goals are supporting their autonomy (environmental factor), they further develop higher levels of self-efficacy beliefs (Greene et al., 2004). Conversely, when students give up as a result of low self-efficacy, the teacher divides the task into smaller parts which becomes attainable for them (environmental factor). The last reciprocal interaction exists between environmental factors such as classroom goals and students' behaviors. For example, students in the mastery classrooms in which the teacher provides them some degree of authority over their learning process and give them opportunities to make decisions (environmental factor), use maladaptive forms of strategies less frequently such as self-handicapping and preference to avoid novelty (behavioral factor) (Turner et al., 2002). To finish, students' behaviors also effect classroom environment. If the students employ a strategy inaccurately (behavioral factor), the teacher explains effective use of that strategy once more (environmental factor). In sum, SCT proposes that personal, environmental, and behavioral factors effect students' learning bi-directionally.

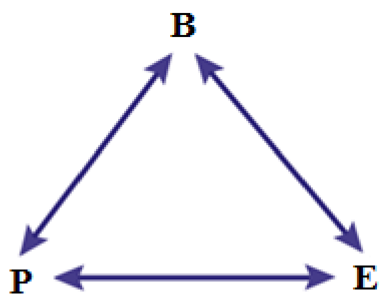


Figure 2.1 Bandura's Triadic Reciprocal Determinism

Source: Bandura, 1986, p. 24

According to SCT, the learner has an active role in his/her learning process, and the teacher designs classroom tasks in a way to activate him/her. Schunk (2001) explains the role of students in the learning process as "rather than being passive recipients of information, students contribute actively to their learning goals and exercise control over goal attainment" which SRL sticks well to (p.125). Bandura (1997) explains the control of learner over his/her learning process with the term "the agency of learner" which defines the intentional actions of the learner. According to the theorists who work on self-regulation, "learning is not something that happens to students; it is something that happens by students. They assume that, for learning to occur, students must become proactively engaged at both a covert and an overt level" (Zimmerman, 2001; p.33). In line with SCT, SRL is defined as "self-generated thoughts, feelings, and actions that are planned and cyclically adopted to the attainment of personal goals" (Zimmerman, 2000; p.14).

According to SCT, all learners are assumed to use self-regulatory learning processes to some degree; therefore, such concepts as *un-self-regulated learners* or l*ack of self-regulation* are not acknowledged (Winne, 1997). The degree of students' self-regulation is based on the degree to which students are metacognitively, motivationally and behaviorally active in the learning process (Zimmerman, 1986). In another paper, Zimmerman (1994) associates SRL with the degree of choice students have in their motivational orientations, the methods they employed, the duration of task, the learning outcomes, and the arrangement of physical or social environment. If the teacher determines all these areas of learning, students' learning is externally controlled and students have less chance to employ self-regulatory processes. Additionally, students may use different self-regulatory processes at varied degrees in different courses. Therefore, SRL is not a general trait rather it is context specific (Zimmerman, 2001).

Zimmerman (2001) explains common issues in SRL in line with the SCT under five dimensions: students' motivation, self-awareness, key-processes, social and physical environment, and acquiring capacity. First of all, *students' motivation* includes their self-efficacy beliefs, outcome expectations and goal orientations; highly self-regulated learners believe in their capacity to successfully perform task, anticipate positive outcomes as a consequence of effort, and set challenging goals for themselves. Second, *self-awareness* is dwelled on including self-observation and self-recording strategies in which the learner observes under what conditions s/he learns better such as time of the day, place to study, and duration of study periods and uses diaries or worksheets to record his/her learning material. Third, SCT further explores *key-processes*: self-observation, self-judgment, and self-reactions. Self-observation is important to monitor subsequent learning. Self-judgment refers to assessing existing performance with personal goals. Self-reactions such as not giving up in case of failure helps student sustain their effort. Next, *social and physical environment* includes modeling and enactive mastery experiences. Coping models are more influential due to perceived similarity, and enactive mastery experiences are very effective in determining self-efficacy beliefs. Finally, *acquiring capacity* means that self-regulatory skills and strategies develop from social environment to self-source. Different aspects of learning based on SCT being summarized in this paragraph, thorough details will be provided throughout this chapter.

2.2 Components of Self-Regulated Learning

In his pioneer paper, Zimmerman (1986) defines highly self-regulated learners as motivationally, behaviorally, and metacognitively active participants in their learning process. Consequently, SRL consisted of three main components: motivation, cognitive strategies (behavioral action), and metacognition. What motivates students, which strategies students employ for the attainment of personal goals, and which processes increase students' self-awareness become important issues to explain. These three components of SRL are described in this section in association with the present study.

However, these three components of learning (motivation, cognitve strategies, and metacognition) are not distinct from each other, rather they are interrelated (Zimmerman, 2000). For example, the knowledge of different cognitive strategies is not enough in order to succeed. Students also need to possess higher levels of self-efficacy beliefs in applying these strategies, test their effectiveness, and revise not working strategies according to changing conditions (monitor them). Therefore, the source of students' motivation (such as self-efficacy beliefs), the processes that increase their self-awareness (metacognition), and the strategies that students use to accomplish their own goals are important issues to explain students' academic self-regulation and in turn their achievement (Zimmerman, 2001).

2.2.1 Motivation

SRL is a goal driven process and students' goals are influential in all phases of Zimmerman's model. Highly self-regulated learners set their own goals with respect to their strengths and weaknesses and choose appropriate learning strategies to accomplish their goals. Next, they employ these strategies and monitor their implementation. Last, they evaluate their progress with respect to whether they have achieved their learning goals or not. As a result, students' *goal orientations* are commonly studied in the SRL literature. Students' *self-efficacy beliefs* are also an influential motivational factor that improves students' learning. Students make judgments about their capabilities related to specific tasks and situations and engage in a learning activity and/or sustain their effort based on their self-efficacy beliefs. Highly efficacious students set more challenging goals, employ different cognitive and metacognitive strategies, and produce adaptive reactions (changing the unuseful learning strategy, not giving up in case of failure).

2.2.1.1 Students' Goal Orientations

In line with the Achievement Goal Theory (AGT), students' goal orientations are defined as students' reasons for the engagement in a learning activity (Elliot, 1999). Achievement goals are commonly conceptualized as mastery goals versus performance goals and students who set mastery goals use self-regulatory learning strategies more frequently (Pintrich, 2000). In a recent article, Hulleman, Schrager, Bodmann and Harackiewicz (2010) emphasize that in the achievement goal literature, constructs having different operational definitions have been named in the same way. For example, both Achievement Goal Questionnaire (AGQ) and Patterns of Adaptive Learning Survey (PALS), two of the most commonly used instruments in the literature, include the same construct labeled as “performance-approach goal”; however, they define it differently. The most recent version of AGQ (Elliot & McGregor, 2001) focuses on comparison or competition among peers. On the other hand, PALS explains the same construct taking into account demonstrating competence or ability to others. Accordingly, Hulleman and his colleagues suggest that researchers should clearly define the goal constructs they have been investigating in order to let comparisons among different studies and test the theory. In the present study, students’ goals are defined based on Elliot and his colleagues’ work.

Initial studies were governed by the dichotomous framework which categorized students’ goals as mastery goals versus performance goals. Mastery goals focus on the mastery of the task, developing new skills, and following students’ curiosity. On the other hand, performance goals give priority to getting higher grades, receiving rewards, comparing themselves with classmates, and getting approval from others (Ames, 1992). Students with mastery goals perform adaptive learning behaivors such as persistence in the event of failure, choosing challenging tasks, using deep-processing strategies, and possesing intrinsic motivation (Dweck & Leggett, 1988; Harackiewicz et al., 2000; Kaplan & Midgley, 1997; Meece, Blumenfeld, & Hoyle, 1988; Pintrich & De Groot, 1990). However, students with performance goals give value to grades and are motivated by extrinsic rewards such as their teacher’s approval (Ames, 1992; Harackiewicz et al., 2000; Dweck & Leggett, 1988; Jagacinski & Nicholls, 1987).

Initial studies revealed inconsistent results for performance goals and consistent results for mastery goals. Consequently, Elliot and his colleagues proposed a trichotomous framework in which they divided performance goals into two categories, namely: performance-approach goals and performance-avoidance goals. They supported it with empirical evidence (Elliot, 1999; Elliot & Church, 1997; Elliot & Harackiewicz, 1996). For example, Elliot and Church (1997) associated mastery goals with high competence expectancy and achievement motivation; performance-approach goals with high competence expectancy, achievement motivation, and fear of failure; and performance-avoidance goals with low competence expectancy and fear of failure. Later on, Elliot and McGregor (2001) highlight that mastery goals studied in the dichotomous and trichotomous frameworks reflect only mastery-approach type goals and not include items possibly defining mastery-avoidance type goals. As a result, they proposed a theoretical model, 2 x 2 Achievement Goal Framework, to test how this approach-avoidance differentiation works for the mastery type goals. They conceptualize students' goal orientations according to two criteria: (a) how competence is defined and (b) how competence is valanced. Accordingly, they propose four goal orientation constructs: performance-approach, performance-avoidance, mastery-approach, and mastery-avoidance. They tested the 2 X 2 framework against dichotomous and trichotomous models and results of empirical studies supported the 2 X 2 framework. Although there is still a debate on whether the mastery-avoidance goals are essential in defining the goal constructs (Hulleman & Rhee Bonney, 2006), there are few empirical studies supporting the 2 X 2 achievement goal framework (Bartels & Magun-Jackson, 2009; Conroy & Elliot, 2004; Kadioglu, Uzintiryaki & Capa-Aydin, 2009, Ntoumanis, Thøgersen-Ntoumani & Smith, 2009; Sungur & Senler, 2009; Van Yperen, 2006). In line with recent modifications in the AGT, the present study is also guided by the 2 x 2 achievement goal framework.

Students' goal orientations are influenced by the messages that the teacher sends in the classroom. At the beginning of the 1990s, students' goal orientations were guided by the dichotomous framework; and mastery goal orientation was accepted as the one that promotes SRL. One of the most influential papers in the AGT literature was published by Ames (1992) giving suggestions to researchers and teachers about how to design classroom tasks to help students set mastery type goals. Accordingly, teachers can design classroom tasks in such a way that support development of new skills, use challenging tasks, provide students some degree of authority over their learning process, give them responsibility and/or opportunities to make decisions about the learning process or learning products, and evaluate students' progress without making comparisons but rather by emphasizing self-referenced standards. Ames's work triggered research on classroom goals, i.e. classroom goal structure. Classroom goals are frequently categorized as mastery versus performance goal structures. Performance goal structure is described as the classroom environment that focuses on grades and comparisons among students, while mastery goal structure explains the classroom practices that emphasize learning and understanding, the use of self-referenced standards for evaluation, and accept failure as a part of learning. Although there is little empirical research on classroom goal structures, they provide clear evidence that students' goal orientations are influenced by the messages that the teachers send in the classroom. These studies link students' perceptions of classroom goal structures to strategy use (Greene et al., 2004), social satisfaction and task value (Townsend, & Hicks, 1997), avoidance strategies (Turner et al., 2002), help-seeking (Karabenick, 2004), and coping strategies in school (Kaplan, & Midgley, 1999).

More recently, a body of research investigates the interaction among classroom goal structures and students' personal goal orientation types. Although literature examining this interaction is relatively new and the links are not clear, it supports the existence of the interaction between classroom goal structure and students' personal goals (Kaplan, Gheen & Midgley, 2002; Murayama & Elliot, 2009; Shun & Youyan, 2008; Urdan, 2004; Wolters, 2004). For example, Meece, Anderman and Anderman (2006) find that mastery goal structure supports mastery goal orientation and associate this interaction with adaptive form of learning outcomes such as cognitive strategy use. On the other hand, they link performance goal structure to performance goal orientation and maladptive form of learning outcomes such as self-handicapping. These studies are relatively new and comparisons among studies are incomplete. Therefore, further empirical studies are required.

2.2.1.2 Students' Self-Efficay Beliefs

In view of SCT, students' beliefs about their own capacity determine how much they are desired to engage in a learning task and complete it. Therefore, students' self-efficacy beliefs are the fundamental factor that supports students' learning and academic progress. Self-efficacy beliefs are defined as ''people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances'' (Bandura, 1986, p. 391). Learners with high level of self-efficacy beliefs tend to select more challenging tasks, use different cognitive strategies, persist in case of failure and consecutively increase their academic performance. In the same way, highly efficacious students use deep processing strategies such as elaboration and organization while working on a task). Linnenbrink and Pintrich (2003) state that students with high self-efficacy beliefs engage in academic work behaviorally (persistence in case of failure), cognitively (more strategy use) and motivationally (increased interest in the content) which in turn increase students' learning and achievement (see Figure 2.2). On the other hand, students with low level of self-efficacy beliefs prefer rehearsal strategy (surface level). As a result of using deep processing strategies, students achieve better. Studies support the relationship between students' self-efficacy beliefs and their academic performance (Greene et al., 2004; Linnenbrink & Pintrich, 2003; Schunk & Zimmerman, 1997; Zuhso, Pintrich & Coppalo, 2003). SCT proposes bi-directional relationship among personal (self-efficacy beliefs), behavioral (persistence in a task), and environmental (teacher feedback) factors (Bandura, 1986). For example, learners with high level of self-efficacy beliefs tend to select more challenging tasks, use different cognitive strategies, persist in case of failure and consecutively enhance their learning and academic performance. As a result of experience of success after working hard on a task, the learner's self-efficacy belief increases.

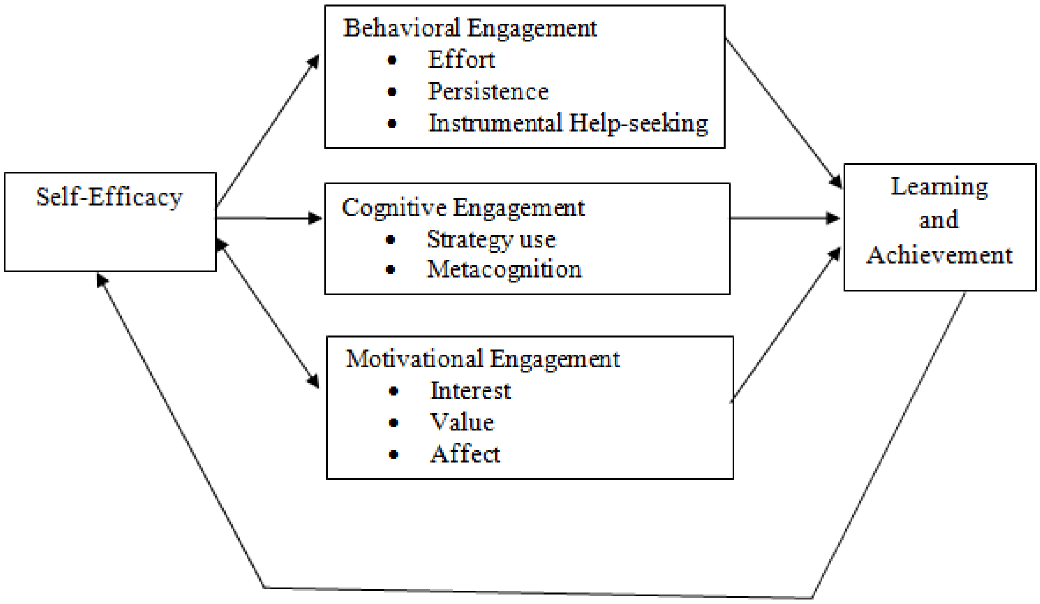


Figure 2.2 A general framework for self-efficacy, engagement and learning
Source: Linnenbrink and Pintrich (2003) p.122

Bandura (1997) differentiates self-efficacy from self-concept and self-esteem which is commonly used together. Self-concept, which describes how individuals approach towards themselves, is an indicator of individuals' composite opinions about themselves. It can be formed as a result of personal experiences or evaluation of others. Since self-concept consists of several characteristics associated with the learner, it does not explain the behaivors of students explicitly. Self-concept is accepted as a general phenemona, while self-esteem and self-efficacy are more specific. Self-esteem is an indicator of self-worth that an individual devotes on herself/himself, while self-efficacy explains capability of doing something. Self-efficacy beliefs are domain and task specific (Bandura, 1986). Students make judgments about their capabilities related with a specific task and a particular situation. That's why these two constructs used interchangeably. However, they are not related. For example, when a student believes that s/he can not design an experiment, it indicates low self-efficacy belief. However, that student does not necessarily lower her/his self-esteem, the worth that she attributed to herself/himself. S/he may still put high self-worth in herself/himself. According to Bandura (1997), among these three self-concepts, self-efficacy is superior in explaining students' learning, since it includes students' judgements associated with a specific task. Additionally, Bandura (1997) emphasizes that, since students' own judgements determine their behavior, accuracy of these judgements is an important issue. As students get older, they possess more academic experience and can assess their weaknesses and strengths more accurately.

Bandura (1986) attributes development of self-efficacy beliefs to four sources: mastery experience (enactive attainment), vicarious experience, social persuasion, and physiological states. *Mastery experience* refers to the learner's experience of success or failure as a result of doing the task himself/herself. When a learner experiences success at the end of participating in a task, s/he increases his/her self-efficacy beliefs. Conversely, experience of failure decreases them. Bandura states that "a strong sense of self-efficacy is developed through repeated successes, occasional failures are unlikely to have much effect on judgments of one's capabilities" (p. 399). *Vicarious experience* occurs when a learner does not do the activity himself/herself and develops through observation of a model. In vicarious experience, perceived similarity between the learner and the model is an important factor. Peer (coping) models are more helpful in developing self-efficacy beliefs, since peers possess comparable experiences (Schunk & Hanson, 1985). According to Schunk (2001), mastery experience is the most effective factor in developing self-efficacy beliefs since it provides feedback to the learner about his/her performance. On the other hand, vicarious experiences may be helpful while learning complex skills, since it prevents the learner from experiencing failure.

However, the experience of success is not enough to increase self-efficacy beliefs; the individual should also evaluate the experience of successes and reasons for it intentionally. *Social persuasion* refers to the encouraging statements of others that persuade the individual that s/he has the capability required to master given task. To close, *physiological states* include physical and/or emotional states such as shakes, aches, and fear. How people perceive this stress effect their self-efficacy beliefs. If they interpret it as a sign of incapability, this will decrease their self-efficacy beliefs. However, if they interpret it as normal sings and not related to their capability, this will not lower their efficacy beliefs and will not decrease the effort they put into the task.

Related literature supports the relationship among self-efficacy beliefs and academic performance: highly efficacious students use cognitive and metacognitive thinking skills more often, and in turn increase their academic performance (Aurah, 2013; Aurah, Cassady & McConnell, 2014; Greene et al., 2004; Nasser-Abu Alhija & Amasha, 2012; Phan, 2009; Phan, 2010; Pintrich & De Groot, 1990; Sadi & Uyar, 2013; Sperling et al., 2004; Sungur, 2007; Yumusak et al., 2007). Highly efficacious students use deep processing strategies while working on a task, such as elaboration and organization. On the other hand, students with low level of self-efficacy beliefs tend to use rehearsal strategy (surface level) more often. Afterwards, students using deep processing strategies achieve better. When the related literature was examined, empirical evidence could be found to explain the mediator effect of cognitive and metacognitive strategies in the relationship between self-efficacy beliefs and achievement in diverse disciplines. In a recent study, Sadi and Uyar (2013) examined this relationship in high school biology context. Results of SEM analysis showed that self-efficacy beliefs have direct effect on biology achievement. In addition, metacognitive self-regulation strategies play a mediator effect: students who possess higher levels of self-efficacy beliefs use metacognitive self-regulation strategies more often and increase biology achievement in turn. Similar direct and indirect effect for self-efficacy beliefs and mediator role of cognitive strategies is also found in English (Greene et al., 2004) and Mathematics (Nasser-Abu Alhija & Amasha, 2012) courses. In another study, Phan (2010) found support to explain the mediator effect for cognitive strategy use in the relationship between self-efficacy and achievement in the context of educational psychology course. However he did not find any direct effect of self-efficacy on achievement.

As a result of their review of related literature, Linnenbrink and Pintrich (2003) propose the following suggestions for practioners to improve students' self-efficacy beliefs in actual classrooms:

1. Feedback provided by the teacher is an important source of self-effcicay. While giving feedback, teachers should evaluate the student's performance on a specific task. It should also include information about how to revise the strategy and increase performance. The feedback should not be general like "good work" or "well done"; but rather it should be specific to the student's performance and include both strength and weakness of the student in performing a task.

2. Classroom tasks should be challenging for the students. When students put effort on a challenging task and experience success, this increases their self-efficacy beliefs. However, experience of success in easy tasks is not helpful.

3. Teachers should encourage students to attribute failure to changeable causes such as effort rather than stable causes such as ability.

4. Focus on self-efficacy beliefs rather then self-esteem as a general trait.

2.2.2 Cognitive Strategies (Behavioral Action)

As explained in Figure 2.1, Bandura (1986) explains cognitive strategies as an element of *behavioral factors* that affect learning in his triadic reciprocal determinism model. Similarly, according to Zimmerman (1986) all definitions of SRL include being *behaviorally active* in the learning process. More specifically, self-regulation takes account of self-generated actions (Zimmerman, 2000). Highly self-regulated learners possess a repartuare of cognitive strategies among which they choose the most appropriate one according to their learning goals and demands of a task. Therefore, Winne and Perry (2000) use the term *strategic action* while explaining effective use of cognitive strategies. In conclusion, all these terms with slightly different wording refer to the cognitive strategies or behavioral actions that students use while performing a task.

One of the most influential papers in the learning strategies literature is written by Weinstein and Mayer (1986) approximately three decades ago. They define learning strategies as “behaviors that the learner engages in during learning that are intended to influence affective and cognitive processing during encoding” (p.316). Encoding process refers to the internal cognitive processes such as selecting and organizing new information. Weinstein and Mayer (1986) group learning strategies basically in three categories: cognitive strategies including rehearsal, elaboration, and organization strategies; metacognitive strategies labeled as comprehension monitoring strategies; and affective and motivational strategies.

In this section, the researcher focused on cognitive strategies associated with self-regulated learning; namely rehearsal, elaboration, and organization strategies. *Rehearsal strategy* helps learner to activate the information in working memory. It includes strategies such as reading the material over and over and memorizing a list of items. However, the learner does not make any connection with his/her previous knowledge. Although rehearsal strategy may be helpful in learning, it is not associated with deeper processing and meaningful learning and commonly called as surface level strategy. On the other hand, *elaboration* and *organization* strategies are known as deep-processing strategies since they support cognitive engagement (Biggs, 1999; Entwistle, 1988; Ramsden, 1992; Weinstein & Mayer, 1986). The learner uses *elaboration strategy* while making connection between new and existing information. For that purpose learners generally make analogies and paraphrase given information (restate in their own words). Moreover, *organization strategy* is helpful when outlining the material to be learned. By this way, learner can associate different chunks of information and select useful ones. Headings and subheadings or creating charts and concepts maps can be used to show the link among pieces (Weinstein & Mayer, 1986).

Previous studies provided empirical evidence to support the link between strategy use and achievement (Diseth, 2011; Greene et al., 2004; Liem, Lau, & Nie, 2008; Pape & Wang, 2003; Phan, 2009; Phan 2010; Pintrich & DeGroot, 1990; Sperling et al., 2004; Yumusak et al., 2007; Zusho et al., 2003). However, they express study strategies in a condensed way. For example, Pintrich and DeGroot (1990) examined cognitive strategies as a combination of rehearsal, elaboration, and organization strategies and found positive relationship with achievement (with Pearson product moment correlation coeficients (r) changing between .18 and .20). Similarly, Diseth (2011) and Liem et al. (2008) explored learning strategies in two categories; deep versus surface strategy. Likewise, Greene et al. (2004) investigated cognitive strategies as a whole and found significant direct link from stratgy use to achievement (β=.15). For the studies which explore cognitive strategies as rehearsal, elaboration and organization; generally rehearsal strategy is negatively associated with achievement while elaboration and organization strategies are positively associated. Contrary to related literature, among cognitive and metacognitive strategies only rehearsal strategy made significant positive contribution to achievement in general chemistry class (Zusho et al., 2003).

2.2.3 Metacognition

The term “hands-on” is commonly used in science education literature, indicating students’ behavioral engagement. However, doing the experiments by themselves is not enough to improve learning; cognitive engagement in the activity and development of understanding of related concepts is also important; that is, the activities also should be "minds-on" and students should have control on their cognitive system (Linnenbrink & Pintrich, 2003). Metacognitive strategies help the learners evaluate their learning progress with reference to their learning goals and make adjustment while processing (Pintrich, 1999). As a result, being metacognitively active is an essential component of SRL. However, definition of metacognition is unclear and there are several methodological issues which require further investigation (Veenman, Van Hout-Wolters, & Afflerbach, 2006). The concept of metacognition which is explained as a component of SRL consistent with social cognitive perspective, its relation to other components of SRL, and instructional aspects that support development of metacognitive thinking are given in this section.

The term metacognition was initially proposed by Flavell (1979) and defined as "knowledge and cognition about cognitive phenomena" (p. 906). He introduced the concepts of metacognition and cognitive monitoring to the literature. He proposes that monitoring cognitive processes is observed in terms of metacognitive knowledge, metacognitive experiences, goals (or tasks), and actions (or strategies). This article activated research on the definition of metacognition and its components. In educational research the definition and classification of Brown (1987) has been used widely. She explains metacognition as "one's knowledge and control of own cognitive system" (p. 66).

In line with her definition, Brown (1987) proposes two general categories of metacognition: "knowledge of cognition" versus "regulation of cognition". Knowledge of cognition explains students' knowledge about their cognitive system. It can be further classified in three categories: declarative knowledge, procedural knowledge, and conditional knowledge. Declarative knowledge refers to students' knowledge about themselves as a learner and the factors that affect their performance. Next, procedural knowledge includes students' knowledge about how to employ a procedure. Finally, conditional knowledge explains students' knowledge about why and when to employ a specific strategy. Learners develop more knowledge about their cognition as they get older since they gain more experience (Alexander, Carr & Schwanenflugel, 1995). On the other hand, regulation of cognition describes the processes that students use to control their learning. It includes planning, monitoring, and evaluation processes. Planning includes setting goals for learning, selecting appropriate strategies, activating prior knowledge, allocating different resources, and management of time. Monitoring refers to awareness of cognitive systems during performing a task like assessing the effectiveness of learning while carrying out the task. Evaluation includes processes that students use to evaluate the quality of the products and the regulatory processes. Researchers employ this categorization in different studies and found high correlations among two components of metacognition (Schraw & Dennison, 1994, Schraw & Moshman, 1995; Sperling et.al., 2004; Sungur & Senler, 2009). For example, Sperling et al. (2004) examined the relationship between *knowledge of cognition* and *regulation of cognition* for two different samples and found the r values as .75 and. 68. Nonetheless, Veenman, Kok, and Blöte (2005) underline that knowledge of cognition does not automatically support use of regulation of cognition strategies. This issue needs further investigation. When SRL literature is searched, mostly, regulation of cognition strategies is associated with self-regulatory processes (Pintrich & De Groot, 1990; Pintrich & Garcia, 1991).

Empirical evidence is found to support the relationship between metacognition and other learning outcomes such as students' self-efficacy beliefs, use of cognitive strategies, and achievement (Pintrich & De Groot, 1990; Sperling et.al., 2004; Linnenbrink & Pintrich, 2003; Sungur, 2007; Yumusak et al., 2007). For example, Pintrich and DeGroot (1990) examined cognitive strategies grouping rehearsal, elaboration, and organization strategies together and self-regulatory strategies as a combination of metacognitive self-regulation and effort management strategies. They found very high positive correlation (r= .83) between strategy use and self-regulatory strategies suggesting that students who use rehearsal or elaboration strategies frequently also use metacognitive strategies as well. Likewise, Sperling et al. (2004) examined the correlation between rehearsal, elaboration, and organization strategies and metacognitive self-regulation. They found that elaboration (r=.39) and organization (r=.58) strategies positively correlated with metacognition, while there was no significant correlation between rehearsal strategy and metacognition (r=.09). Surprisingly, Spada and his colleagues (2006, 2012) found negative effect of metacognition on surface level strategy use (rehearsal strategy). Sperling et al. (2004) state “theoretically, metacognitive awareness may precede effective strategy use” (p.134). The relationship between cognition and metacognition is complex and ambiguous; therefore, it needs further discussion (Veenman et al., 2006). On the other hand, the relationship between students’ self-efficacy beliefs and metacognitive strategy use is stronger. Highly efficacious students use metacognitive strategies more often (Linnenbrink & Pintrich; 2003; Pintrich & De Groot, 1990; Sperling et al., 2004; Sungur, 2007; Yumusak et al., 2007).

The relevant literature provides inconsistent results for the relationship between metacognition and achievement. Sadi and Uyar (2013) provide an empirical evidence for a link between metacognitive self-regulation strategy and in educational psychology course (β=.49). Muis and Franco (2009) reached similar findings that is found a positive relationship between metacognitive self-regulation strategy and achievement (β=.69). On the other hand, Yumusak et al. (2007) did not find significant contribution of metacognitive self-regulation strategy to achievement. Unexpectedly, Sperling et al. (2004) found negative correlations between SAT math scores and knowledge of cognition (r=-.31) and regulation of cognition (r=-.44) components of metacognition. These inconsistent results encourage researchers for further examination and extra consideration on the measurement of the concepts of metacognition and achievement.

There are a couple of well-known metacognitive intervention programs that are planned to enhance student's metacognitive thinking in actual classroom settings. One of the earlier and most influential studies was the Project to Enhance Effective Learning (PEEL) project which was conducted in Australia to enhance high school students' metacognition in different classes such as science and English (Baird & Mitchell, 1989; Baird & Northfield, 1992; Gunstone & Baird, 1988). The Cognitive Acceleration through Science Education (CASE) project was another influential project conducted in England with 7th and 8th graders (Adey, Robertson, & Venville, 2002; Adey & Shayer, 1994). The youngest group, consisted of graded 1 to grade 6 students, was studied in the Metacognitive Enhancing Teaching Activities (META) project in USA by Hennessey (1999). Moreover, Georghiades (2004) investigated fifth graders metacognitive thinking skills in Cyprus studying in the unit of 'Current Electricity". Yuruk, Beeth and Andersen (2009) developed metaconceptual teaching intervention in USA. They investigated high school students' understanding and durability of physic concepts in the unit of "Force and Motion". This study was inspired another study conducted in Turkey by Kirbulut (2012). She employed Metaconceptual Teaching Instruction in high school chemistry classroom in in the unit of "States of Matter". All these studies focused on developing conceptual understanding, durability of concepts, increased awareness in students' cognitive strategies, and monitoring cognitive strategies effectively and make reflections on the learning process. Although some studies were not supporting difference in conceptual understanding, they reinforced duration of concepts (Georghiades, 2004). Recently, students' metacognitive skills and processes have measured more accurately, and metacognitive interventions were found to improve understanding of concepts and strengthen duration of those concepts (Yuruk et al., 2009; Kirbulut, 2012).

2.3 Zimmerman's Self-Regulatory Model

SRL includes several processes associated with effective learning such as cognitive strategies, metacognition, motivation, and social supports in the classroom. Zimmerman (2002) proposes a cyclic model based on SCT to explain how students utilize self-regulatory processes in order to increase the effectiveness of their study and enhance their learning. His model includes three phases: forethought, performance and self-reflection (see Figure 2.3). The *forethought phase* includes the preparatory processes that students use to get ready for learning. Next, in the *performance phase*, students are in action that is they employ different strategies and make the necessary changes if required. Finally, in the *self-reflection phase*, which occurs after learning, the learner judges the effectiveness of her/his learning process. As a result of the evaluation of his/her study process, the learner sets new goals for further learning. As mentioned earlier; SCT proposes bi-directional interactions among personal, behavioral, and environmental factors (Triadic Reciprocal Determinism Model, Bandura, 1986). Since all these factors are changing continually during a study period, students need to make some changes throughout their learning process. For example, when a student notices that a learning strategy does not help him/her to achieve his/her learning goal, s/he makes the necessary adjustments such as revising his/her learning goal or changing his/her strategy. Hence, Zimmerman's model is cyclic as students evaluate the efficiency of their previous learning experience and set learning goals for further study accordingly.

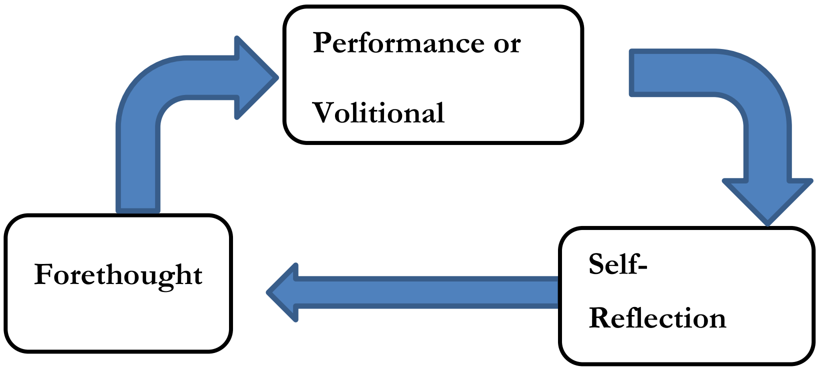


Figure 2.3 Cyclical phases of self-regulation
Source: Zimmerman, 2000, p.16

Table 2.1 summarizes the sub-processes that students utilize in different phases of their learning. Forethought phase includes *task analyses* and *self-motivational beliefs*. While analyzing the task, highly self-regulated learners initially determine their personal goals for learning; that is to say, they determine the purpose of their study. Next, students choose the necessary strategies to achieve their goals considering the demands of the task and facilities in the learning environment. In order to employ the required strategies effectively and accomplish their learning goals, students' motivational beliefs such as their self-efficacy beliefs, outcome expectations and goal orienttaions also play an important role in the learning process. Among motivational beliefs, self-efficacy-beliefs and goal-orientations are more commonly associated with SRL (Zimmerman, 2000).

In the next phase, performance phase, students implement, monitor, and regulate the accuracy of their strategies. Highly self-regulated learners can use *self-control* and *self-observation* processes in this phase. Students use self-control processes to concentrate on the learning task and adjust their work accordingly. The following can be given as examples to effective self-control processes that enhance students' learning: self-instruction, explaining the processes that they follow while working on the task; imagery, creating mental images to code information; attention focusing, conscentarting on the task; and task strategies, strategies that students use to arrange their work such as note-taking and reading comprehension. Self-observation includes self-recording and self-experimentation processes. Self-recording process includes students' records about their progress and factors that affect their learning such as where and when to employ which strategy. Additionally, students may test the efficiency of different factors that affect learning to identify more efficient learning processes. For example, they may experiment on factors such as studying at different times of the day, working at different environments and/or trying different strategies to solve a problem (Zimmerman, 2000).

SRL is a cyclic process and requires evaluation of learning process and learning outcome in order to assess their own learning progress, change learning strategies if necessary and/or set new goals for further learning. Students may use *self-judgment* and *self-reaction* processes in the self-reflection phase. Self-judgment requires evaluation of the effectiveness of the learning process and making causal attributions. To do so, students compare the learning outcomes with learning standards (or their learning goals) and look for reasons of learning outcomes. Self-reaction process consists of students' level of self-satisfaction and the adaptive or defensive reactions they produce as a result of self-judgment process. When the students put a high value on the task, they experience a high level of self-satisfaction after accomplishing the task accurately. Moreover, students may generate adaptive reactions after failure; i.e. they change their learning goals or study strategies and continue working on the task. However, students may also produce defensive reactions such as procrastination and/or cognitive disengagement in order not to experience disappointment in future performance (Zimmerman, 2000).

Table 2.1 Phases of Zimmerman's Model and sub-processes of it

CYCLICAL SELF-REGULATORY PHASES		
Forethought Phase	Performance/Volitional Control Phase	Self-Reflection Phase
Task analysis • Goal setting • Strategic planning	**Self-control** • Self-instruction • Imagery • Atention focusing • Task strategies	**Self-judgement** • Self-evaluation • Causal attribution
Self-motivation beliefs • Self-efficacy • Outcome expectations • Intrinsic interest/value • Goal orientation	**Self-observation** • Self-recording • Self-experimentation	**Self-reaction** • Self-satisfaction/affect • Adaptive-defensive

Source: Zimmerman, 2000, p.16

2.4 Development of Self-Regulated Learning

As explained in Table 2.1, SRL includes effective use of several self processes such as self-observation, self-instruction, self-reaction, and self-efficacy. However, development of these self-regulatory skills initially occurs in social environment. By interacting with the social environment, the learner internalizes the social skills and employes them into new situations on their own (Schunk, 2001; Zimmerman, 2000). Both Zimmerman (2000) and Schunk (2001) emphasize that maturation (as the learner gets older) or passive engagement with the learning environment does not result with the acquisition of self-regulatory skills.

Self-regulatory skills develop in four levels transferring from social sources to self-source: observation, emulation, self-control, and self-regulation (Schunk, 2001; Zimmerman, 2000). Table 2.2 gives description of each level and the source of the self-regulatory skills. In the *observation level,* the learner observes the model and the model describes the key features of the self-regulatory skill. The learner gains vicarious experience in this level. Next, in the *emulation level*, the learner copies the skill under the guidance of the model. In this level, the learner possesses some degree of mastery experience. Then, in the *self-control level*, the source of the self-regulatory skills shifts from social sources to self-source partially. The learner employs the observed skills to himself/herself but in similiar task conditions. Finally, in the *self-regulation level*, the learner can use the skills in different task conditions himself/herself.

Schunk (2001) underlines that social comparison is important throughout these levels and developmental limitations of the learner such as age difference is important in making sufficient social comparison and in turn in developing SRL tasks. Based on meta-analysis of intervention studies conducted in elementeray and secondary schools, Dignath and Buttner (2008) state that students use some SRL skills both in elementary and secondary level; however, they become more aware of their learning/thinking processes by time. As monitoring requires high cognitive engagement, it is a complex strategy process even for adults (Alexander et al., 1995). Paris and Newman (1990) and Zimmerman (1990) also support the claim that students at elementary grades have trouble in using cognitive and metacognitive strategies.

Table 2.2 Developmental Levels of Self-Regulatory Skills

Level of Development	Description	Social Influences (Schunk, 2001)	Self Influences (Schunk, 2001)
Observation	Vicarious induction of a skill from a proficient model	Models Verbal description	
Emulation[a]	Imitative performance of the general pattern or style of a model's skill with social assistance	Social guidance Feedback	
Self-control	Independent display of the model's skill under structured conditions		Internal standards Self-reinforcement
Self-regulation	Adaptive use of skill across changing personal and environmental conditions		Self-regulatory processes Self-efficacy beliefs

[a] This level was referred to as imitation in prior descriptions.

Source: Zimmerman (2000, p.29) and Schunk (2001, p.143)

2.5 Classroom Applications of Self-Regulated Learning

As discussed earlier in this chapter, there are so many constructs associated with SRL. This creates difficulty in comparing self-regulatory practices in actual classrooms. In this section, the interventions conducted based on SCT and specifically based on Zimmermans' cyclic SRL Model was discussed. The first remarkable contribution came from Pintrich and his colleagues at the University of Michigan. They designed "Learning to Learn" course for the first year undergraduate students to support their life-long learning (Hofer, Yu, & Pintrich, 1998; McKeachie, Pintrich, & Lin, 1985; Pintrich, McKeachie & Lin, 1987). The course was designed to help students get succeeded at their undergraduate programs, and become independent learners. The course aimed to improve students' cognitive and metacognitive skills and increase their motivation. The course included a theory section, in which researchers explain why a strategy support students' learning, and a laboratory section, in which students employ these strategies in diverse disciplines. A significant outcome of this course is the development of one of the most widely used instruments in the SRL literature, the MSLQ (Pintrich et al., 1991). Researchers collected and revised the items they used to evaluate the effectiveness of this course, and in four years (from 1982 to 1986) they had a repertoire of self-reported items which in turn formed MSLQ. Another important outcome of this course is the book named "Learning to learn: The skill and will of college success". VanderStoep and Pintrich (2003, 2007) wrote their experiences and suggestions to college students in a friendly way. This book initially explains how to become a self-regulated learner and defines both skill and will as key components of it. It includes explanations, suggestions and workouts for the development of different strategies such as goal setting, resource management, attention focusing, and cognition and metacognition.

However, "Learning to Learn" course was not integrated into curricullum rather given as a preparatory strategy instruction course for freshmen. Hattie Biggs, & Purdie (1996) underline that strategy instruction works better in the actual classroom setting integrated into based on their meta-analyses. By time, SRL intervention programs were employed in diverse diciplines: mathematics (Arsal, 2009; Bell & Pape, 2012; Fuchs et al., 2003; Schunk, 1998; Yetkin-Ozdemir & Pape, 2012), writing (several studies conducted by Harris, Graham and their colleagues: Graham & Harris, 2012; Harris & Graham, 1999 etc.), reading comprehension (Housand & Reis, 2008; Souvignier & Mokhlesgerami, 2006), science (Cleary, Platten & Nelson, 2008; Cleary & Zimmerman, 2004; DiBenedetto & Zimmerman, 2010; Labuhn et al., 2008a, 2008b; Sungur, 2004), sports (Cleary, Zimmerman, & Keating, 2006; Kitsantas & Zimmerman, 1998; Kolovelonis, Goudas & Dermitzaki, 2011), and musics (Nielsen, 2001; Pitts, Davidson & McPherson, 2000; Ramdass & Bembenutty, 2012). Dignath and Buttner (2008) report that most of the intervention studies, designed to develop SRL skills in actual classrooms, are conducted in the domain of mathematics and next in writing/reading based on their meta-analyses. Just a few studies are conducted in the domain of science and no study in high school chemistry classroom is encountered by the researcher.

In the SRL literature, three meta-analyses conducted by Hattie et al. (1996), Dignath and Buttner (2008), and Donker et al. (2014) provide valuable information about the effect of these intervention programs on learning outcomes. All three meta-analyses explored studies including an intervention program and a control group, Hattie et al. (1996) cover the literature between 1983 and 1992, Dignath and Buttner (2008) cover between 1993 and 2006, and Donker et al. (2014) cover between 2000 and 2012. All three meta-analyses include studies searched from the same data bases. They reveal that intervention programs are beneficial for students at different ages and at different subject domains to some degree. Additionally, all three analyses include studies conducted in the field of science education in limited number.

Hattie et al. (1996) examines 51 studies conducted mostly with university students. Nearly half of the studies focus on strategy training programs within a subject domain and the rest in the form of learning-to-learn programs outside a subject domain. This early meta-analyses has the mean weighted effect sizes of .45; in detail .57 for performance, .16 for study skills, and .48 for affect dimensions. Accordingly, intervention programs increases academic performance surprisingly less effect on study skills. This study offers that strategy instruction works better in the actual classroom context, and specific attention should be given to active student participation and metacognitive awareness.

Later on, Dignath and Buttner (2008) investigates 74 studies 49 of which are conducted at primary level and 25 of which are conducted at secondary level. They search for the effect of intervention programs on three outcomes associated with SRL namely academic performance, strategy use, motivation. The analysis involves studies conducted after the meta-analysis of Hattie et al. (1996). Most of the studies are in mathematics (N=28), next in reading and writing (N=26), and 20 studies are in other subject domains including science. The average effect size (Cohen's d) is 0.69 for all studies, .61 for primary school, and .54 for secondary school. For primary school, intervention programs support academic performance (R^2=.44) most, next motivation (R^2=.40), and least strategy use (R^2=.33). However, for secondary school level the effect size for motivation cannot be calculated due to the limited number of studies. Similar to primary school intervention programs contribute mostly to academic performance (R^2=.94) and then to strategy use (R^2=.59). In both school levels, the intervention programs, directed by the researcher, conducted in the domain of mathematics, and lasted longer, works better. At primary school, the highest effect size is found for motivational variables in math performance, social-cognitive theories are more influential, and group work has a negative effect. On the other hand, in secondary level, the highest effect size is found for strategy use in reading/writing performance, metacognitive learning theories are more influential, and group work has a positive effect.

The latest meta-analysis is conducted by Donker et al. (2014) after the publication of the Handbook of Self-Regulation (Boekaerts, Pintrich &

Zeidner, 2000). It includes 58 papers and 95 interventions at primary and secondary school levels. Most of the studies are conducted in mathematics (N=44), next in reading (N=23), writing (N=16), and science (N=9). The remaining three studies are conducted in other subject domains. Researchers search for the effect of different categories (cognitive strategy, metacognitive strategy, management strategies, and motivational aspects) on academic performance. Different from Dignath and Buttner (2008), they investigate several sub-categories associated under these categories. For example, cognitive strategy category includes rehearsal, elaboration, and organization strategies. Additionally, they conduct analyses separately for each subject domain.The average mean effect size (Hedges' g) is found =.66. Results reveal that among metacognitive strategies planning and monitoring strategies and among cognitive strategies elaboration strategy makes highest contribution to academic performance, indicating that students prefer these strategies get higher performance. Management and motivational strategies are less frequently used. On the other hand, the effect size of goal orientation strategy has a negative value, indicating that this strategy is less helpful compared to other significant strategies. Only this meta-analysis provides specific information related with science education. Unfortunately, none of the strategies contribute significantly to in science performance. Additionally, publication bias which distorts the result of meta-analyses exists only in the domain of science which indicates that interventions with high effect size in the domain of science have higher chance of being published. Accordingly, results for science domain should be interpreted critically.

More specifically, in the domain of science at high school level, only a limited number of intervention studies are conducted (Cleary, Platten & Nelson, 2008; Cleary & Zimmerman, 2004; DiBenedetto & Zimmerman, 2010; Labuhn et al., 2008a, 2008b; Sungur, 2004; Zion, Michalsky & Mevarech, 2005). Among those, two intervention programs namely *Self-Regulation Empowerment Program (SREP)* (Cleary et al., 2008; Cleary & Zimmerman, 2004) and *SRL* *classroom intervention* (Labuhn et al., 2008a, 2008b) are guided by Zimmerman's (2000) cyclic model to develop high school students' self-regulatory skills in the domain of biology. SREP is designed for ninth grade students who possess adequate learning skills according to standardized statewide test scores and get lower scores than the classroom average in the teacher developed biology tests. The program is developed as a tutoring program after school and tutors are trained graduate students. SREP includes several modules promoting different self-regulatory processes such as task analyses, goal-setting, strategic planning, strategy training, and self-reflection. Each module focuses on a specific self-regulatory process. Results reveal that students, who are below average on the pre-biology test and trained with SREP, improve their self-regulatory skills over time. In turn, they get average or more than average scores on the post-biology test. On the other hand, SRL classroom intervention is designed within biology curriculum covering nutrition unit. The intervention administered by science teachers lasts eight sessions, 45 minutes per session, and focusses on goal-setting, strategic planning, motivational control, self-monitoring, and self-evaluation processes. Additionally, it includes group work, peer discussions, and individual seatwork. Results reveal positive effect on self-regulatory skills. Additionally, the intervention creates no change on post-biology test, but favors intervention group in retention test administered six months after the intervention, indicating that students, who receive SRL classroom intervention, remember the related concepts even after months. There seems to be no intervention program developed to improve high school students' self-regulatory processes in the domain of chemistry.

2.6 Inquiry-Oriented Instruction

The accelerate development of scientific knowledge and technology also activates the reforms in science education. Accordingly, science educators focus on development of LLL skills to help individuals adapt themselves to technological innovations (EU Council, 2002; National Agency, 2013). To achieve this goal *inquiry oriented instruction* guide educational reforms (Anderson, 2002). Linn, Davis, and Bell (2004) explain inquiry as “the intentional process of diagnosing problems, critiquing experiments, and distinguishing alternatives, planning investigations, researching conjectures, searching for information, constructing models, debating with peers, and forming coherent arguments” (p.4). Similarly, American National Research Council (1996; p. 23) defines inquiry as “the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world.” Accordingly, the term inquiry is used in the meaning of *scientific inquiry*, *inquiry learning*, and *inquiry teaching* (Anderson, 2002). The “diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work” statement in the definition referred to scientific *inquiry*. *Inquiry learning* is described as “the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world”. In line with this definition, inquiry learning is an active learning process and students are defined as self-directed learners (as given in Table 2.3). However, the definition of inquiry teaching is not well-stated. It can be explained as the learning activity presented to students in order to make them to develop knowledge and understandings of scientific ideas and of how scientists study. In Table 2.3 Anderson (2002) compares traditional pedagogy with inquiry-oriented pedagogy in terms of teacher’s role, students’ role, and students’ work. In inquiry-oriented pedagogy, teachers have a role of coach and facilitator, students have a role of self-directed learner, and learning process can be defined as student-directed. See Table 2.3 for complete information.

Table 2.3 Traditional versus Inquiry Oriented Pedagogy

Traditional Pedagogy	Inquiry Oriented Pedagogy
Teacher Role	
As dispenser of knowledge	**As coach and facilitator**
Transmits information	Helps students process information
Communicates with individuals	Communicates with groups
Directs student actions	Coaches student actions
Explains conceptual relationships	Facilitates student thinking
Teacher's knowledge is static	Models the learning process
Directed use of textbook, etc.	Flexible use of materials
Student Role	
As passive receiver	**As self-directed learner**
Records teacher's information	Processes information
Memorizes information	Interprets, explains, hypothesizes
Follows teacher directions	Designs own activities
Defers to teacher as authority	Shares authority for answers
Student Work	
Teacher-prescribed activities	**Student-directed learning**
Completes worksheets	Directs own learning
All students complete same tasks	Tasks vary among students
Teacher directs tasks	Designs and directs own tasks
Absence of items on right	Emphasizes reasoning, reading and writing for meaning, solving problems, building from existing cognitive structures, and explaining complex problems.

Source: Anderson, 2002, p.5

Bass, Contant and Carin (2009) explain five essential features of inquiry instruction First, inquiry oriented classrooms presents students open-ended (authentic) questions. Second, students give priority to evidence and plan and conduct investigations (they determine which data are relevant, and how to collect and organize data). Third, students collect evidence using different resources and different investigation approaches and develop descriptions, explanations and generalizations using this evidence. Next, students should employ their knowledge to different conditions. Finally, students make discussions with classmates on the procedures, evidences, explanations, and generalizations. In sum, inquiry-oriented instruction provides opportunities to students evaluate the problems in a scientific way, suggest solutions to these problems and test the accuracy of these solutions. These features of inquiry-oriented instruction support development of SRL skills in several ways. Authentic tasks are challenging for students and activate their curiosity and motivate them. Additionally, students think about the procedure they employ and increase their metacognitive thinking by engaging in discussion with peers. While conducting investigations, making descriptions, and generalization results students employ different behavioral, motivational, and metacognitive strategies such as activating prior knowledge (rehearsal), organizing different forms of evidence (organization), goal setting (motivational), and planning and monitoring (metacognition). Moreover, students are active in several ways in inquiry classrooms, and this supports their control over their own learning process. Since evidence is an essential feature of inquiry, students will evaluate/assess the relevance of the evidence. Furthermore, it integrates science to other subject areas, for example writing their reflections improves not writing skills, gathering and interpreting data requires math skills. What is more, in group work, students model their peers and this will improve their self-efficacy beliefs.

Researchers make different categorizations to define inquiry oriented instruction programs. For example, Colburn (2004) classifies laboratory activities as structured inquiry, guided inquiry and open inquiry considering who is making decisions on the question to be investigated, the procedures to be followed, and the data to be collected and analyzed. Structured inquiry is at one end of the spectrum, the teacher provides students a step-by-step instruction but the students form the data table and select important data with respect to their observations. On the other hand, open inquiry is at the other end of the spectrum; students make almost all the decisions, identifies the question to investigate, designs the procedure, and collect relevant data and interprets them. Science fair projects can be given as an example of open inquiry in which the teacher provides little guidance. Guided inquiry exists between structured and open inquiry in the spectrum. The teacher introduces the research question to the students, and the students design the experiment, collect relevant data and interpret them. Colburn (2004) suggests that the teacher can start with using structured inquiry, and when the students feel comfort with the activity, and then s/he can make a shift to guided inquiry and next to open inquiry.

According to Kirschner, Sweller, and Clark, (2006) without appropriate level of guidance students will lose their way and cannot gain necessary knowledge and abilities. Accordingly they suggest guided-inquiry rather than open inquiry. In line with their recommendations, guided inquiry approach was implemented in the present study. The guided inquiry approach supports the feedback loop in Zimmerman's (2000) cyclic SRL model. Teachers provide feedback to students about their learning process and conceptual understanding through asking open-ended questions. Accordingly, students will evaluate its effectiveness of their strategies and monitor their learning process.While planning the inquiry instruction; the principles listed in Table 2.3 are taken into consideration. The students investigated the previously described problem situations, with the provided materials and equipment. They hypothesized, collected and analyzed data, offered explanations for their findings, communicated their findings and conclusions to their friends, and criticized their and others' investigations.

Schraw et al. (2006) presented the link between instructional strategies and development of self-regulatory processes remarkably based on their review of studies published in science education journals. They suggest six instructional strategies to support cognitive, metacognitive and motivational processes in science classes. Table 2.4 summarizes their suggestions for science educators. Authors argue that science education literature mostly focuses on metacognitive processes and pays less attention to the self-regulation in a more comprehensive manner. According to Schraw et al. (2006)'s suggestion the inquiry approach is employed in the present study to support high school students' chemistry achievement and self-regulatory skills.

Table 2.4 Ways the Six Instructional Strategies Increase Cognitive, Metacognitive, and Motivational Processes.

	Cognitive processes	Metacognitive processes	Motivational processes
Inquiry	Promotes critical thinking through experimentation and reflection	Improves explicit planning, monitoring, and evaluation	Provides expert modeling
Collaboration	Models strategies for novices	Models self-reflection	Provides social support from peers
Strategies	Provides a variety of strategies	Helps students develop conditional knowledge	Increases self-efficacy to learn
Mental Models	Provides explicit model to analyze	Promotes explicit reflection and evaluation of the proposed model	Promotes radical restructuring and conceptual change
Technology	Illustrates skills with feedback. Provides models and simulates data	Helps students test, evaluate, and revise models	Provides informational resources and collaborative support
Personal Beliefs	Increases engagement and persistence among students	Promotes conceptual change and reflection	Promotes modeling epistemology characteristic of expert scientists

Source: Schraw, G., Crippen, K., and Hartley, K. (2006). (p.131)

2.7 Summary of Related Literature

The self-regulation construct was explored in line with the SCT which explains how the personal, environmental, and behavioral factors affect learning process. According to Bandura (1986)'s Triadic Reciprocal Determinism Model, bi-directional relationship exists among these factors. Additionally, SCT suggests agency of learner; i.e. students actively participate in the learning process in order to accomplish their learning goals.

More general terms SRL is defined as motivationally, behaviorally, and metacognitively active participation of the learner in the learning process (Zimmerman, 1986). As a result, SRL is composed of three components: motivation, cognition (behavioral action), and metacognition which are interrelated (Zimmerman, 2000). In the existing SRL literature, students' goals and self-efficacy beliefs were examined to explain their motivational orientations. Students' determine their own goals, select appropriate strategies to achieve these goals, and set criteria to evaluate the effectiveness of their study based on their goals. In line with recent modifications in the AGT, the present study is also guided by the 2 x 2 achievement goal framework which proposes four goal constructs: performance-approach, performance-avoidance, mastery-approach, and mastery-avoidance. Highly self-regulated learners prefer mastery type goals. Self-efficacy belief is another important motivational construct which is linked to SRL. Students judge their capacity associated with a specific task. In the current study, students' self-efficacy beliefs are investigated specific to chemistry tasks: self-efficacy beliefs in chemistry laboratory and in understanding of basic chemistry concepts. As for cognitive strategies, rehearsal, elaboration, and organization strategies are commonly associated with self-regulated learning. Highly self-regulated learners prefer elaboration and organization strategies. Finally, metacognitive strategies help the learners assess their study with reference to their learning goals and monitor the learning process. Although the definition of metacognition is ambiguous, metacognitive intervention programs support understanding of concepts and improve the duration of those concepts.

Zimmerman (2000) proposes a Self-Regulatory Model considering the reciprocal relationships among personal, behavioral, and environmental factors. His model is cyclic since personal, behavioral, and environmental factors are constantly changing which in turn requires revision of learning goals and adjustments in the learning process. His model includes three cyclic phases: forethought, performance and self-reflection. Students utilize several sub-processes in different phases of their learning. Accordingly, in the literature several variables are associated with SRL which creates difficulty in comparing current studies.

Initial empirical studies are conducted to help undergraduate students be successful at their programs which is known as "Learning to Learn" course. Later on, SRL studies are conducted in the actual classroom setting integrated into curricular activities. Most of these studies are conducted in the domain of mathematics and next in writing/reading. However, very limited number of studies are existed in the science classes and no intervention study is encountered in high school chemistry classroom. Most of these intervention studies are conducted based on Zimmerman' SRL Model. Among those just a few studies are conducted in the domain of science at high school level. Two intervention programs namely *Self-Regulation Empowerment Program (SREP)* and *SRL classroom intervention* are well-known applications of Zimmerman's (2000) cyclic model in the domain of biology.

Based on their review of studies published in science education journals, Schraw et al. (2006) suggest six instructional strategies to support cognitive, metacognitive and motivational processes in science classes. Among these strategies inquiry approach is also suggested. In addition, authors argue that science education literature mostly focuses on metacognitive processes and pays less attention to the self-regulation in a more comprehensive manner.

Finally, when the SRL studies in science classes in Turkey is examined, most of them are conducted either in elementary science course (Ilgaz, 2011; Israel, 2007) or with pre-service science teachers (Arsal, 2010; Imer-Cetin, 2013; Saribas, 2009; Vural, 2012). Again, any study is not found in high school chemistry class. These studies suggest improvement in different variables associated with SRL such as metacognitive self-regulation or self-efficacy beliefs.

CHAPTER 3

METHOD

This chapter includes four sections: research design, implementation of treatment, ethical concerns, and assumptions, limitations and delimitations. First, *the research design* of the study is explained under three subtitles: Mixed Methods Design, Quantitatie Approach, and Qualitative Approach. The sample of the study, the variables under interest, the instruments used, the data collection procedures, and the data analysis approaches are described separately for Quantitative and Qualitative practices. Second, *implementation of treatment* section explains the instructional materials developed for the experimental group and how the instruction is implemented in both groups. Third, the *ethical principles* employed to show respect for participants and protect their rights are explained under ethical concerns title. Finally, the *assumptions, limitations and delimitations* of the current study are given.

3.1 Research Design

3.1.1 Mixed Methods Design

SRL is a multi-dimensional construct including several components as metacognition, motivation, and strategic action. The measurement of those components has been under question among researchers over decades. Winne and Perry (2000) suggest using different instruments to cover different aspects of SRL. In line with their suggestion, this study was designed based on mixed method approach: both quantitative and qualitatitive data were collected and analyzed for the purpose of comparing results in an effort to provide better understanding of students' self-regulatory processes. Teddlie and Tashakkori

(2009) introduce mixed method approach as the third methodological approach in social and behavioral sciences and define research designs as Qualitative-Mixed Method-Quantitative continuum. Although several studies were conducted based on mixed method approach even before the development of the theory (Greene, 2007), the definitions and guidelines for practice are still developing and ambiguous. The earlier empirical studies present a research base for the development of mixed method theory and explain related concepts. In the first issue of *Journal of Mixed Methods Research*, Tashakkori and Creswell (2007) define mixed method research as "research in which the investigator collects and analyzes data, integrates the findings, and draws inferences using both qualitative and quantitative approaches or methods in a single study or a program of inquiry" (p.4). The "qualitative-quantitative debate" is partially ended with using qualitative and quantitative methods together in the same study. However, how to integrate qualitative and quantitative approaches (methods) together is an important issue. Since the theory of mixed method research is still developing, there is not a commonly accepted mixed method design as clearly stated by Greene (2007): "… the process of developing a thoughtful and appropriate mixed method design is less a process of following a formula or a set of prescriptive guidelines and more an artful crafting of the kind of mix that will best fulfill the intended purposes for mixing within the practical resources and context at hand" (p.129). However, a bunch of literature emerged to provide practioners with some recommendations to increase consciousness in all phases of their research which includes mixed method design.

In order to support the development of a common language on mixed method inquiry, a terminology parallel to Greene (2007) is used throughout the present research. Since qualitative and quantitative paradigms possess dissimilar assumptions, how to combine both methodologies is the major concern among mixed method researchers. Greene (2007) proposes different stances to clarify this issue. Among those the *complementary strengths stance*, which suggests the use of quantitative and qualitative methods with nonoverlapping weaknesses and complementary strengths together to provide a complete understanding of the phenemona (SRL in this study), was employed in the present study. In addition, Greene (2007) categorizes mixed method designs considering two criteria: (1) whether the qualitative and quantitative methods are implemented independently or interactively and (2) the degree of importance of qualitative and quantitative methods. In this study, the SRL phenemona was studied using both qualitative and quantitative methods with equal importance for the intent of comparing results. Both qualitative and quantitative methods were employed simultaneously and implemented independently. Qualitative and quantitative data were analyzed separately and results coming from two sources were compared while making inferences and conclusions. Figure 3.1 displays the mixed method design of the present study. The data collection and analysis processes in both methods were held separate, but the results coming from both sources were compared and contrasted in order to make more comprehensive inferences.

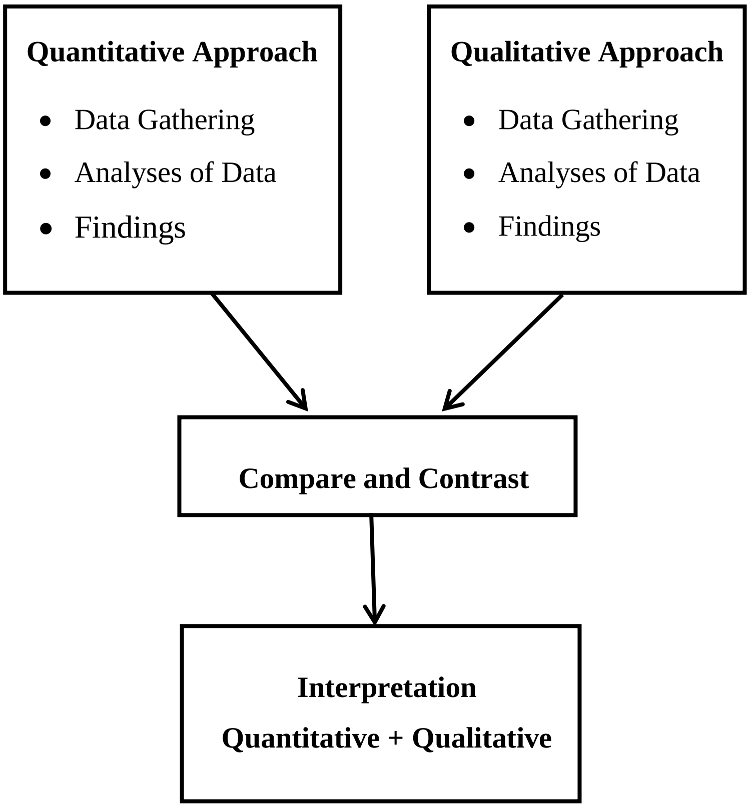


Figure 3.1 The Mixed Method Design of the Present Study

Accordingly, in this chapter, the data collection and analysis processes are described separately under quantitative and qualitative approaches sections. In the quantitative section, the effect of self-regulatory instruction (SRI) on SRL variables (cognitive and motivational variables) was investigated. In qualitative research, the focus was to understand how students employed the self-regulatory processes while learning chemistry concepts and how these processes developed over time. Quantitative data were collected via questionnaires and achievement test before and after the intervention. On the other hand, the qualitative data were collected via interviews, journals, and think aloud protocols. Table 3.1 summarizes the mixed methods design features of the present study: the constructs being studied, which instruments are administered to whom, and which instruments measure which constructs.

Table 3.1 Mixed Methods Design Features of the Present Study

	Pretest & Postest	Interview	Journal	Think-Aloud Protocol
Sample / Construct	N=78 Whole Group	N=8 Focal Students from both Groups	N=4 Focal Students from the Experimental Group	N=8 Focal Students from both Groups
Goal orientation variables	✓	✓		
Self-efficacy variables	✓	✓		
Cognitive and metacognitive strategies	✓	✓	✓	✓
ASEAB*	✓		✓	✓

* ASEAB: Achievement in Solubility Equilibrium and Acids and Bases

3.1.1.1 Quantitative Approach: Nonrandomized Control Group Pretest-Posttest Design as a Type of Quasi Experimental Design

The first research question of the present study investigated whether any significant change occurred on learning outcomes (DVs) over time in two groups of students. An intervention program (SRI) was developed in order to support students' use of self-regulatory learning processes such as planning, monitoring and evaluating the efficiency of learning process that was directed with students' personal goals. The independent variable (SRI) was manipulated: The researcher developed learning materials and assignments, designed lesson plans, and decided on the duration of the treatment and so forth. Two intact classes of the same chemistry teacher were used as the research setting. As a result, Quasi Experimental Design best served the purpose of the research considering the following features: examining the effect of treatment on dependent variable, manipulation of independent variable, and use of existing classrooms (Fraenkel, Wallen, & Hyun, 2012). More precisely, the research design employed in this study was named as *Nonrandomized control group pretest-posttest design* (Dimitrov & Rumrill, 2003) as a type of Quasi Experimental Design. Random assignment of students to groups was not practically possible since school administration did not give consent, therefore it was *nonrandomized* design. It was *control group* design for the reason that the intervention group was compared with a control group. Additionally, the instruments were employed as pre-tests before the instruction and as post-tests after the instruction to both groups. Thus, we called it *pre-test-post-test* design. Table 3.2 demonstrates the quantitative design of the study.

Table 3.2 Quantitative Research Design of the Study: Nonrandomized Control Group Pre-Test-Post-Test Design

Groups	Pre-test	Treatment	Post-test
EG	SEABT GOS HCSS CMSS	SRI	SEABT GOS HCSS CMSS
CG	SEABT GOS HCSS CMSS	TDCI	SEABT GOS HCSS CMSS

In Table 3.2, EG represented the Experimental Group taught with Self-Regulatory Instruction, while CG signified the Control Group taught with Traditionally Designed Chemistry Instruction. SEABT was the Solubility Equilibrium and Acids and Bases Test, GOS was the Goal Orientation Scale, HCSS was the High School Chemistry Self-Efficacy Scale, and CMSS was the Cognitive and Metacognitive Strategies Scale. SRI standed for Self-Regulatory Instruction and TDCI referred to Traditionally Designed Chemistry Instruction. The instruments were administered before and after the intervention to both groups in order to test the change which occurred over time.

3.1.1.1.1 Population and Sample

All the 11^{th} grade students attending regular public high schools in Ankara, the capital of Turkey, and taking chemistry course as a requisite of their major (Science and Mathematics) were selected as the target population of the study. Among those, 12 regular public high schools located in Keçiören region, a sub-urban district in Ankara, were selected as accessible population (Ortaogretim Genel Mudurlugu, 2011).

The required sample size was determined using power analysis program GPower3 (Faul, Erdfelder, Lang, & Buchner, 2007). When the researcher set the effect size as .50, the alpha level as .05, the power as .80, the number of groups as 2, and the number of measurements as 11; the required sample size was 75. Because the implementation of the study required a long period of time, and the new method was challenging and demanding for the classroom teacher, consent of school administration and teacher enthusiasm were necessary. Therefore, among nonrandom sampling methods, *convenience sampling method* was selected against the researcher's will (Fraenkel et al., 2012). Two intact classes of the same chemistry teacher from a public high school in Keçiören region were conveniently selected among the accessible population. All 78 students of the cooperative teacher voluntarily agreed to participate. Students in both classrooms were coming from low socio-economic background families. Their ages ranged from 15 to 20 with a mean of 17.3 in the experimental group and 17.1 in the control group.

One class of the cooperative teacher was assigned as the experimental group; while, the other was assigned as the control group by flipping a coin (Slavin, 2007). The experimental group consisted of 38 students, while the control group involved 40 students. Table 3.3 presents the distribution of students with respect to gender and the treatment group.

Table 3.3 The Frequency of Students with respect to Gender and Treatment Group

Group	Female	Male	Total
Experimental	21	17	38
Control	25	15	40
Total	46	32	78

Additionally, students' chemistry achievement level before the treatment was assessed based on their sores on teacher-developed midterm exams employed prior to the present study. The means of each exam for both groups and the average of first semester chemistry course grades (average of three teacher-developed midterm exams) are given in Table 3.4. The scores were given out of 100. The control group did better on the first exam, while the experimental group did better on the second exam. The mean scores were close for both groups on the third exam. When the first semester chemistry achievement scores were examined, it was almost the same for both groups: 61.76 for the experimental group and 61.63 for the control group. Accordingly, both groups were approximately at the same achievement level based on teacher's grading before the intervention.

Table 3.4 Means of Students' Chemistry Achievement Scores on the Previous Teacher-Developed Chemistry Exams

Treatment Group	Midterm I	Midterm II	Midterm III	Average of Midterm I, II, III
Experimental	76.76	67.84	40.68	61.76
Control	84.75	60.77	39.38	61.63

*Midterm I, II, and III scores were given out of 100

3.1.1.1.2 Variables

The present study explored how SRI affected a number of variables associated with SRL. There were eleven dependent variables (DVs) and an independent variable (IV) in this study. Treatment group (experimental versus control group) was the IV that was manipulated. The DVs included several variables associated with SRL. For simplicity, the DVs were categorized into two groups: motivational variables versus cognitive variables. Mastery-approach goal, mastery-avoidance goal, performance-approach goal, performance-avoidance goal, chemistry self-efficacy for cognitive skills (CSCS), and self-efficacy for chemistry laboratory (SCL) were categorized as motivational variables; learning strategies (rehearsal, elaboration, organization, and metacognitive self-regulation) and achievement in Solubility Equilibrium and Acids and Bases were classified as cognitive variables. Table 3.5 presents the characteristics of these variables.

Table 3.5 Characteristics of the Variables Investigated in This Study

Type of Variable	Variable Name	Continuous/ Categorical
DV	ASEAB*	Continuous
DV	Mastery-approach goal	Continuous
DV	Mastery-avoidance goal	Continuous
DV	Performance-approach goal	Continuous
DV	Performance -avoidance goal	Continuous
DV	CSCS	Continuous
DV	SCL	Continuous
DV	Rehearsal	Continuous
DV	Elaboration	Continuous
DV	Organization	Continuous
DV	Metacognitive self-regulation	Continuous
IV	Treatment group	Categorical

* ASEAB: Achievement in Solubility Equilibrium and Acids and Bases

3.1.1.1.3 Instruments

Quantitative data were collected using the following instruments: Solubility Equilibrium and Acids and Bases Test (SEABT), 2 x 2 Goal Orientation Scale (GOS), High School Chemistry Self-efficacy Scale (HCSS), and Cognitive and Metacognitive Strategies Scale (CMSS). The instruments were administered as pre-tests before the intervention to determine whether there was any difference between the two groups at the beginning of the study and as post-tests after the intervention to measure the change in 11th grade students' achievement in Solubility Equilibrium and Acids and Bases, use of learning strategies, and perceived motivation.

3.1.1.1.3.1 Solubility Equilibrium and Acids and Bases Test (SEABT)

SEABT, developed by the researcher, was used as a measure of students' achievement in chemistry covering two topics from the national 11^{th} grade chemistry curriculum, Solubility Equilibrium and Acids and Base Units. The content and learning objectives of the test were determined based on national 11^{th} grade chemistry curriculum, instructional objectives defined by the researcher (see Appendix A and B), textbooks, and related literature. At the beginning, the table of specifications was prepared as a guide for initial item pool. Later on, 45 multiple choice items with one correct response and four distractors were prepared bearing in mind item writing strategies. Afterwards, for content validity evidence, the table of specifications and test items were sent to three experts in chemistry education and they were asked to to fill the table of specifications considering level of items and corresponding objectives. Where there was a difference in opinion, an agreement was reached as a result of face to face discussions with the experts. Additionally, the test was examined by an expert from chemistry department for the check of accuracy of scientific knowledge and clarity of language. Necessary revisions were made based on expert opinions before the pilot study.

The 45-item test was piloted with 154 11^{th} grade high school students from two different high schools in Keçioren district. Item analysis using ITEMAN program was performed to select items having varied item difficulty level, discriminating well, and covering the content of both units. *Item difficulty* is the proportion of students who answered the item correctly. The item-difficulty values around .50 maximizes total score varience and reliability values (Crocker & Algina, 1986). *Item discrimination index* indicates that students with high scores on the overall test are those who also respondes that item correctly. In other words, students with low scores could not get the correct answer. The decisions on item discrimination were also done using the criteria suggested by Crocker and Algina (1986). The item discrimination index above .40 indicates a very good item that requires no revision. If the item discrimination index is between .30 and .39, those items are reasonably good and need little or no revision. The items with item discrimination index between .20 and .29 definitely need revision. Finally, the items with an item discrimination index below .19 are considered as poor items and should be removed from the test. *Subject matter judgement* was done by the researcher. If the same subject matter was covered in two different items, the item with better item discrimination index and targetted item difficulty level was selected. As a result, 30 items were selected for the final version of SEABT and 15 items were excluded critically (see Appendix C for detailed information on the results of item analyses for the 45-item piloted test). The *table of specifications* for the final version of the SEABT, the 30-item test, is given in Table 3.7. Half of the items (N=15) were selected around moderate item difficulty level (50%); half of the rest of the items (N=8) had high item difficulty (26.67%) and the remaining 7 items (23.33%) were selected among easy items. Six of the excluded items were difficult and not well discriminating. Four of the easy items and one of the difficult items were deleted considing percentage of item difficulties in the final test. The subject matters of those items were covered in other items with desired item difficulty level. The remaining four items were removed since the same subject matter was covered in another item with better item discrimination index. A sample item from the test is given in Table 3.6. (See Appendix D for 30 item SEABT).

Table 3.6 Sample Item from SEABT (Item 25)

A researcher measures the pH values of the solutions given in the table below. S/he adds some red onion juice and observes the color changes as given below:

Sample	pH	Color
Digestive fluid	1.9	Pink
Vinegar	3.4	Pale pink
Milk	6.4	Pale green
Baking powder	8	Green
Detergent	10	Yellow

What will be the color of the 0,4 M HX solution when some red onion juice is added?

Ka (HX) = $2,5 \times 10^{-4}$

*A) Pink B) Pale pink C) Pale green D) Green E) Yellow

* Correct answer

Table 3.7 Table of Specifications for SEABT

The Subject Matter Dimension		The Cognitive Process Dimension			
		Remember	Understand	Apply	Analyze
Solubility Equilibrium	A. Solutions and Dissolution	1	2, 3, 4		
	B. Solubility and Solubility Equilibrium	5	6, 10	7, 8, 9,	
	C. Precipitation		11, 12, 14	13, 15	
Acids and Bases	A. Definition of Acids and Bases, General Properties of Acids and Bases	16, 17	18, 21, 22	19, 23	
	B. Strength of Acids/Bases, Dissociation of Pure Water			20	
	C. Equilibrium of Weak Acids/Bases, Neutralization				25
	D. Neutralization and Titration		30	24, 27	28
	E. Hydrolysis and Buffer Solutions		26, 29		

In addition to the analysis of item difficulty, item discrimination, and subject matter judgements, another criterion for a good test is measuring the construct with high reliability. *Reliability* is defined as the degree to which the test scores are consistent when the same test or alternate test forms are administered to the same individuals under equivalent conditions (Crocker & Algina, 1986). Reliability of the test scores is explained with the "True Score Theory" which proposes that the observed score of an individual includes his/her true score on the measured construct and error of measurement (Crocker & Algina, 1986). Accordingly, reliability coefficient explains the amount of observed score variance attributed to the true score variance. The values above .70 are accepted as satisfactory (Nunnaly, 1978). It means that 70% of the observed score variance is explained with the true score variance. Since all test administrations include some degree of measurement error, it is not possible to measure individual's true score. Among different reliability coefficients, The Kuder-Richardson (KR) formula was used to compute internal consistency of the achievement test since the items were dichotomously coded ("1" for correct response and "0" for wrong response or missing item). According to Crocker and Algina (1986), KR20 should be preferred when test items possess diverse item difficulty levels. In the present study, the KR-20 reliability coefficient was found to be .76 for for the pre-SEABT and .82 for the post-SEABT, which pointed to internally consistent test scores for both administrations.

3.1.1.1.3.2 Goal Orientations Scale (GOS)

The GOS which was based on the most recent conceptualization of Achievement Goal Theory was used to measure the type of goals which students pursued while studying for chemistry course. It was originally developed by Elliot and McGregor (2001) based on the 2 x 2 achievement-goal framework. Achievement goals were conceptualized based on (a) definition of competence (mastery and performance) versus (b) valance of competence (approach and avoidance). Consequently, it included four subscales: mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance. Mastery-approach goals place emphasis on understanding the topic (e.g., “It is important for me to understand the content of chemistry course as thoroughly as possible”); while, mastery-avoidance goals focus on avoiding misunderstanding (e.g., “I worry that I may not learn all that I possibly could in chemistry class”). On the other hand, students with performance-approach goals give importance to doing better than others (e.g.,“It is important for me to do better than other students in chemistry class”); while, students with performance-avoidance goals try to avoid doing worse than others (e.g., “My goal for chemistry class is to avoid performing poorly”). High score on a subscale indicates that students utilize that type of goal more frequently while studying for the chemistry course.

The instrument was originally administered to 148 undergarduate students from psychology department. A seven-point rating scale ranged from 1 (not at all true of me) to 7 (very true of me) was used. The 2 x 2 achievement-goal model provided a good fit to the data: $\chi 2$ (48, N=148 = 60.49, p>.05); Root-Mean-Sqaure Error of Approximation (RMSEA) = .042; Tucker-Lewis Index (TLI) = .99; and Comparative Fit Index (CFI) = .99 (Elliot & McGregor, 2001). The reliability coefficients of the original study were found to be quite high: ranged between .83 and .94 for the initial measurement and between .85 and .97 for the subsequent measurement.

The 2 x 2 GOS was translated and adapted into Turkish culture by Senler and Sungur (2007) at elementary science course. Senler and Sungur (2007) preferred to use a five-point rating scale [ranging from 1 (never) to 5 (always)] for simplicity considering the age of the students. It included 13 items measuring four subscales. Findings indicated a good model fit to the data: Goodness of Fit Index (GFI) = .92; CFI = .92; Normed Fit Index (NFI) = .90; Standardized Root Mean Square Residual (SRMR) = .07. The Cronbach’s alpha coeffiecients were altered between .64 and .84.

It was also piloted with 348 high school students in chemistry course (Kadioglu, Uzuntiryaki & Capa-Aydin, 2010). In that study, parallel to the original study (Elliot & McGregor, 2001) a seven-point rating scale ranging from 1 (never) to 7 (always) was used bearing in mind the age of the students. The number of items in the GOS decreased to 12, measuring four factors (mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance). Check Appendix E for sample items from the scale. Results of Confirmatory Factor Analysis (CFA) revealed a good model fit to data for the four factor model with the following fit fit indices: RMSEA= .079, SRMR=.060, Non-Normed Fit Index (NNFI) =.93, CFI=.95. The Cronbach alpha reliability coefficients ranged from .72 to .85.

Table 3.8 presents the Cronbach's alpha reliability coefficients and 95% confidence intervals for the goal orientation variables for pre-GOS and post-GOS in the present study. When it was examined, the values were found to be between .62 and .84 for pre-test scores and between .71 and .82 for post-test scores. Only the pre-test measurement for performance-avoidance goal construct was found to be below .70 with the value of .62. However, its 95% confidence interval [.44, .74] included the criteria of .70. When item-total statistics were examined: if item 12 was deleted, there would be a slight increase from .62 to .65. Since item deletion did not create much improvement, the item was kept in the following analyses.

Table 3.8 Cronbach Alpha Reliability Coefficients and 95% Confidence Intervals for pre-GOS (Time I) and post-GOS (Time II)

Construct	Time I			Time II		
	Reliability coefficient	95% Confidence Interval		Reliability coefficient	95% Confidence Interval	
		Lower Bound	Upper Bound		Lower Bound	Upper Bound
Performance-approach	.76	.67	.85	.82	.74	.88
Performance-avoidance	.62	.44	.74	.71	.57	.80
Mastery-approach	.84	.77	.90	.80	.71	.87
Mastery-avoidance	.80	.70	.86	.77	.67	.85

3.1.1.1.3.3 High School Chemistry Self-Efficacy Scale (HCSS)

The HCSS was preferred to assess high school students' self-efficacy beliefs in chemistry course, since it included two self-efficacy subscales defined specific to high school chemistry tasks: chemistry self-efficacy for cognitive skills (CSCS) and self-efficacy for chemistry laboratory (SCL). This scale was originally developed in Turkish by Capa-Aydin and Uzuntiryaki (2009) and it was consisted of 16 items measuring two subscales. CSCS measures students efficacy-beliefs in cognitive tasks such as describing structure of an atom (e.g., "How much can you describe the structure of an atom?"); while, SCL focuses on confidence in psychomotor skills such as using laboratory equipment (e.g., "How well can you use the equipment in the chemistry laboratory?"). High score in CSCS or SCL indicates that students feel confident in that particular domain.

The original study was conducted with 362 tenth grade high school students (Capa-Aydin & Uzuntiryaki, 2009). Researchers used a nine-point rating scale

1 for “very poorly” and 9 for “very well”. The results of CFA provided a good-model-fit to the data [NNFI=.97; CFI=.98; RMSEA=.09 (90% CI=.09, .10)]. The reliability coefficients were also found to be high, .90 for CSCS and .92 for SCL.

The HSCS was also piloted with 236 eleventh grade high school students by the researcher. CFA was run using LISREL program. The fit indices revealed satisfactory fit to the data: NNFI = .94; CFI = .96; RMSEA=.096; (90% CI=.083, .108); and SRMR= .077. The Cronbach alpha reliability coefficients were .83 for CSCS and .86 for SCL. See Appendix E for the sample items from the scale.

Table 3.9 presents Cronbach’s alpha reliability coefficients and 95% confidence intervals for pre-HCSS and post-HCSS in the current study. Cronbach’s alpha coefficients for CSCS for both pre-test and post-test scores were the same with the value of .88. For SCL construct, it was .90 for pre-test scores and .92 for post-test scores. Accordingly, the self-efficacy constructs possessed quite high reliability cofficients in the current study.

Table 3.9 Cronbach Alpha Reliability Coefficients and 95% Confidence Intervals for pre- HCSS (Time I) and post- HCSS (Time II)

	Time I			Time II		
		95% Confidence Interval			95% Confidence Interval	
Factor	Reliability coefficient	Lower Bound	Upper Bound	Reliability coefficient	Lower Bound	Upper Bound
CSCS	.88	.84	.92	.88	.83	.92
SCL	.90	.87	.93	.92	.89	.94

3.1.1.1.3.4 Cognitive and Metacognitive Strategies Scale (CMSS)

The rehearsal, elaboration, organization, and metacognitive self-regulation subscales of Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991) were referred to the Cognitive and Metacognitive Strategies Scale (CMSS) in the present study. These subscales were choosen, since they reflected fundamental cognitive and metacognitive strategies defined by Weinstein and Mayer (1986) in their distinguishing chapter on learning strategies. They were also accepted as effective learning strategies and commonly associated with SRL in the related literature. The CMSS was composed of 26 items measuring students' use of different cognitive and metacognitive strategies. Rehearsal strategy is used to activate the information in the working memory (e.g., "When I study for this class, I practice saying the material to myself over and over"). Contrariwise, elaboration strategy helps making connection between new and existing information (e.g., "When I study for this class, I pull together information from different sources, such as lectures, readings, and discussions"). Furthermore, organization strategy is used to outline the information (e.g., "When I study the readings for this course, I outline the material to help me organize my thoughts"). Finally, metacognitive self-regulation strategies include planning, monitoring, and evaluation processes that the learner uses to control their learning (e.g., "I ask myself questions to make sure I understand the material I have been studying in this class). High score on a subscale indicates that students use that strategy more often while studying chemistry topics.

The original study was conducted with 380 college students from 14 subject domains such as chemistry, education, and psychology (Pintrich et al., 1991). Students rated themselves on a seven-point rating scale 1 for "not at all true for me" and 7 for "very true of me." The fit indices were not very well ($\chi 2/df$ =

2.26; GFI = 0.78; and RMR = 0.08) in the English version; however, the factors were supported with the theoretical evidence.

The instrument was translated and adapted into Turkish by Sungur (2004) in high school biology course. The fit indices for Turkish data with 488 high school students were also not very well ($\chi 2$/df = 4.5, GFI = 0.71, and RMR = 0.08). The Cronbach alpha reliability coefficients ranged from .76 to .85 for Turkish version.

This scale was also piloted with 236 eleventh grade students taking chemistry course by the researcher. Better fit indices ($\chi 2/df$ (1616.499/424) = 3.81, RMSEA = .049 (90% CI =.046, .051), SRMR= .049, CFI = .89, and NNFI = .87) than the original indices were found and the model provided a good fit to the data. The Cronbach alpha reliability coefficients were found to be between .68 and .82. See Appendix E for the sample items from the Turkish version of the scale.

The Cronbach's alpha reliability coefficients and 95% confidence intervals for pre- CMSS and post-CMSS scores in the current study are given in Table 3.10. The Cronbach's alpha coefficients found to be between .76 and .85 for pre-test and .62 and .85 for post-test scores. Only the reliability value for the post-organization strategy measurement was below .70. When item-total statistics were examined: if item 18 was deleted, there would be a slight increase from .62 to .65. As deleting the item did not result with much increase in reliability, the item was saved in the subsequent analyses.

Table 3.10 Cronbach Alpha Reliability Coefficients and 95% Confidence Intervals for pre-CMSS (Time I) and post-CMSS (Time II)

Subscale	Time I			Time II		
		95% Confidence Interval			95% Confidence Interval	
	Reliability coefficient	Lower Bound	Upper Bound	Reliability coefficient	Lower Bound	Upper Bound
Rehearsal	.80	.72	.86	.80	.71	.86
Elaboration	.76	.67	.84	.78	.70	.85
Organization	.83	.75	.88	.62	.46	.74
Metacognitive self-regulation	.85	.79	.89	.85	.80	.90

3.1.1.1.4 Quantitative Data Collection Procedure

The pre-tests and post-tests were administered to both groups by the researcher with the help of the cooperative teacher. The pre-tests were administered two weeks earlier than the intervention started, after the teacher finished her regular teaching in the previous unit. The administration process took three class hours, one week chemistry course programme. Initially, the questionnaire composed of GOS, HCSS, and CMSS was given to students which took approximately two class hours. In the third class hour, the SEABT was administered as pre-test. The intervention started at the same time in both groups with the introduction of laboratory environment and safety rules in the chemistry laboratory.

After a 12-week intervention, the post-tests were administered to both groups by the researcher with the support of the teacher likewise the pre-tests. Administration of post-tests also took three class hours, one week chemistry program. This time students in both groups completed answering the questionnaires (GOS, HCSS, and CMSS) in one class hour, and the administration of post-SEABT took one and a half class hours.

3.1.1.1.5 Quantitative Data Analysis

The SPSS program was used to analyze the quantitative data. First, as missing data were found to be distributed randomly, they were replaced with the mean of the corresponding treatment group on the interested variable. Second, the outliers were checked. Third, means and standart deviations of the dependent variables, and the bivariate correlations among them were calculated as descriptive statistics. Fourth, inferential statistics were employed to test the hypotheses. Mixed Multivariate Analysis of Variance (MANOVA) was performed since it was a mixed factorial model with a between-subjects factor (treatment) and a within-subjects factor (time). Dimitrov and Rumrill (2003) emphasized that the F value for the interaction term (treatment x time) should be interpreted to claim the change that occurred as a result of the intervention in a pretest-pottest design.

In line with the suggestions of Huberty and Morris (1989), the DVs were divided into two groups regarding conceptual proximity: motivational variables versus cognitive variables. Motivational variables were performance-approach goal, performance-avoidance goal, mastery-approach goal, mastery-avoidance goal, CSCS, and SCL. Cognitive variables contained rehearsal, elaboration, organization, and metacognitive self-regulation strategies and achievement in Solubility Equilibrium and Acids and Bases. As a result, two separate mixed-MANOVAs (one for motivational variables and one for cognitive variables) were run. The first analysis was conducted for motivational constructs to test the first three null hypotheses given in Chapter 1 under section "1.2 The Null Hypotheses". The grouping independent variable (between-subjects factor) was treatment and the repeated measure independent variable (within-subjects factor) was time (testing period). Six dependent variables were performance approach-goal, performance-avoidance goal, mastery-approach goal, mastery-avoidance, CSCS, and SCL. The second mixed-MANOVA was conducted for learning strategies and achievement to test fourth, fifth and sixth null hypotheses in section "1.2 The Null Hypotheses". Similarly, treatment was the between-subjects factor, and time (testing period) was the within-subjects factor. Five dependent variables included rehearsal, elaboration, organization, and metacognitive self-regulation strategies, and achievement in Solubility Equilibrium and Acids and Bases.

3.1.1.1.6 How to Control Threats to Internal Validity

Internal validity means that the change occured on the DV is explained with the IV and not any other unplanned variable(s) (Fraenkel et al., 2012). The outcome of a study may be attributed to a variable different from the IV(s) which is not considered by the researcher. The strategies to minimize possible alternative causes of the findings of the present study are discussed in this section. Fraenkel et al., (2012) classiffied ten threats to internal validity: subject chracteristics, mortality, location, instrumentation, testing, history, maturation, attitudes of subjects, regression, and implementation threats.

Subject chracteristics like age, gender, and socioeconomic status may favor one group regarding the variables studied. The best strategy to minimize this threat is randomly assigning subjects to groups or matching each subject in the experimental group with another student in the control group based on a certain subject characteristic such as age or gender. Unfortunately, both methods could not be employed in the present study. Rather more information about the characteristics of subjects possibly related to the outcomes of the study was reported such as gender, age, and socioeconomic status of students' families. Additionally, method (testing both groups before and after the treatment) and statistical approach (using mixed-MANOVA) helped to minimize this threat.

Mortality threat occurs when subjects of the study is lost for the duration of the study. The loss of subjects was critical if they respond different from the remaining subjects. Since there was no loss of subjects during intervention, it was assumed that likelihood of this threat is almost none or very low. In order for a precise control on this threat, the ratio of missing data was checked which was found to be quite low, and they were replaced with the mean of the related group.

When the groups are taught or the instruments are employed in different locations, this may generate another threat namely *location threat.* For example, when students are taught at different classes with different facilities, the outcomes of the study may be affected by these different conditions. The most important threat to internal validity in the present study was location threat, because students had never worked at the chemistry laboratory. Both classes had the same facilities. For instance, they did not have computers, so simulations were run in the computer class. To minimize this threat, control group also used the chemistry laboratory and computer class in addition to their regular class. Additionally, students from both groups took all the tests in their regular classrooms and the interviews were conducted at the same place. The questionnaires and the achievement test were implemented at their regular classes.

Instrumentation threat occurs in two forms: the characteristics of data collector and any bias generated by the data collector. All the instruments were implemented to both groups by the same data collectors (the researcher with the help of the teacher). Data collector bias was minimized by giving numbers to students rather than using their real names, and standardizing the implementation and scoring processes of the instruments. For standardized evaluation, the data were entered into SPSS program and the average and total scores were calculated by the program. As a result, this threat was controlled cautiously.

A *testing* threat considers the possible pre-test effect on the post-test. When students take a pre-test, they may guess what is studied and pay more attention to the intervention. In this study, both groups were pre-tested before the intervention and it was expected to affect both groups in the same way. Additionally, the pre-tests were administered two weeks before the study and the treatment lasted 12 weeks, which was long enough to avoid recalling initial responses.

When an unexpected event occurres, it might affect the implementation of the treatment or testing process, in turn it may affect the results. *History threat* was controlled by observing all the classes; the observation notes included information about the place, time, and other events that took part throughout the study. For example, during the implementation of acid-base unit, a volcano in Iceland erupted and the ash clouds affected all over Europe. At that time all the news announced it, acid rains were discussed in association with the volcano eruption. In both classes, the event was mentioned similarly but not discussed in detail. This event was assumed to affect both groups equally.

The duration of the study may result in *maturation* of students and the time itself may explain the change occurred on the DVs instead of the intervention. This threat was controlled by using a comparison group, giving the intervention at the same time to both groups, and covering the topics at parallel times. Additionally, the subjects were from high schools and they were not expected to mature this fast since the study did not last years.

Attitudes of subjects create a serious threat in the experimental studies that should be controlled carefully. It may occur in three ways. First, when the subjects of the experiental goup realize that they are part of a novel and/or superior treatment, they may want to help the researcher and increase their attention during treatment (Hawthorne effect). Second, the subjects in the comparison group may notice that the other group taking a special treatment and they may increase effort as a result. Third, control group subjects may feel that no treatment was given to them and they may get demoralized and as a result decrease their effort. All these threats explain the way subjects perceive a study and their involvement in it. To deal with this threat, similar experiences were provided to both groups. Both groups conducted experiments in the laboratory (experimental group used guided-inquiry approach while conducting the experiments and experiments in the control group was cookbook type); used simulation (inquiry method for experimental group, lecturing for control group); took their courses in their regular classes (inquiry method for experimental group, lecturing for control group); and solved algorithmic questions in their regular classes. The researcher attended all the classes in both groups and started to make observations with the previous unit. It took approximately six weeks to make the class accustomed to the researcher's existence before the actual study started. It was observed that the novel activities planned for the control group were perceived as satisfactory by the control group students and they neither compared themselves with the experimental group nor demanded more activities. Additionally, a few recitation hours were added to the instruction in the experimental group considering their request to solve more algorithmic questions.

Regression threat occurs when subjects are selected from remarkably high or low performance groups. In the present study both classes were selected from regular public high schools. No extreme groups like gifted students were compared with average students. When pre-test scores were examined, students in both groups were found to respond similarly.

Implementation threat is vital when different people implement different methods (such as the researcher teaching the experimental group and the teacher teaching the control group) or the same person implementing both methods but favoiring any of the compared methods and treat that group differently. This threat was minimized using the following strategies: The same teacher instructed both groups; the teacher was reminded several times that this study did not evaluate her teaching; she was trained before the treatment; the difficulties she encountered during implementation were discussed after each class; and the daily lesson plans for both groups were discussed with the teacher a week before the class. In addition, all the class hours were observed in both groups to ensure that the teacher implemented the instruction following the given guidelines.

3.1.1.2 Qualitative Approach: Case Study

In an attempt to understand in what ways the SRI contributed/supported students' use of SRL processes the qualitative approach was also employed in addition to quantitative approach. In order to provide in-depth understanding of how SRL phenomenon worked in real-life context, the *case study method* as a qualitive approach was utilized in the present study. Yin (2009) defines case study method as a practice of inquiry that focused on in depth understanding of a phenomenon in real life context. Additionally, the data collection and analyses procedures are guided by existing theory. Moreover, the data are gathered from multiple sources in order to get detailed understanding of the studied phenomenon. The second research question that inquired how students utilized the self-regulatory processes while studying for chemistry course was explored via the case study method. Since students in the control group also utilized self-regulatory processes to some degree while studying for the chemistry course, each classroom was accepted as a case, in other words, as a unit of analyses. Accordingly, two cases were explored in the present study: self-regulatory practice in the experimental group and self-regulatory practice in the control group. Four students were selected from each class as representative instances of their cases.

3.1.1.2.1 Participants

Out of 78 students joined in the present study; four students were selected from the experimental group and four students were selected from the control group as focal students for comprehensive examination of their cases. To get information from varied achievement levels and from both gender groups in each case, the students were selected using *maximum variation sampling* method (Patton, 2002). To cover different achievement levels, one low achiever, two moderate achievers, and one high achiever were chosen from each treatment group. In order to determine students' achievement level, their performance on the first midterm examination prepared by the cooperative teacher (Midterm 1) and pre-SEABT were considered in addition to the cooperative teacher's judgments. Initially, students' scores were transformed into z-scores in order to make comparison among Midterm 1 and pre- SEABT scores. Z-scores between -.5 and +.5 were indicated medium achievement level, below -.5 were accepted as low achievement level, and above +.5 were accepted as high achievement level. In order to represent both gender groups, five of the focal students were selected among males and three of the focal students were chosen among females. Moreover, in the experimental group, students worked in groups of four or five members. In order to represent the self-regulatory processes of different study groups, focal students were selected among the students who worked in different groups in the laboratory. The gender and achievement level of focal students were summarized in Table 3.11.

Table 3.11 The Distribution of Focal Students with regard to Gender and Achievement Level

Student	Gender	Group	Midterm 1	Pre-SEABT	Achievement
Ege	Male	Control	.240	*Missing*	Low
Meryem	Female	Control	.533	1.042	Medium
Tolga	Male	Control	1.119	*Missing*	Medium
Faruk	Male	Control	1.119	-1.384	High
Mete	Male	Experimental	-2.983	-1.870	Low
Fatma	Female	Experimental	.826	.071	Medium
Berat	Male	Experimental	-.053	-.899	Medium
Ayşe	Female	Experimental	1.119	-.414	High

*All the scores were given in terms of z-scores.

**Final decision on students' achievement level was given based on discussions with the cooperative teacher.

3.1.1.2.2 Qualitative Data Collection Instruments

In line with suggestions of Winne and Perry (2000) diverse instruments were used to collect data: interviews, journals, and think aloud protocols. They argue that SRL can be measured both as an aptitude and as an event. An aptitude indicates a relatively stable characteristic that is used to predict students' future performance. For example, questionnaires were administered to measure different student characteristics to predict their learning outcomes. Measuring SRL as an event means that the measurement covers a time span and distinguishes the activity from prior or subsequent events. For example, during think aloud measurement, the SRL processes were measured as an event; explicitly, students were observed while they were performing the task. In conclusion, interviews measured constructs related to SRL as an aptitude, while journals and think aloud protocols (as a special form of interviewing approach) measured SRL processes as an event.

3.1.1.2.2.1 Interview Schedule

In this study, semi-structured interviews were conducted with focal students from both groups before the intervention started to examine their regular learning practices while they were studying for chemistry course. Students were asked to explain their "typical" behavior while they were studying for the course at home. The interviews were used to assess the common SRL processes that focal students engaged in. Therefore, the interviews measure SRL construct as an aptitude (Winne & Perry, 2000).

The interview schedule was prepared based on three cyclic phases of Zimmerman's SRL model (2000): forethought, performance, and self-reflection. The forethought phase included the actions students do before performing the task. For example, in order to explore students' motivational beliefs, they were asked to explain why they studied for chemistry course (sample question: Why do you study chemistry class?). Next, the performance phase covered students' implementation of task strategies, and they gave details about how they studied for the course (sample question: How do you study chemistry class? Can you give examples?). Self-reflection phase included the processes occurred after learning (sample item: Which criteria do you use to evaluate the effectiveness of your work?). The interview schedule was examined by two experts and the revised interview schedule was piloted with high school students in an earlier study (Kadioglu, Uzuntiryaki, & Capa-Aydin, 2006). Results of the pilot study indicated that all questions worked well.

3.1.1.2.2.2 Journals

Journals were collected from the focal students in the experimental group. They were primarily designed as instructional materials for the treatment in the experimental group (SRI) to guide students follow three phases of Zimmerman (2000)'s model (see section "3.2.2 Treatment in the Experimental Group" for detailed information about how journals were used as instructional tools). Students were assumed to write down their learning processes (under forethought, performance, and self-reflection phases) in which they engaged while they were performing the tasks in line with their evaluation and reflection on the processes (see Appendix G for a sample journal and "how journals cover three cyclic SRL phases").

Based on dialogs with the cooperative teacher, high school chemistry curriculum was very loaded in terms subject matter. Since the agenda of regular curriculum was followed in the present study, the time was limited. In order to use the time efficiently, journals were filled by the reporter of the group and reflected group performance. Accordingly, each journal was used to assess the SRL processes that the groups' of focal students use and the eight journals overall were evaluated to track the development of SRL processes in groups of focal students over the course of the study.

3.1.1.2.2.3 Think Aloud Protocols

Think aloud protocol is a special form of interview technique. Winne and Perry (2000) explain the difference among two techniques in the quotation below:

> ”If the student is prompted to describe SRL while engaging with an authentic task, the method is a think aloud and SRL is measured as an event. In contrast, if the student is prompted to describe SRL based on memories about what is “typical” of behavior under a certain set of circumstances or to offer judgements about what probably would be typical behavior in a plausible future situation, the protocol is an interview and SRL is measured as an aptitude.” (p.545)

In the current study, think aloud protocol is employed to understand the cognitive and metacognitive processes that students involved in. They were given authentic tasks and asked to explain loudly what they were doing or what they were thinking while working on the task. The tasks were authentic; that is, students were encouraged to explain a novel case using the concepts that they had learnt in the class. The cases were related to student’s daily life experiences, applications of concepts, and the results of made-up laboratory tasks which were extension of students’ own laboratory expreciences. For example, regarding daily life experiences, the following real life case was given to students: “During medical radiological examination of gastro-intestinal tract, patients drink barium sulfate solution. Although Barium (Ba^{+2}) ion was a highly toxic ion, barium sulfate ($BaSO_4$) solution was harmless to the patient. The Ksp value for barium sulfate is also given” (see Appendix F.1). Students were asked to explain the reason of why barium sulfate solution was harmless to the patient using the concepts they had learnt in the Solubility Equilibrium Unit. Related to applications of concepts, students were given a conceptual task in the Acids and Bases Unit and asked to think on whether the pH of a weak acid solution could take a smaller value than the pH of a strong acid solution (see Appendix F.2). Finally, a table including results of a titration of a weak acid solution with a strong base solution was given as a made-up laboratory task in the Acids and Bases Unit. Students were asked to interpret the data. In Journal 8 students explored titration of a strong acid with a strong base and titration of a strong base with a strong acid. However, they did not do the titration of a weak acid or a weak base. The task was totally authentic for students and required to employ the concepts they had learnt in the Acids and Bases Unit into a made-up laboratory experiment.

The think aloud technique was totally novel to the students and they were afraid to speak out something wrong. Accordingly, two algorithmic questions were given to students related to Solubility Equilibrium Unit in order to help them feel comfortable and encourage them to explain their reasoning whether it was true or wrong. The algorithmic questions were typical classroom practice in the control group. The cooperative teacher mostly focused on calculations but did discuss them conceptually. In the present study, they were added to the protocols in order to measure students' conceptual awareness on those algorithmic tasks rather than observing mathematical calculations.

It should be noted that the think aloud protocols were not employed in the classroom while students were learning the task. They were employed after each unit but students were given authentic tasks to be explained. Two separate think aloud protocols including six tasks related to each topic were prepared, one for Solubility Equilibrium Unit and the other for Acids and Bases Unit.

3.1.1.2.3 Qualitative Data Collection Procedure

The qualitative data were collected by the researcher. The interviews and think aloud protocols were conducted in private with the focal students in both groups at the school during class hours with the permission of school administration and the classroom teachers. Students were informed about the confidentiality of the data that no one from the school would see their answers and their answers would be reported using pseudonym.

The interviews were conducted with focal students from both groups before the intervention started. Since the focal students were selected based on pre-test scores, the interviews were done the week after the pre-tests were administered and the week before the intervention started. The interviews were conducted at an empty room at school. During the interviews the researcher and the interviewee were alone. And the students were informed that their teacher or school administration would not access to the interview data. Each interview lasted approximately 20 to 40 minutes, around a class hour. All interviews were tape-recorded and transcribed verbatim.

The journals were used both as an instructional tool to guide students' learning and as a measurement tool for data collection for the researcher. They were filled by the students in the experimental group during class hours and collected by the researcher after class hours. The researcher took the journals, scanned them, and disctributed back to the students.

The think aloud protocols were also conducted with the focal students from both groups at the end of each unit. Similar to the interviews, the protocols were conducted at school during class hours. The researcher met with each student in an empty and quite room. Students were informed about the confidentiality of the data and the results would not be graded. While the students were performing the task, the researcher asked additional questions to encourage them explain the task more detailed, and to understand their thinking approach and/or why they selected a specific strategy. Additionally, the researcher used questioning techniques to give prompts to students in order to encourage them continue thinking on the task when they gave up. After the Solubility Equilibrium Unit finished in six week period, the first think aloud protocol was conducted in the seventh and eighth weeks. Meanwhile, the instruction on the Acids and Bases Unit started in both groups. At the end of the intervention, initially the post-tests were administered in order not to interrupt the regular curriculum. The second think aloud protocol on the Acids and Bases Unit was conducted after post-tests; in the meantime, the teacher started the instruction in the following chemistry unit. Each protocol took from 22 to 41 minute, and was audio-recorded and transcribed verbatim.

3.1.1.2.4 Qualitative Data Analysis

3.1.1.2.4.1 Analyses of Interviews

The interviews were audio recorded during the implementation and the data were transcribed later on. Throughout the transcription it was noticed that the students used the language in an informal way and frequently construct unstructured sentences. As a result, from time to time it became challenging to transcribe and code the interviews. All the transcribed data were coded by the researcher and the interview of a focal student was coded by an expert in chemistry education. In case of disagreement, the raters reached consensus as a result of face to face discussion on the cases. In order to assess the degree of agreement among two raters, the inter-rater reliability was calculated by dividing the number of *likewise coded items* into the *total number of codes*. The inter-rater reliability was found to be .81 for the interviews which was quite high.

Next the transcribed data were analyzed with respected to the self-regulatory phases and associated processes and sub-processes given in Table 3.12. The codes were emerged from Zimmerman's SRL model (2000) which was explained in section "*2.3 Zimmerman's Self-Regulatory Model*" in detailed.

Table 3.12: The self-regulatory phases, associated processes and sub-processes, and sample excerpts used for the analyses of interviews

Phase	Process	Sub-process	Explanation	Sample excerpt
Forethought Phase	Motivation	Performance-approach goal	Focus on getting higher grades than classmates	"The fact is, to be best in class, to compete among the best students is very good."
		Performance-avoidance goal	Avoid doing worse than others	*Not observed*
		Mastery-approach goal	Give importance to developing new skills	"I believe the one who understands chemistry is a successful student, I think the grade is not important."
		Mastery-avoidance goal	Avoid not understanding the concepts	*Not observed*
		Self-efficacy beliefs	Believe in his/her capacity to successfully explain his/her laboratory observations	"For example, I am good at solubility equilibrium. Thus, I believe I can answer all the questions."
		Outcome expectations	Anticipate positive outcomes as a result of effort	*Not observed*
		Value beliefs	Believe in the importance of the course to be successful in the University Entrance Examination (*Utility Value*)	"In the university exam, we will be asked similar topics, and our future depends on this."

Table 3.12 (continued)

Phase	Process	Sub-process	Explanation	Sample excerpt
Forethought Phase	Strategic planning		Choose a strategy considering the demands of the task and organize implementation of that strategy intentionally	*Not observed*
Performance Phase	Self-control	Self-instruction	Explain the processes that they follow while working on the task	*Not observed*
		Attention focusing	Tidy his/her room up to concentrate on the task	"For example, if there is not a background music, I can not study, because I lose my attention."
		Task strategies	Strategies such as note-taking and reading comprehension	"For example, when studying from a textbook, there is a bold section, text written in bold, I study those sections."
		Imagery	Create mental images to code information	"For example, periodic table, it is all defined, eight A groups, eight B groups, then block D, block F, all of them. It is useful, because I can imagine differently. I can liken it to something I want."

Table 3.12 (continued)

Phase	Process	Sub-process	Explanation	Sample excerpt
Performance Phase	Self-observation	Self-recording	Students' records about when to employ which strategy	*Not observed*
		Self-experimentation	Experiment on factors such as studying at different times of the day	"I have already tested it. I did not study an exam, I did not think I would succeed in that, in fact I understood the topic, but I did not study. I got "4" from that exam. Then, I understood the topic, but I studied the exam. In that exam, I did not miss any questions and I got 5. In other words, I increased (my grade), then I understood the importance of studying an exam."
Self-Reflection Phase	Self-judgment	Self-evaluation	Evaluation of the effectiveness of the learning process by comparing the learning outcomes with the learning goals	"If you can solve questions, then it (your study) is effective. If you cannot solve questions, then it (your study) is not effective."
		Causal attribution	Attribute success to ability or effort	"I attribute success to studying a lot."

Table 3.12 (continued)

Phase	Process	Sub-process	Explanation	Sample excerpt
Self-Reflection Phase	Self-reaction	Self-satisfaction	Experienced after the accomplishment of a task that s/he put a high value on successfully	*Not observed*
		Adaptive	Changing learning goals or study strategies after failure and continue working on the task	“In order to increase a low grade, I would study more to the next exam.”
		Maladaptive	Quit and/or decrease effort after experience of success	“If I get a good grade, actually, I won’t study much to the next exam.”
		Defensive	Procrastination and/or cognitive disengagement in order not to experience disappointment in future performance	“If I stuck at some point while solving problems, I will get disappointed and I will not continue (studying)."

3.1.1.2.4.2 Analyses of Journals

Since journals were designed to guide students follow three self-regulatory phases, they were analyzed in order to identify the phases and associated processes that students used (see Table 3.13). When students described what they would do, it was coded under *planning activity* proccess. If students prepared a table or any other forms of list before they engaged in an activity, it would indicate *planning data recording* process. They were also asked to report expected outcomes before the activity which was their *predictions*. During the activity, students reported the *procedure* they followed and their *observations*. Additionally, they made conclusions based on their observations which were indicating *inferenc*e. After the activity, students compared their predictions with their observation notes and reported whether they experienced any *unexpected outcomes*. They also summarized the concepts and principals they learnt which was coded as *assessing learned material*. Moreover, students reported if they *experienced any difficulty*. When they finished working on the task and wrote down their reflections on their learning experiences, they applied what they had already observed/learnt in the laboratory into new conditions which was considered as *evaluation* of the teaching and/or *elaboration* of concepts. Finally, the students were asked to evaluate each journal in terms of challenge, motivation, interest, helpfulness in learning concepts, efficiency of group work, used resources, and deficiencies of the task for the purpose of *assessing the activity*.

Table 3.13: The self-regulatory phases and associated processes used for analyses of journals

Zimmerman's Phase	Processes
Forethought Phase	1. Planning activity 2. Planning data recording 3. Predictions
PerformancePhase	1. Procedure 2. Observation Data 3. Inference
Self-ReflectionPhase	1. Unexpected outcomes 2. Assessing learned material 3. Experienced difficulties during activity 4. Evaluation /Elaboration 5. Assessing the activity

The processes were evaluated in four categories: "*non-existent*", "*not satisfactory*", "*satisfactory,*" and "*not applicable"*. When students did not report anything related to the particular self-regulatory process, it was coded as "*non-existent*". However, *non-existent* did not ensure that students did not use that process; rather, it indicated that the group did not write down what they did. Additionally, if the information that students reported was *irrelevant*, that process would be also accepted as "*non-existent*". For example, while describing what they would do, if students reported what they did, it was coded "*non-existent*" in terms of *planning activity* process. If the students reported the process with deficiencies, it would be coded as "*not satisfactory*". For instance, while stating their inferences, if the students came up with the right conclusion but did not explain their reasoning, it was coded as "*not satisfactory*" inference. On the other hand, if they explained their reasoning with respect to their observations, it was accepted as a "*satisfactory*" inference. Finally, when the process was not relevant considering the activity, it was marked as *not* *applicable* (*NA*). For example, in Journal 7, the reaction of metals with acid and base solutions was done by the teacher as a demonstration due to safety considerations. Therefore, the teacher planned the activity not the students.

All the journals for the focal students from the experimental group were coded by the researcher. Additionally, eight journals for one of the students were coded by the same expert in chemistry education. In case of disagreement, the consensus was reached as a result of face to face discussion. In order to assess the degree of agreement among two raters, the inter-rater reliability was calculated which was found to be .85 for the journals.

3.1.1.2.4.3 Analyses of Think Aloud Protocols

Same as the interviews, the think aloud protocols were audio recorded during the implementation and transcribed afterwards. The students also used an informal language and often constructed unstructured sentences throughout both think aloud protocols. Next the transcribed data were analyzed according to the codes and themes given in Table 3.14. The codes were emerged from the related literature (Biggs, 1999; Brown, 1987; Entwistle, 1988; Kirbulut, 2012; Pintrich et al., 1991; Ramsden, 1992; VanderStoep & Pintrich, 2007; Weinstein & Mayer, 1986; Yuruk et al., 2009).

All the think aloud protocols for the focal students from both groups were coded by the researcher and two think aloud protols belonged to the same student were coded by the same expert as who codded other qualitative instruments. Likewise, consensus was reached as a result of face to face discussion and inter-rater reliability was calculated to assess the degree of agreement among two raters. It was found with the value of .73 for think aloud protocols which was slightly lower than the value for journals and interviews. It was also at satisfactory level.

Table 3.14 The codes and themes for analyses of think aloud protocols

Theme	Codes
Rehearsal	1. Say over and over 2. Read over and over 3. Memorize key words 4. Memorize list 5. Repeat the words 6. Copy the material to recall information 7. Underline or shadow the material presented in the class 8. Memorize new information 9. Memorize list
Elaboration	1. Summarize main points / Write down most important 2. Paraphrasing – restate in his/her own words 3. Ask questions to each other 4. Make analogies 5. Make generalizations 6. Expand notes with examples questions; generative note taking 7. Forming an image or sentence to relate items 8. Describe how new information relates to existing one
Organization	1. Group or order the content/items to be leant based on shared properties 2. Identify important parts and make connections 3. Outline a material especially studying for course content 4. Draw charts/diagrams 5. Headings and subheadings 6. Create tables/concept maps to show relationship among items

Table 3.14 (continued)

Theme	Codes
Metacognitive Self-Regulation	**Metaconceptual Awareness** 1. Awareness of aims of activities 2. Awareness of existing experience 3. Awareness of everyday applications of a topic 4. Awareness of what you learned 5. Awareness of what you did not know **Metaconceptual Monitoring** 1. Monitoring understanding of an idea 2. Monitoring the consistency between existing idea and ideas from other people/sources 3. Monitoring the consistency between existing experience and new experience 4. Monitoring change in ideas **Metaconceptual Evaluation** 1. Evaluation of existing idea 2. Evaluation of existing experience 3. Evaluation of ideas from other people/sources
Achievement in Solubility Equilibrium and Acids and Bases	1. Wrong response 2. Wrong response with poor/insufficient (scientific) explanation 3. Partially correct response 4. Correct response without (scientific) explanation 5. Correct response with irrelevant (scientific) explanation 6. Correct response with poor/insufficient (scientific) explanation 7. Correct response with (scientific) explanation

3.1.1.2.5 Trustworthiness of the Qualitative Study

Trustworthiness of the findings in qualitative studies is discussed through credibility, transferability, dependability, and confirmability (Creswell, 2013).

The term *credibility* means that what is observed in the context is consistent with what is experienced by the students. It is used in place of *internal validity* in a quantitative study. To increase credibility of findings, the present study was covered two units period approximately four months. The researcher observed all the classes in both groups using an observation checklist. Additionally, the researcher started to attend classes a unit before the implementation and observed each chemistry class in order to gather a deeper understanding of the natural context. By the time the intervention started the students got accustomed to the researcher and started behaving more typically. In addition, different methods (interviews, journals, and think aloud protocols) were used to gather data from different sources. Moreover, whenever needed students were asked to clarify their statements during the interviews and think aloud sessions.

Transferability is a term associated with the *external validity* of the results. It explains the extent to which the findings can be applied to other contexts. To achieve transferability, the chemistry classroom context and the characteristics of focal students were described. In addition, quotations from the interviews and think alouds, and sample sections from the journals were given. Furthermore, to reflect the diversity among students, maximum variation sampling method was used.

The *dependability* and *confirmability* of a qualitative research is associated with *reliability* issues in quantitative studies. These issues were explained more detailed while explaining qualitative data collection. In this study, dependability and confirmability were checked in three ways. First, the role of the researcher was described in detail. Second, how the data was collected and the data analysis processes were described in depth. Third, data collected from one focal student (interview, think aloud, and journal) and two class hour obeservations from both groups were coded by an expert from the field of chemistry education to determine the inter-rater reliability.

3.2 Implementation of Treatments

Guided-inquiry approach was employed in the experimental group while *traditional teaching method* that could be called as *lecturing method* was used in the control group. Implementation of treatment could be summarized mainly under three sections; *introducing concepts*, *laboratory practice*, and *solving algorithmic* questions. Each practice will be explained in detail for experimental and control groups separately. During the intervention both groups followed the 11th grade national chemistry curriculum. The chemistry course was three 40-minute sessions each week. The intervention process took totally twelve weeks, 36 class hours for experimental group and 34 class hours for control group (For the experimental group 17 class hours in classroom, 17 class hour in chemistry laboratory, and two class hours for simulation. For the control group 28 class hours in classroom, five class hour in chemistry laboratory, and a class hour for simulation). See Table 3.15 for the summary and comparison of what was done in each group week by week. Implementation of each treatment would be explained more detailed in the following section.

Table 3.15 Summary of implementation process in the experimental (SRI) and control group (TDCI)

Time	Experimental group (SRI)	Control group (TDCI)
Before treatment	*** Administration of Pre-tests**	*** Administration of Pre-tests**
Before treatment	*** Solving algorithmic questions related with previous unit** *** Pre-interviews with focal students**	*** Solving algorithmic questions related with previous unit** *** Pre-interviews with focal students**
Week 1	* Introducing laboratory environment (equipment, chemicals), Laboratory Safety (Laboratory; 1 class hour) * Formation of groups, discussion of effective group work (Laboratory; 1 class hour) *** Introduction to Solubility Equilibrium Unit: Discussion on "How much do I know? How much do I remember?"** (Classroom; 1 class hour)	* Introducing laboratory environment (equipment, chemicals), Laboratory Safety (Laboratory; 1 class hour) * Introduction to Solubility Equilibrium Unit, Distribution of lecture notes to students, Giving basic definitions (Classroom; Lecturing; 1 class hour) * Definition of Solubility and Factors effecting solubility; The teacher did the experiment (demonstration) and explained what was observed (Laboratory; Lecturing; 1 class hour)
Week 2	* General discussion on of how to work in the laboratory and introducing journals (Laboratory; 1 class hour) *** Journal 1: Solutions** (Laboratory; 2 class hours) Solutions, types of solutions, and solubility concepts were covered; Introduction to Solubility Equilibrium	* Introduction to Solubility Equilibrium (Ksp concept); Writing ionization equations for different salts; Writing Ksp expressions of given salts (Classroom; Lecturing; 1 class hour) * Solving algorithmic questions related with solubility and Ksp calculations; Calculate Ksp from the solubility and vice versa (Classroom; Lecturing; 2 class hours) (Ions were listed in a handout to help students)

Table 3.15 (continued)

Time	**Experimental group (SRI)**	**Control group (TDCI)**
	Semester Break (Two weeks)	
Week 3	***** Writing ionization equations; (Ions were listed in a handout to help students); Ionization Equation (complete the table); Introduction of Ksp from Kd; Writing Ksp expressions of given salts; Solve algorithmic questions (discuss on the case and results) (Classroom; Inquiry Approach; 1 class hour) *** Journal 2: The Effect of Temperature on Solubility** Calculate the solubility of the salt; the effect of heat on solubility; discussion of the solubility-temperature graph; Calculate solubility than calculate Kc, write ionization equation (discuss on the case and results) Other factors effecting solubility were summarized by teacher (Laboratory; 2 class hours)	***** Common ion effect; factors effecting solubility was mentioned; Algorithmic questions related with calculation of Ksp in pure water and in a solution (Classroom; Lecturing; 1 class hour) ***** Whether participation would occur or not Calculate the ion product (Qsp) and compare it with Ksp (Classroom; Lecturing; 1 class hour) ***** Calculation of limit concentrations of ions in order to or not to precipitate; calculation of ion concentration after precipitation (Classroom; Lecturing; 1 class hour)

Table 3.15 (continued)

Time	Experimental group (SRI)	Control group (TDCI)
	Semester Break (Two weeks)	
Week 4	*** Journal 3: Let's Examine Solubility at Microlevel** Particulate nature of matter Demonstration on the computer and whole class discussion Saturated versus unsaturated solutions; Solubility; soluble versus slightly salts; Ksp concepts were covered (Computer Laboratory; Inquiry Approach; 2 class hours) ***** Solving algorithmic questions related with solubility and Ksp calculations; Calculate Ksp from the solubility and vice versa (discuss on the case and results) (Classroom; Inquiry Approach; 1 class hour)	***** Demonstration on the computer Saturated versus unsaturated solutions; Solubility; soluble versus slightly salts; Ksp concepts were covered (Computer Laboratory; 1 class hour) ***** Repetition of types of algorithmic questions solved until that day and solving extra algorithmic question related with each type (Classroom; Lecturing; 2 class hours)

Table 3.15 (continued)

Time	**Experimental group (SRI)**	**Control group (TDCI)**
Week 5	*** Journal 4: Does it precipitate?** Whether a precipitate occur when two solutions mixed; Discussions on how to write the total ionic reaction; which chemical precipitate; solubility equilibrium (Laboratory; 2 class hours) ***** Solving algorithmic questions related with solubility and Ksp calculations; Calculate Ksp from the solubility and vice versa; Minimum amount of ions required to precipitate; How to use solubility difference of different salts as a separation method (Classroom; Inquiry Approach; 1 class hour)	***** Solving extra algorithmic questions from different sources (Classroom; Lecturing; 2 class hours) ***** Solve algorithmic questions from previous university entrance examination questions (Classroom; Lecturing; 1 class hour)
Week 6	*** Concluding Activity for Solubility Equilibrium Unit: Discussion on "How much do I remember?** (Classroom; 1 class hour) ***** General discussion of the journals (Classroom; 1 class hour) *** Introduction to Acids and Bases Unit: Discussion on "How much do I know? How much do I remember?"** (Classroom; 1 class hour)	***** Experiment from the textbook p59/60, Precipitation (Laboratory; Cookbook type; 1 class hour) ***** Selective precipitation as separation method; solving algorithmic questions (Classroom; Lecturing; 1 class hour) ***** Acid-base definitions; Distribution of lecture notes (Classroom; Lecturing; 1 class hour)
Week 7 and Week 8	*** Think Aloud Protocol on Solubility Equilibrium Unit**	*** Think Aloud Protocol on Solubility Equilibrium Unit**

Table 3.15 (continued)

Time	Experimental group (SRI)	Control group (TDCI)
Week 7	*** Journal 5: Acid or base?** Safety warning (Laboratory; 2 class hours) ***** Summary of acid-base definitions-related with laboratory experiments; Historical development of definitions (Classroom; Inquiry Approach; 1 class hour)	***** Metal oxides and their properties; Metals and their reactions with acids and bases (Classroom; Lecturing; 1 class hour) ***** Repeat the previous topic; definitions and properties of acids and bases (Classroom; Lecturing; 1 class hour) ***** Ionization of water; Solving algorithmic questions related with dissociation of pure water and the equilibrium constant expression (Kw), definition of Kw pH and pOH concept; pH scale (Classroom; Lecturing; 1 class hour)
Week 8	*** Journal 6: How much acidic or how much basic?** Ionization of water, equilibrium Kw, Le Chatelier's principle, pH scale was defined connecting with what they did in the laboratory; Strong and weak acids and bases (Laboratory; 2 class hours) ***** pH scale was discussed connecting with what they did in the laboratory; Different indicators were discussed and their color changes were pictured; Exercise papers were distributed, Solving algorithmic questions related with dissociation of pure water and the equilibrium constant expression (Kw), pH and pOH concepts and pH scale (Classroom; Inquiry Approach; 1 class hour)	Solving algorithmic questions related with dissociation of pure water and the equilibrium constant expression (Kw), pH and pOH concepts and pH scale (Classroom; Lecturing; 1 class hour) Metals reactions with acids and bases(Classroom; Lecturing; 1 class hour) Laboratory: Litmus paper and universal pH paper, Acid or base? What is the pH value? (Laboratory; Cookbook type; 1 class hour)

Table 3.15 (continued)

Time	Experimental group (SRI)	Control group (TDCI)
Week 9	***** Solving algorithmic questions covering previous topics (Classroom; Inquiry Approach; 1 class hour) ***** General properties of acids and bases, metal and nonmetallic oxides and their reactions with acids and bases; Metals and their reactions with acids and bases; Followed lecture notes but not distributed to students. (Classroom; Lecturing; 1 class hour) *** Journal 7: Acid-Base Reactions with Metals** Initially students shared their predictions, than for safety the teacher did it as demonstration; students wrote down their observations and whole class discussion of the results (Laboratory; Inquiry Approach; 1 class hour)	***** Solving algorithmic questions covering previous topics (Classroom; Lecturing;1 class hour) ***** Metals reactions with acids and bases For safety the teacher did it as demonstration; First she summarized the topic than did the experiment and explained the outcomes (Laboratory; Cookbook type; 1 class hour) ***** Definitions of strong/weak acids/bases; ionization rate; Introduction to equilibrium constant expression for an acid (Ka) or a base (Kb);and solving algorithmic questions related with these concepts (Classroom; Lecturing;1 class hour)

Table 3.15 (continued)

Time	Experimental group (SRI)	Control group (TDCI)
Week 10	***** Solving algorithmic questions covering metals reactions with acids and bases and properties of acids and bases (Classroom; Inquiry Approach; 1 class hour) ***** Lecturing Ionization percentage Ka and Kb Connects to students experiences in the lab(Classroom; Inquiry Approach; 1 class hour ***** Ionization percentage Ka and Kb Algorithmic questions (Classroom; Inquiry Approach; 1 class hour	***** Summary of Strong/weak acids/bases and ionization rate; Solving algorithmic questions related with them (Classroom; Lecturing;1 class hour) ***** Definition of neutralization reaction and solving algorithmic questions (Classroom; Lecturing;1 class hour) ***** Solve algorithmic questions that students could not solve at home (Classroom; Lecturing;1 class hour)

Tabletop 3.15 (continued)

Time	**Experimental group (SRI)**	**Control group (TDCI)**
Week 11	***** Ionization percentage Ka and Kb; Algorithmic questions (Classroom; Inquiry Approach; 1 class hour) ***** Neutralization reaction; Titration as an analytic technique (Classroom; Inquiry Approach; 1 class hour) ***** Teacher demonstration; Solving algorithmic questions (Labratory; 1 class hour)	***** Teacher demonstration (Laboratory; 1 class hour) ***** Solving algorithmic questions related with titration (Classroom; Lecturing; 2 class hours)
Week 12	*** Journal 8: Acid-Base Titration** Solving algorithmic questions related with titration (Labratory; 2 class hours) ***** National Holiday (1 class hour) **Concluding Activity for Acids and Bases Unit: Discussion on "How much do I remember?** (Classroom; 1 class hour; one class hour was took from another teacher)	***** Repeat topics Solve questions about the whole acids and bases unit (Classroom; Lecturing;1 class hour) ***** National Holiday (2 class hours)
After treatment	*** Administration of Posttests**	*** Administration of Posttests**
After treatment	*** Think Aloud Protocol of Acids and Bases Unit**	*** Think Aloud Protocol of Acids and Bases Unit**

3.2.1 Treatment in the Control Group

The teacher continued her regular teaching namely *lecturing method* in the control group. However, in order to minimize some threats to internal validity, some arrangements were done consistent with the teacher's *traditional approach*. The teacher's common practice could be summarized as giving the concepts and formulas to students by distributing lecture notes and solving as many multiple choice questions as possible. Particularly, she aimed at preparing her students for university entrance examination. Therefore, it can be stated that she was promoting performance-approach goal orientations, i.e. focusing on getting high scores on the University Entrance Examination.

The teacher used *lecture notes* which she had prepared before the class using different resources to *introduce the topic*. These notes included definition of concepts, basic principles, and some formulas which were needed to solve algorithmic questions. After distrubuting the notes to the students at the beginning of each unit, she explained the concepts going through these notes and the students listened to their teacher at their desks without doing anything. When they did not understand any point, the teacher reviewed one more time. She was dominantly using lecturing method and during lecturing she was using strategies such as reviewing the topic whenever students asked, emphasizing key features of the topic, giving real-life examples, making connections between new and prior concepts, and highlighting common errors students did.

After introducing new concepts, she started *solving multiple choice questions* in order to reinforce the basic principles and calculations. She believed that, if she solved more questions, the students would encounter with more different types of questions and get better prepared for the university entrance examination. The teacher and students categorized the questions basicly in two categories: *algorithmic questions* requiring mathematical calculations versus *conceptual questions* that did not require any calculations but asking applications of concepts or principles. Initilally, the teacher gave the questions to the students (Sometimes wrote the examples onto the board and other times distributed photocopies). She did not give any time to students to think on the questions and directly explained how to solve them. She initially emphasized key words given in the questions and then gave some tricks to students to solve the questions as quickly as possible. Meanwhile, the students followed her: at the initial examples they were doing nothing but just following the teacher, soon after they were copiying what the teacher wrote on board. Whenever they were confused, the teacher repeated the solution one more time. While solving questions (mostly algorithmic questions), the teacher gave tips and formulas to solve the questions, increased the difficulty level of questions throughout the unit, emphasized test techniques to solve the questions faster rather than conceptually explaining the cases. By this way, the teacher promoted memorization of solutions of different type of questions and gave messages for the importance of performance goals. If time was left in the class, the teacher solved the questions that the students could not solve at home. A simulation activity was designed for the experiemtal group to investigate the introduced concepts at microlevel. Since it was a novel activity for students, an hour demonstration activity using the simulation was also planned for the control group for the purpose of minimizing *attitudes of subjects threat* to internal validity. Again, for the control group lecturing method was employed in line with the teacher's traditional teaching approach. She directly explained the demonstrated solutions and did not give time to students to think on the examples.

In order to control novelty effect and attitudes of subjects as a threat to internal validity of the study, some *laboratory activities* were conducted in the control group. While planning the activities in the control group, thre researcher asked the teacher if she had used the laboratory regularly, how it would be. In line with the teacher's descriptions, five laboratory activities were prepared for the control group. It was arranged that both groups were entered to the laboratory at the same week. Initially, the teacher introduced laboratory environment and safety rules. The first activity was related to solutions concept parallel to Journal 1. The teacher prepared some solutions, performed the experiment in front of the students and explained what they observed to the students. Meanwhile, the students followed her. In the second activity, an experiment related to precipitation from the textbook (see Appendix I), which was parallel to Journal 4, was carried out. This experiment could be called cookbook type; the steps were clearly defined and a table to fill the results was given in the students' textbook. The students worked in groups. They formed the groups themselves; in other words, they worked with their close friends. The third activity was about types of acids and bases parallel to Journal 5 and 6. The teacher gave students some acid and base solutions and asked them to measure solutions' acidic or basic chracteristics using lithmus paper and universal pH paper. The students worked in groups again; they formed their groups at the class time. The fourth activity was on the reaction of acids and bases with a metal (parallel to Journal 7) while the last activity was related to titration topic (parallel to Journal 8). In these last two activities, the teacher used demonstration method simply without asking any questions to the students. In general, *during the laboratory activities*, the teacher used mostly *demonstration method*; the activities were precisely structured and the teacher was active all the time. Additionally, if required, the students formed their own groups based on their friendship. They gave brief reports which did not discuss results at the end of each activity. See Appendix J for sample group reports for the control group.

3.2.2 Treatment in the Experimental Group

The experimental group was instructed with the SRI based on guided inquiry approach. There were three chemistry classes a week, mostly two class hours were dedicated to laboratory activities (guided by journals) and one class hour was used as summary of laboratory experiences and solving extra questions related to the topic. In this section, initially, the journals as the main instructional material for the experimental group are explained. Next, implementation of treatment in the experimental group in terms of introducing concepts, laboratory practice, and solving algorithmic questions parallel to the treatment in the control group is given. Finally, the implementation of journals in the experimental group is summarized step by step.

In the present study, journals designed to help students monitor their scientific inquiry under teacher's guidance were the most important part of the instruction in the experimental group. They were developed based on Zimmerman's three cyclic phases (forethought, performance, and self-reflection phases). How the journals cover these three SRL phases is given in Appendix G. In the *forethought phase*, each journal started with an introductory section: students' prior knowledge was prompted here and new concepts were introduced related with the task. Next, the purpose of that task was stated explicitly. Additionally, the equipment and chemicals that students could use were listed. Students were also informed about the time given for that task. Then, they were asked to plan what they would do to accomplish the task, write down their predictions, and prepare a table to report the collected data. In the *performance phase*, after getting feedback from the teacher about their study plan, students started performing the task and wrote down their observations into the table that they had prepared in the forethought phase. In the *self-reflection phase*, students were asked to compare their predictions with their observations to activate their metacognitive thinking. Likewise, they were stated the concepts they learnt and the inferences they came up with at the end of the task. To help students get necessary environmental help or teacher support, they also reported the difficulties they experienced. This way, students were encouraged to see difficulties/errors as a part of learning process and teacher guidance were provided to help students overcome these obstacles. At the end of each journal, students were given open-ended conceptual questions in order to assess whether they could apply what they had already observed/learnt in the laboratory into a new conditions. Some journals included extra information for the students who were interested. Finally, the students were asked to evaluate each journal to provide feedback to the researcher.

Eight journals covering national curricular objectives on Solubility Equilibrium and Acids and Bases Units were designed by the researcher. Initial four journals included tasks related to the Solubility Equilibrium Unit and the remaining four journals explored concepts associated with the Acids and Bases Unit. An important concern in experimental studies was whether extra time was given to the experimental group or whether students at the experimental group did extra work at home. To control this, journals were prepared to be completed at two class sessions. Additionally, no assignements were given the students. The purpose and content of each journal are described below:

Journal 1: Solutions

Based on pre-interviews with students and face to face communication with the teacher, it was found that almost all of the students had no or very limited laboratory experience. Therefore, Journal 1 was designed to help students get some kind of laboratory experience before the actual intervention started and get familiar with the laboratory equipment and procedures. It was kept simple and covered solutions concept given at ninth grade. The focus was helping students get accustomed to the laboratory environment, experience group work, and have familiarity with journals. The definition of the solution concept and examples from daily life were given and then students were asked to identify whether the given mixtures were solutions or not. They were also encouraged to prepare new mixtures with given materials and identify them.

Journal 2: The Effect of Temperature on Solubility

The solubility concept and the effect of temperature on solubility were studied in this task. Different types of salts (potassium chlorate, sodium nitrate, calcium chloride etc.) were given to students and they were asked to design an experiment to test the maximum amount of solid that water can solve. Later on, the definition of solubility concept was given and they were asked to calculate the solubility of the salt they had chosen at the previous step. Then, students designed an experiment to test how the solubility of that salt changed with temperature. They were asked to define the variables they picked up, how they would measure them, and which hypothesis would be tested. If they completed these steps before the class time, they could continue working on a different salt.

Journal 3: Let's Examine Solubility at Microlevel

After studying solutions and solubility concepts in the laboratory at macrolevel, in this task students examined the same concepts at microlevel. The "Salts and Solubility" simulation designed by PhET and translated into Turkish by the researcher was used (see Appendix M for the approval letter for the use of "Salt and Solubility" simulation). Solubility, solubility product constant (Ksp), the concepts of high solubility versus low solubility were covered. A sample view from the simulation is given in Figure 3.2.

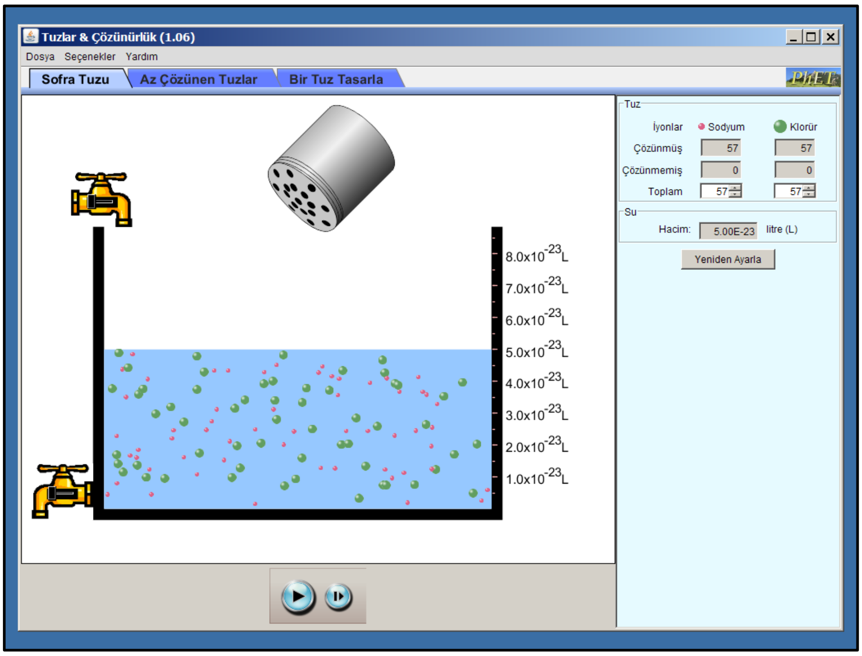


Figure 3.2 A sample view from the "Salts and Solubility" simulation

Journal 4: Does it precipitate?

This task was developed to investigate whether a precipitate occurs when two salt solutions were mixed together. Different solutions were prepared by the teacher and samples were distributed to groups. They were asked to design an experiment to test the research question. Students were encouraged to write down their predictions based on the table given at the end of the journal and Ksp values of the salts given in their textbooks.

Journal 5: Acid or Base?

In this task, students identified whether a substance had acidic or basic property (adapted from Koseoglu & Tasdelen, 2008). The task included three steps. First, the teacher prepared a few commonly used acid (hydrochloric acid and acetic acid) and base (sodium hydroxide and ammonia) solutions and asked students to identify whether these solutions were acid or bas using some common acid-base indicators (blue litmus paper, red litmus paper, methyl orange, and phenolphthalein). In this step students could identify the colors of different indicators. At the second step, they could work with one of these indicators to test whether the solutions they usually encountered in their kitchens or bathrooms possessed acidic or basic property. At the third step, they were given a purple liquid (purple cabbage acid-base indicator) and asked to identify whether this purple liquid could be used as an acid-base indicator.

Journal 6: How much acidic or how much basic?

In the previous activity students had identified acidic and basic property (adapted from Koseoglu & Tasdelen, 2008). In this activity they tested the strength of the acid and base solutions they had studied earlier in the previous journal (see Appendix G for the journal designed for this activity). The acid dissociation constant (Ka), the base dissociation constant (Kb), the pH and pOH concepts were also discussed on different examples. The difference between the strength and the concentration of any acid or base solutions were argued.

Journal 7: Acid-Base Reactions with Metals

In this task, students explored whether any reaction occurred between different metals [active (magnesium), semi-precious (copper), and amphoteric (aluminum)] and three acid/base solutions (hydrochloric acid, sulfuric acid, and sodium hydroxide). Because of safety reasons this activity was done as a demonstration. First, students made their predictions, wrote the equations for the possible reactions, and reported whether they expected any gas product or not. Later on, the teacher added small pieces of metals into different solutions and the students wrote down their observations and compared them with their predictions. The teacher facilitated the discussion to help students make infrence based on their observations. It could be said that, the teacher was hands-on active and the students were minds-on active.

Journal 8: Acid-Base Titration

Titration is one of the most frequently used methods in the chemistry laboratories. Usually students have difficulties in understanding related acid-base concepts and employing this technique. In this activity, initially the teacher employed the technique as demonstration, and discussed related concepts such as acid and base solutions, the strength of an acid or a base solution, the use of an indicator, naturalization reaction, the equivalence point, pH graph, and interpret pH change during titration process. Students were given a hydrochloric acid solution with unknown concentration and asked to measure its concentration using 1M sodium hydroxide solution. They were also supposed to graph the results. In the second activity, students identified the concentration of sodium hydroxide solution with the use of 1M hydrochloric acid solution. By this way students practiced both titration examples: titration of a strong acid with a strong base and titration of a strong base with a strong acid.

Implementation of treatment can be explained under three sections; introducing concepts, laboratory practice, and solving algorithmic questions. Treatment in the experimental group was mostly based on *laboratory activities* led by the journals. Each journal included an introductory section in which *new concepts were introduced* related with the task or students' prior knowledge was prompted. As a result, while *introducing the concepts* in the experimental group, the teacher mostly discussed the key features of the topic, gave real life examples, and emphasized the errors that students commonly did. Meanwhile, the students felt more comfortable to ask unclear points compared to the students in the control group.

The treatment in the experimental group mostly included *laboratory practice* based on guided-inquiry approach. Initially the activities were more structured inquiry, by the time the students got more laboratory experience, the activities became more open inquiry and the students were more active. As mentioned earlier, *journals* were designed to help students monitor their learning. Based on the related literature, the SRI tasks (journals) were developed considering the following principles.

In order to *motivate* students to initiate a learning activity and sustain effort even in case of obstacles, the tasks should be challenging at the same time attainable for the students. In the activities, learning the material and developing new skills (mastery goal orientation) were emphasized. When students believed in their own capability, they would choose challenging tasks, persist longer, spend more effort on the task, and try new strategies (Bandura, 1997).

The instruction in the experimental group (SRI) was based on *guided-inquiry approach* in which students planned and conducted the tasks in line with group discussions, reported their observations as they planned and made inferences based on their observations. Unfortunately, in Turkey the teachers did not use laboratory environment for the reasons such as highly loaded chemistry curriculum, large classroom sizes, dominance of algorithmic questions, and/or problems in classroom management. Therefore, it was most of the students' first laboratory experience. Among different inquiry techniques, guided inquiry approach was preferred, i.e., the research problem was provided by the teacher. The rest of the inquiry process was monitored by students: the hypothesis to be tested, the procedures to be applied, and the data to be collected were all determined by the students. During the experiments, students made descriptions, explanations, or predictions based on their observations. In addition, they made conclusions and generalizations considering the data they collected and their existing knowledge (Colburn, 2004). To complete the task successfully, students used strategic planning and time management strategies to monitor different resources. By this way, they had control on their own learning process and took the responsibility.

Students *worked in small groups* consisted of four students (only two groups among nine groups contained five students). Students were provided with a guide (see Appendix K) for effective group work revised from Perry et al. (2011). Students were assigned to one of these three group roles: supervisor, technician, and reporter. In the groups who were composed of four members, there were a supervisor, a reporter, and two technicians. In the five membered groups, there were a supervisor, two reporters, and two technicians. Students were suggested to change group roles in each journal. Initially group members selected the supervisor and then the supervisor distributed other group roles. The supervisor was responsible for gathering group members together, assigning group roles, checking whether group members fulfilled their roles, making necessary adjustments for the effective use of time and resources, reading the directions aloud, leading within group discussions, and participation of each group member to the within group discussions. The technicians checked the equipments, prepared the experiment setting as a result of within group discussion, gathered the chemicals and explained the safety rules of the chemicals to the group members, kept the equipment in order on the bench to avoid possible accidents, and cleaned the bench after the task completed with the help of other group members. Finally, the reporter(s) wrote down the group work onto the journals as a result of within group discussions. Students shared their opinions with group members and came up with a decision as a result of small group discussions. They planned and conducted the experiments according to the group's agreement. They gave priority to evidence while discussing the results. Students were given a handout (see Appendix L) to support efficient group discussion which was adapted from Bloom (2006). This handout included suggestions for listening to others' explanations, arguments or debates; and thinking or explaining their own ideas. Students were suggested to respect others' ideas, acknowledge contribution of each group member to the discussions, not to intrupt others' speaking, make clear and understandable statements, evaluate others' ideas in terms of accuracy, rationality or consistency with evidence, compare others ideas with their own, responde to them or enlarge their ideas with a question or a comment, propose alternative explanations, and ask for editional evidence or examples. At the end of each activity whole classroom discussions were done to share within-group experiences with other groups and come up with conclusions.

Students were given *some degree of choice* in classroom activities and assignments as Paris and Paris (2001) suggested for SRIs. For example, groups could design the experiments in their own way, work with various chemicals or household substances, and report results in a different way. In addition, when they finished the task earlier than expected, they could search for answers to the questions they wondered.

In order to improve students' *metacognitive thinking* journals were used to assist them. During the activities, students reflected on what they had already known about a given task, and what and why they were doing at that time (Georghiades, 2004). Journals also provided students a chance to assess effectiveness of their learning process which was essential in SRL (Paris &

Paris, 2001). Small group discussions and whole class discussions were also used to help students think on their learning. See appendix G for a sample journal in the Acids and Bases Unit.

A simulation task on solutions was used in order to help students picture the concepts, which they had studied at macroscobic level during their *laboratory practice*, at microscobic level. The experimental group spent two class hours in working on the *Salts and Solubility* simulation, initially the teacher showed a few demonstrations to explain how the simulation worked. Later on, in line with the journals, for each activity she asked students their predictions, discussed them as a class, than the teacher showed the simulation. Students chose the salts to be worked on. Different salts with different ion charges were examined. Students also asked the teacher additional questions to be investigated.

Solving algorithmic questions was the most important part of the teachers' traditional teaching approach. Students were also appreciating the teachers' effort. Some algorithmic questions were also included in the experimental group. Some of the algorithmic questions used in the control group were also solved in the experimental group. They were used as means of discussing concepts rather than using chemistry as a tool for mathematics. Initially the tasks were performed in the laboratory, and then some questions related with those activities were discussed in the class. By this way the algorithmic questions were connected with students' laboratory experiences. Initially the teacher wrote the question on board and gave some time to students to think on the case and try to solve themselves. After that, the class discussed the case in line with their laboratory experiences, then did required calculations, and argued whether the results were reasonable or not. In conclusion, the algorithmic questions were designed in a way to apply students' laboratory experiences in new context.

Below, the implementation of journals in the experimental group is summarized (see Appendix H for sample lesson plan for Journal 6 “How much acidic or how much basic?”):

1. Each laboratory session guided by a journal started with a whole class discussion in order to identify students’ prior knowledge and encourage students to engage students to the task.
2. Next the teacher distributed the journals to the students.
3. Time was given to students to discuss what they would do to accomplish the given task within their groups. They were also encouraged to write their plans down to their journals. Meanwhile the teacher checked students’ plans in terms of accuracy and safety issues. She asked open-ended questions to students to guide them when they needed.
4. After getting approval from the teacher, the students made a plan for data recording and write down their predictions.
5. Next, the teacher distributed the chemicals to the technicians of the groups. Note that the laboratory equipment were already on students’ benches in order not to loose time.
6. Then students started the experiment and the teacher walked around the class, observed groups, and guided them by asking open-ended questions whenever necessary.
7. The reporter of the group wrote down their observations to the journals as they planned.
8. When the students completed the task, the teacher gave time to students to make inferences based on their observations,discuss the unexpected outcomes if they had any, assess what they had learnt, talk over the difficulties they had experienced during activity, and discuss the tasks given at the end of each journal for the purpose of evaluation. Meanwhile, students assessed the activity individually.

9. Later on, in order to share experiences of different groups and discuss the concepts and principles based on groups' observations, whole class discussions were conducted.
10. If groups finished the task earlier than the other groups or the given time, they could continue working with different materials.

3.2.3 Treatment Fidelity

When testing a cause-effect relationship, treatment fidelity is an important concern in order to claim the treatment caused the change. To asses it, it should be reported whether SRI was employed as it was supposed/planned to be. The following strategies were followed in order to enhance treatment fidelity:

1. The journals were prepared by the reaearcher in a way to help students follow all three phases of SRL. Fundamental steps of the instruction were derived from the related theory.
2. The journals were discussed with the experts from the field and revised in view of their opinions.
3. A guide was prepared for the teacher about the new teaching method (SRI based on guided inquiry approach). The lesson plans were distributed to the teacher two weeks earlier than the implementation and weekly meetings were done to discuss the journals face to face. She was also informed about the basic differences between the two teaching methods repeatedly.
4. After each class, the implementation was reviewed with the teacher, she assessed the difficulties she experienced and the necessary modifications for future classes were done.
5. While making some adaptations like including question solving section to the experimental group, the principles of quided inquiry method was employed.
6. An observation checklist was prepared to assess whether the treatments (SRI in the experimental group and TDCI in the control group) were

employed as they were supposed to be in both classes as an evidence for treatment fidelity. It included five sections: introducing the topic, solving algorithmic questions, the nature of laboratory practice, the features of the laboratory tasks, and motivational aspects (Ames, 1992; Blumenfeld, 1992; Meyer & Turner, 2002; Paris & Paris, 2001; Perry, 1998; Pintrich & Schunk, 2002; Yetkin, 2006). All chemistry classes of both groups were observed by the researcher throughout the study capturing approximately four months time period. The researcher rated the checklist during each class hour for both groups. Two class hours from each group was also observed and coded by an expert from the chemistry education (the inter-rater reliability was found to be .78). Frequency of classroom practices for experimental and control groups are given Table 3.16.

7. In order to encourage students behave naturally, the researcher started observing both classrooms in the previous unit. As a result, when the intervention started both goups were familiar with the researcher and the classroom context became more natural.

Table 3.16 Frequency of classroom practices for experimental and control groups

	Experimental Group			Control Group		
	# of Obs.	Yes	%	# of Obs.	Yes	%
Introducing Topic						
1. The teacher gave/presented the concepts.	13	5	38.5	14	10	71.4
2. The teacher reviewed previous concepts.	13	5	38.5	14	8	57.1
3. The teacher clarified/reviewed terms, procedures, and problem statements.	13	7	53.8	14	13	92.9
4. The teacher gave feedback to students.	13	4	30.8	14	1	7.1
5. The teacher emphasized key features.	13	10	76.9	14	12	85.71
6. The teacher gave real life examples.	13	10	76.9	14	10	71.4
7. The teacher compared concepts.	13	5	38.5	14	11	78.6
8. The teacher connected new concepts and prior concepts.	13	5	38.5	14	11	78.6
9. The teacher outlined the material.	13	7	53.8	14	7	50.0
10. The teacher gave the formula.	13	2	15.4	14	7	50.0
11. The teacher asked open-ended questions to students about the concepts.	13	6	46.2	14	3	21.4
12. The teacher emphasized the errors that students did commonly.	13	8	61.5	14	9	64.3
13. The teacher made an analogy.	13	1	7.7	14	1	7.1
14. The teacher explained the graphs.	13	2	15.4	14	1	7.1

Table 3.16 (continued)

	Experimental Group			Control Group		
	# of Obs.	Yes	%	# of Obs.	Yes	%
Introducing Topic						
15. The students explained/discussed the graphs.	13	2	15.4	14	1	7.1
16. The teacher checked/discussed assignments.	13	0	0.0	14	0	0.0
17. The students copied the board.	13	3	23.1	14	13	92.9
18. The students asked unclear points.	13	10	76.9	14	6	42.9
Solving Algorithmic Problems						
1. The teacher directly gave/explained the solution of the question.	10	2	20.0	23	23	100
2. The teacher gave time to students to think on the questions.	10	10	100	23	0	0.0
3. The teacher related the algorithmic problem to the students' laboratory experience.	10	10	100	23	0	0.0
4. The teacher explained the problem case.	10	4	40.0	23	23	100
5. The teacher asked additional conceptual questions about the algorithmic problems.	10	10	100	23	0	0.0
6. The students evaluated whether the results were reasonable.	10	9	90.0	23	0	0.0

Table 3.16 (continued)

	Experimental Group			Control Group		
	# of Obs.	Yes	%	# of Obs.	Yes	%
Chemistry Laboratory Practice						
1. The students planned the activity.	21	15	71.4	6	0	0.0
2. The students got support from the teacher.	21	21	100	6	3	50.0
3. The students shared their ideas with group/class.	21	21	100	6	3	50.0
4. The students worked in groups.	21	16	76.2	6	2	33.3
5. The students evaluated their own work.	21	13	61.9	6	0	0.0
6. Students planned how to report data.	21	11	52.4	6	0	0.0
7. Students monitored the process.	21	12	57.1	6	0	0.0
8. Students wrote their predictions.	21	9	42.9	6	0	0.0
9. Students reported the results in an organized way.	21	11	52.4	6	0	0.0
Features of the Laboratory Task						
1. The students had some degree of choice on the learning material.	21	14	66.7	6	2	33.3
2. The students chose what to do during the experiment.	21	9	42.9	6	0	0.0
3. The steps of the experiment were given to students.	21	6	28.6	6	6	100
4. The tasks were authentic and challenging for students.	21	17	81.0	6	6	100

Table 3.16 (continued)

	Experimental Group			Control Group		
	# of Obs.	Yes	%	# of Obs.	Yes	%
Motivational Aspects						
1. The teacher stressed mastery goal (learning new strategies, improving learning as a focus etc.)	36	24	66.7	34	4	11.8
2. The teacher stressed performance goal (grades, rewards etc.)	36	9	28	34	31	91.2
3. The teacher encouraged students that they were capable of doing the job.	36	19	52.8	34	3	8.8
4. The students modelled each other (peer modelling).	36	11	30.6	34	0	0.0
5. The teacher encouraged students to share their ideas.	36	21	58.3	34	4	11.8

3.3 Ethical Concerns

This study was conducted in a regular/natural high school setting; first, necessary permissions were taken from the University Ethical Board (Research Review Board of the METU) and the Ministry of National Education (MoNE) (See Appendix N). The permission process took approximately three months. Second, the school administration was informed about the purpose of the study and the research process, and their permission was asked for. Third, the cooperative teacher was enlightened about the research process and her role throughout the study. She volunteerly agreed to participate in the study. Forth, since the age of the sample was below 18, the consent forms were sent to students' parents, they were informed about the research process and their permission was asked. Finally, students were asked for permission and voluunter participation. They were informed that they could leave the study whenever they wanted. All students were agreed to participate and all involved untill the end of the study.

After getting permission from all stakeholders, two intact classes of the same chemistry teacher were studied. Although necessary permissions were taken from the University Ethical Board and the MoNE, the teacher did not agree to videotype her classroom, so the class sessions could not be videotaped. Fortunately, she agreed to use the audio recorder, and all stakeholders were informed about the use of an audiotape during the permission process. The participants were guaranteed that the data would be kept confidential. Students' real names were not used rather the data from different instruments and different times were matched using their ID numbers and reported using pseudonym. Additionally, both groups took safety guidance for their laboratory work before entering the laboratory.

3.4 Assumptions, Limitations and Delimitations

The assumptions of this present study are stated below:

1. Students completed the instruments independently, sincerely and accurately.
2. The teacher and the researcher were not biased.
3. Students from experimental and control group did not work together troughout the study.
4. The SEABT, GOS, HCSS, and CMSS measured related constructs validly and reliably based on the results of pilot studies.

The limitations and delimitations of the study are stated below:

1. The study was limited to one regular public high school in Ankara.
2. The study was limited to 11th grade students from "Science and Mathematics" major.
3. The study was limited to the "Solubility Equilibrium" and "Acids and Bases" units lasting for 12-week period.
4. The self-report instruments were used for data collection which was based on students' memories of their learning practice rather than what they actually did.
5. Students' achievement was measured using multiple-choice test. However, this measurement technique cannot describe students' reasoning behind their answers (i.e., students can give a correct response with a wrong scientific reasoning or they can give a wrong response even though they have correct reasoning).
6. The classrooms could not be videotaped. As a result, the group work could not be observed in detail.
7. The variables were delimited to the 11 variables choosen by the researcher and commonly studied in the SRL literature.
8. The theoretical model was delimited to Bandura's SCT.
9. The SRL Model was delimited Zimmerman's Cyclic Model (2000).

CHAPTER 4

RESULTS

This chapter includes three main sections: results of quantitative analyses, results of qualitative analyses, and summary of results. Results of quantitative analyses are presented under three subtitles: preliminary analysis, descriptive statistics, and inferential statistics. The findings from qualitative analyses are given separately for two cases: self-regulatory practice in the experimental group and self-regulatory practice in the control group. To explain self-regulatory practice in the experimental group, the analyses of interviews, journals, and think aloud protocols are presented for four students in the experimental group as typical examples of their cases. And then, analyses of interviews and think aloud protocols are given for four students in the control group as representative instances of self-regulatory practice in the control group. Finally, the findings reached through different sources are summarized.

4.1 Results of Quantitative Analyses

4.1.1 Preliminary Analysis

To begin with, the ratio of *missing data* was calculated. When entire pre-test items were examined, the missing data were distributed to different items in different ratios and scattered through different cases. The highest amount of missing data was 10 out of 78 students which made up 12.8% of the responses and belonged to a pre-test item. Deleting the cases containing missing responses would affect sample size seriously. Tabackhnick and Fidell (2007) underline that “The pattern of missing data is more important than the amount missing” (p.62). According to their suggestion, *the Little's MCAR test* was run for all pre-test items to test whether missing data were random or followed a pattern. Non-significant result for the Little's MCAR test (χ^2 (50) = 61.53, p > .05) indicated that the missing data were random. Since the missing responses did not point to any pattern, *the mean replacement procedure* was safely employed to deal with the missing data. The missing values on the experimental group data were replaced with the mean values of each item in the experimental group. Likewise, the missing values on the control group were replaced with the means of each item in the control group. Fortunately, the students completed all post-test measurements.

Next, the data were checked in terms of univariate and multivariate outliers. Since both *univariate and multivariate outliers* affect the results considerably, they should be detected carefully (Stevens, 2009). Any extreme values should be cleaned from the data file or their influence should be decreased. In a normal distribution, 99.7% of the scores are distributed between ±3 standard deviations of the mean. To check *univariate outliers*, *standard scores (z-scores)* for each DV were calculated and the z-scores below (-3) and above (+3) were accepted as outliers. Only a few scores slightly out of this range were detected. Again there were a few cases out of ±4 standard deviation range. In line with Tabackhnick and Fidell (2007)'s suggestion, in order to minimize the influence of an outlier, the outlying case can be one standart deviation unit below or above the closest boundary score. When the data were checked once more, there was not such a condition. Therefore, all cases were kept in the data file.

Multivariate outliers are also important in multivariate statistics. *The Mahalanobis distance value* was calculated to test if any multivariate outliers existed. The critical value for six DVs is 22.46 and for five DVs is 20.52 (Tabackhnick & Fidell, 2007). For the six motivational variables used in the first analysis, the maximum value for the Mahalanobis distance was 20.43; and for the second analysis (for the five cognitive variables), it was 26.65. When the extreme values were checked, only one case from the control group was above the critical value. In order to detect whether that *multivariate outlier was influential or not, Cook's distance* was calculated. Since it was found to be below 1.00, that case was not influential, and as a result all cases were kept in the data.

4.1.2 Descriptive Statistics

Means and *standard deviations* for all DVs and the *correlations* among them are reported as descriptive statistics. Higher mean values indicated that students set that goal type more often, felt more confident in that domain (cognitive skills or laboratory applications), used those cognitive strategies more frequently, and had higher achievement. Additionally, higher correlations indicated that students using one self-regulatory skill also used the other one equally. On the other hand, low correlations showed that any two skills were employed independently. The size of correlation coefficients are assessed in line with the following criteria: ±.00 – ±.30 little if any correlation, ± .30 – ±.50 low positive (negative) correlation; ±.50 – ±.70 moderate positive (negative) correlation; ±.70 – ±.90 high positive (negative) correlation, and ±.90 – ±1.00 very high positive (negative) correlation (Hinkle, Wiersma & Jurs,1998).

The *means* and *standard deviations* of all DVs measured at Time I (pre-test) and Time II (post-test) are summarized in Table 4.1 separately for experimental and control groups. All of the mean values for goal constructs were found to be above mid-point before and after the treatment. In addition, the students in both groups tended to set approach type goals more often and avoidance type goals less often at both testing times. For self-efficacy constructs, only the mean of SCL for experimental group before the treatment was below the mid-point. The means of other measurements were above the mid-point. The means of all cognitive strategies were above the mid-point for both testing periods and both groups. Moreover, for both test administrations, the groups used all cognitive strategies almost at equal degree; the mean values were altered between 4.93

and 5.45. All students' achievement level before the treatment was very below the mid-point. On the other hand, the experimental group had a mean around mid-point after treatment, while the control group was slightly below the midpoint.

Table 4.1 Means and standard deviations for dependent variables

			Experimental Group				Control Group			
		Mid-	Time I		Time II		Time I		Time II	
Subscale	Range	point	M	SD	M	SD	M	SD	M	SD
Performance-approach	1-7	3.5	5.86	1.04	5.72	1.13	5.95	1.31	5.52	1.48
Performance-avoidance	1-7	3.5	5.26	1.40	4.62	1.67	5.05	1.56	5.13	1.35
Mastery-approach	1-7	3.5	6.46	.80	6.31	1.03	6.32	1.01	6.20	1.09
Mastery-avoidance	1-7	3.5	4.40	1.37	4.80	1.49	5.02	1.38	4.79	1.58
CSCS	1-9	4.5	5.24	.90	5.74	1.31	5.77	1.28	5.50	1.01
SCL	1-9	4.5	3.85	1.73	6.54	1.56	5.81	1.58	6.08	1.53
Rehearsal	1-7	3.5	5.17	1.40	5.37	1.03	5.43	1.42	5.28	1.42
Elaboration	1-7	3.5	5.01	1.02	5.31	.90	4.93	1.24	5.05	1.26
Organization	1-7	3.5	5.20	.99	5.45	5.29	5.11	1.24	5.29	1.53
Metacognitive self-regulation	1-7	3.5	5.12	.83	5.36	.80	5.06	1.14	5.16	1.27
ASEAB*	1-30	15	4.70	2.22	15.71	3.62	3.47	2.54	12.84	4.72

* ASEAB: Achievement in Solubility Equilibrium and Acids and Bases

The *bivariate correlations* among the DVs were examined separately for motivational and cognitive constructs. The correlation matrix for *Pearson product-moment correlation coefficients* for the motivational variables is presented for pre-test and post-test measurements in Table 4.2. The bivariate correlations between goal orientation and self-efficacy constructs were found to be non-signficant before the treatment, showing that these variables were measuring different aspects of student motivation. However, the mastery-approach goal was found to be correlated with both self-efficacy constructs after the treatment, indicating that students who focused on task mastery also possessed high self-efficacy beliefs. Furthermore, the correlations between students' goal orientations were altered from small to medium (Hinkle et al., 1998) before treatment and there was a slight increase regarding correlation coefficients after treatment. The goal orientation constructs sharing a common dimension like performance-approach goal and performance-avoidance goal correlated at higher degree. On the other hand, the goal orientations which did not possess any common variance such as mastery-approach goal and performance-avoidance goal were not related. Accordingly, students who focused on not doing worse than classmates were also focused on getting higher grades than others. However, students who give importance to learning the material were not concerned about falling behind classmates. When the self-efficacy contructs (SCL and CSCS) were examined, they were found to be moderately correlated (Hinkle, Wiersma & Jurs, 1998) to each other before and after the treatment.

Table 4.2 Bivariate Correlations among the Motivational Variables for Pre-test and Post-test Measurements

Subscale	1	2	3	4	5	6
1. Pre-Performance-approach	1.00					
2. Pre-Performance-avoidance	.57**	1.00				
3. Pre-Mastery-approach	.31**	.22	1.00			
4. Pre-Mastery-avoidance	.20	.45**	.22	1.00		
5. PreCSCS	.15	.04	.22	.02	1.00	
6. Pre-SCL	.09	.05	.12	.20	.51**	1.00
Subscale	1	2	3	4	5	6
1. Post-Performance-approach	1.00					
2. Post-Performance-avoidance	.63**	1.00				
3. Post-Mastery-approach	.33**	.06	1.00			
4. Post- Mastery-avoidance	.36**	.44**	.34**	1.00		
5. Post-CSCS	.14	.11	.46**	.12	1.00	
6. Post-SCL	.19	.10	.34**	.14	.64**	1.00

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.3 displays the bivariate correlations among cognitive constructs. Unexpectedly, achievement construct was not significantly correlated with students' learning strategies both before and after treatment. The magnitude of correlations among learning strategies ranged between medium to high (Hinkle et al., 1998) with a slight increase after treatment. The highest correlation was found between metacognitive self-regulation and organization (*r*=.75 for pre-test; *r*=.83 for post-test) strategies. However, the lowest correlation was found between rehearsal and organization (*r*=.26) strategies for pre-test measurement and rehearsal and metacognitive self-regulation (*r*=.33) strategies for post-test measurement. It meant that students, who outlined the material, also evaluated the effectiveness of learning process and made necessary changes in order to achieve learning goals. On the other hand, students who memorized concepts used strategies like outlining the material and monitoring the learning process rarely.

Table 4.3 Bivariate Correlations among the Cognitive Variables for Pre-test and Post-test Measurements

Subscale	1	2	3	4	5
1. Pre-Rehearsal	1.00				
2. Pre-Elaboration	.71**	1.00			
3. Pre-Organization	.26*	.35**	1.00		
4. Pre-Metacognitive self-regulation	.34**	.45**	.75**	1.00	
5. Pre-ASEAB***	.09	.06	.12	.10	1.00
Subscale	1	2	3	4	5
1. Post-Rehearsal	1.00				
2. Post-Elaboration	.76**	1.00			
3. Post-Organization	.39**	.39**	1.00		
4. Post-Metacognitive self-regulation	.33**	.40**	.83**	1.00	
5. Post-ASEAB***	.13	.03	.01	-.01	1.00

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

*** ASEAB: Achievement in Solubility Equilibrium and Acids and Bases

4.1.3 Inferential Statistics (Mixed-MANOVA Analysis)

SRL is a general concept including several sub-processes that students employ to improve their learning. Among those processes, 11 DVs reflecting motivation, cognition and metacognition dimensions were selected. This study was conducted to test whether the treatment based on SRL created any signifincant difference in the means of these DVs among treatment groups in the same way over time. Therefore, it had a between-subject factor (treatment group) and a within-subject factor (testing period). Treatment group was consisted of experimental group and control group, while the testing period included pre-test and post-test measurements. Since there were a within and a between subject factors, a mixed data analyses design was utilized. Specifically, *a mixed MANOVA analysis* was preferred. Huberty and Morris (1989) suggest using MANOVA analysis when interpreting the results of a group of variables together, comparing the influence of each DV on the overall difference, and identifying a system from conceptually related variables or the important constructs for the theory. Moreover, MANOVA took into account the intercorrelations among the DVs instead of testing the single effect of each DV (Stevens, 2009). Considering these ideas, *mixed-MANOVA analysis* was conducted in the present study.

Huberty and Morris (1989) also suggest that when the interested variables can be divided into theoretically meaningful subsets, a separate MANOVA analyses should be conducted for each set of variables. In the current study, 11 outcome variables were grouped into two main categories: motivational variables versus cognitive variables. Motivational variables included performance-approach goal, performance-avoidance goal, mastery-approach goal, mastery-avoidance goal, CSCS, and SCL; while rehearsal strategy, elaboration strategy, organization strategy, metacognitive self-regulation strategy, and achievement in Solubility Equilibrium and Acids and Bases were constituted cognitive variables. As a result, two mixed-MANOVAs were run separately: first analysis was for the motivational variables and second analysis was for the cognitive variables.

4.1.3.1 Testing the Assumptions of mixed-MANOVA

Stevens (2009) explains the importance of assumptions in an inferential test as

> "in ANOVA and MANOVA, we set up a mathematical model based on these assumptions, and all mathematical models are approximations to reality. Therefore, violations of the assumptions are inevitable. The salient question becomes: How radically must a given assumption be violated before it has a serious effect on type I and type II error rates?" (p.217).

This section critically analyzes MANOVA assumptions, and how serious their effect on type I error when they are violated using the guidelines proposed by Stevens (2009). The assumptions associated with mixed-MANOVA are *independence of observations, univariate normality, multivariate normality, linearity, equality of variances, homogeneity of variance-covariance matrices, and multicolinearity.*

Violation of *independence of observations* assumption indicates dependence among observations which might occur in every class. The researcher was aware of that this effect should be assessed thoughtfully in the present study; since, the instruction in the experimental group was based on group work in the laboratory and students were encouraged to support each other's learning through group discussions. In order to minimize the effect of violation of this assumption, the test administration procedure was standardized for both groups and the pre-tests and post-tests were administered individually to the students. They were assumed not to interact during the administration of pre-tests and post-tests. Additionally, students were used as the unit of analysis in the inferential tests.

Next, *univariate and multivariate normality assumptions* are important in inferential statistics. Hinkle et al. (1998) define normal distribution as "…the distribution of normally distributed standard scores with a mean equal to 0 and a standard deviation equal to 1" (p.93). Stevens (2009) states that *multivariate normality* is more rigorous while conducting multivariate analyses. He describes charateristics of *multivariate normality* as "(a) any linear combination of the variables are normally distributed, and (b) all subsets of the set of variables have multivariate normal distributions" (p.222). *Univariate normality* in mixed-MANOVA was satisfied when each DV would be normally distributed both in experimental and control groups. Univariate and multivariate outliers can generate non-normality in both univariate and multivariate distributions (Stevens, 2009). Since both outliers were checked earlier and found to be non-influential, the normality assumption was expected to be satisfied. *The skewness and kurtosis values* close to zero were accepted as indicating normal distribution of scores. Accordingly, univariate normality was checked cautiously for each DV and by calculating the skewness and kurtosis values separately for all DVs for both groups and pre-test and post-test measurements (Check Table 4.4). When statistics given in Table 4.4 were examined, the mastery-approach type goal for all conditions were non-normally distributed and negatively skewed, indicating that most of the scores were gathered above the mean. Except for mastery-approach type goal, the other variables were accepted to be normally distributed. *Histograms and Normal Q-Q Plots* were also checked for all variables and the graphs supported these results. To assess *multivariate normality*, *Mardia's test* was used. Significant result in Mardia's test indicated violation of multivariate normality assumption. Luckily, violation of both univariate and multivariate normality assumptions were robust with respect to Type I error when the group sizes were almost equal (Stevens, 2009). Although results were not affected seriously from non-normality, findings for mastery-approach type goal should be interpreted thoughtfully.

Table 4.4 Skewness and kurtosis values with respect to treatment group and testing period

	Experimental Group				Control Group			
	Time I		Time II		Time I		Time II	
Subscale	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis	Skewness	Kurtosis
Performance-approach	-.731	.121	-.664	-.500	-2.195	5.312	-.795	-.486
Performance-avoidance	-.747	.041	-.114	-1.211	-.763	.182	-.822	.910
Mastery-approach	-1.568	1.277	-2.338	5.778	-2.563	6.547	-1.725	2.522
Mastery-avoidance	-.648	.002	-.471	-.546	-.806	.843	-.484	-.407
CSCS	-.827	.306	.145	-.332	.472	-.593	.324	1.352
SCL	-.248	-.938	-.142	-.970	-.254	.403	-.132	-.569
Rehearsal	-.338	-1.037	-.243	-.754	-.867	.528	-1.295	2.624
Elaboration	-.188	.092	-.380	.114	-.481	-.030	-1.423	2.669
Organization	-.227	-.468	.064	-.871	-1.324	2.950	-.909	.660
Metacognitive self-regulation	-.392	-.582	-.456	-.119	-1.193	2.411	-.438	-.133
ASEAB*	-.179	-.265	.156	-.915	-.908	.187	.195	.024

*ASEAB: Achievement in Solubility Equilibrium and Acids and Bases

Linearity assumption suggests a linear relationship between each pair of DVs (Tabackhnick & Fidell, 2007). To test it, *scatter plots* among any two DVs were drawn separately for pre-test and post-test measurements. Since none of the figures displayed a clear non-linear pattern such as a curve pattern, all the relations were assumed to be linear.

Equality of variances assumption indicates that the variances of all DVs across both groups for two test periods are equal. It was assesed using *Levene's Test of Equality of Error Variances*. The null hypothesis was that the error variances of the dependent variables were equal across groups for both test periods. When the significance values were compared with the alpha (α= .05), all the null hypotheses were failed to reject excapt for post performance-approach scores, pre CSCS scores, and post metacognitive self-regulation scores. Accordingly, the variances of most of the DVs were equal across groups when independently measured for pre-test and post-test scores (See Table 4.5 for motivational variables and Table 4.6 for cognitive variables). Fortunately, violation *Equality of variances assumption* does not distort results seriously.

Table 4.5 Results of Levene's Test of Equality of Error Variances for Motivational Variables

Subscale	Time	*F*	*df*1	*df*2	Sig.
Performance-approach	Pre-test	.001	1	76	.978
	Post-test	4.263	1	76	.042
Performance-avoidance	Pre-test	.201	1	76	.656
	Post-test	3.898	1	76	.052
Mastery-approach	Pre-test	.002	1	76	.969
	Post-test	.422	1	76	.518
Mastery-avoidance	Pre-test	.027	1	76	.870
	Post-test	.004	1	76	.950
CSCS	Pre-test	5.252	1	76	.025
	Post-test	2.833	1	76	.096
SCL	Pre-test	1.163	1	76	.284
	Post-test	.116	1	76	.734

Table 4.6 Results of Levene's Test of Equality of Error Variances for Cognitive Variables

Subscale	Time	*F*	*df*1	*df*2	Sig.
Rehearsal	Pre-test	.243	1	74	.623
	Post-test	1.510	1	74	.223
Elaboration	Pre-test	1.029	1	74	.314
	Post-test	2.037	1	74	.158
Organization	Pre-test	.529	1	74	.469
	Post-test	2.803	1	74	.098
Metacognitive self-regulation	Pre-test	.988	1	74	.323
	Post-test	6.006	1	74	.017
ASEAB*	Pre-test	1.356	1	74	.248
	Post-test	2.434	1	74	.123

*ASEAB: Achievement in Solubility Equilibrium and Acids and Bases

Homogeneity of variance-covariance matrices assumption proposes that covariance matrices of the DVs are equal. It was tested the null hypothesis that the observed covariance matrices of the dependent variables were equal across groups employing *Box's Test*. When the significance values were compared with the alpha ($\alpha = .05$), the assumption was violated for both of the analysis ($p<.05$) (See Table 4.7). Luckily, this assumption is also robust to Type I error when sample sizes were approximately equal.

Table 4.7 Results of Box's Test of Equality of Covariance Matrices for both Motivational and Cognitive Variables

	Analysis 1 Motivational Variables	Analysis 2 Cognitive Variables
Box’s M	122.235	106.802
F	1.304	1.663
$df1$	78	55
$df2$	18138.159	17683.705
Sig.	.037	.002

According to Tabackhnick and Fidell (2007), MANOVA analysis works best when the pairs of DVs are moderately correlated. When the bivariate correlations among the DVs are too high (.90 or above), *multicolinearity assumption* is not satisfied. To test it, *bivariate correlations* among the DVs were checked (Check Table 4.2 for motivational variables and Table 4.3 for cognitive variables). They were all below .90 and the highest correlation coefficient was between organization and metacognitive-self regulation strategies for the post-test measurement with the value of .83. Having not encountered a serious problem in assumption check, the researcher proceeded with the mixed-MANOVA to test the hypotheses.

4.1.3.2 Hypothesis Testing for Motivational Variables

Mixed-MANOVA was a mixed factorial model with a between-subjects factor (treatment) and a within-subjects factor (time). The mixed-MANOVA tested three hypotheses in one analysis: (1) main effect for time (within-subject factor), (2) main effect for treatment (between-subject factor), and (3) interaction effect (time*treatment). The first hypothesis tested whether the mean difference on the linear combination of DVs was significant or not between two testing periods. The second hypothesis tested if the mean difference on the linear combination of DVs was significant or not among experimental and control groups at any time points. Finally, the third hypothesis tested the interaction effect, i.e. whether the effect of the treatment on the linear combination of DVs was the same across experimental and control groups over time.

Table 4.8 summarizes the results of the mixed-MANOVA for motivational variables. In line with Tabackhnick and Fidell's (2007) suggestion; the multivariate test of "Pillai Trace" is reported in this study, since it is robust to violations of homogeneity of variance-covariance matrices assumption when the sizes of the groups are almost equal (largest /smallest < 1.5). It indicated a significant interaction effect: Pillai's Trace = .45, $F(6,71) = 9.69$, $p<.05$, η^2 =. 45. In order to evaluate the practical significance of the interaction effect, the magnitude of the effect size (partial eta squared: partial η^2) was interpreted. Since DVs are recombined in MANOVA, the addition of eta squared coming from each DV can be greater than 1 (Tabackhnick & Fidell, 2007). Despite this limitation, the effect sizes were interpreted based on Cohen's criteria (1988): $\eta^2 = .01$ as a small effect, $\eta^2 = .06$ as a medium effect, and $\eta^2 = .14$ as a large effect. The partial eta squared value "0" interpreted as indicating no relationship between the factors and the DVs; while, the partial eta squared value "1" interpreted as indicating the possible strongest relationship. Accordingly, 45% of the multivariate variance in the linear combination of motivational variables was explained with the interaction effect which point to a large effect size. Moreover, the observed power was found to be 1.00 exceeding the pre-determined power of .80. As the interaction effect was significant, the main effects were not explained.

Table 4.8 Result of Mixed-MANOVA for the Motivational Variables

Source	Pillai Trace	*F*	Hypothesis *df*	Error *df*	Sig.	Partial η^2
Between-subjects treatment group	.129	1.749	6	71	.122	.129
Within-subjects time	.474	10.685*	6	71	.000	.474
Interaction time *treatment	.450	9.686*	6	71	.000	.450

* p<.05

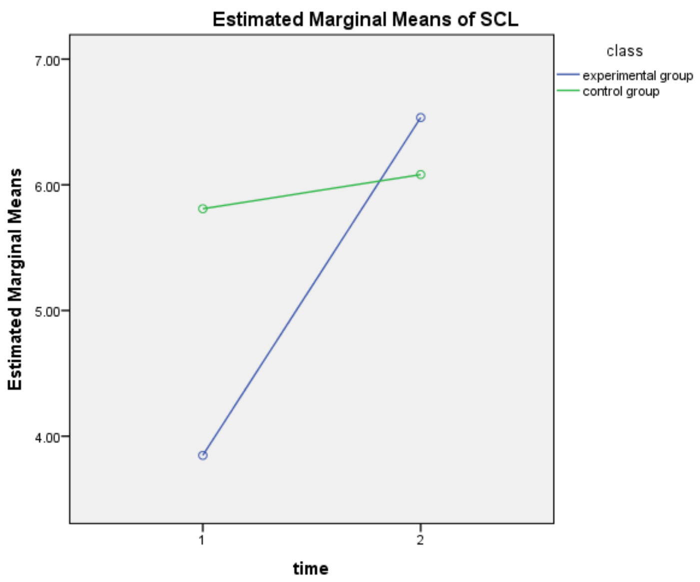
Significant interaction effect explained the overall change in the motivational variables. Next, in order to understand which DVs created this overall effect, the univariate tests for the interaction effect were examined as Post Hoc procedure. The Greenhouse-Geisser and other Epsilon values for Mauchly's Test of Sphericity were found to be 1.000 indicating that sphericity assumption was met. Thus, *the sphericity assumed line* of the univariate tests is reported in Table 4.9. In order to control Type 1 error rate, the *Bonferroni adjustment* was done. The alpha (α=.05) was divided by the number of DVs. The adjusted alpha was found to be .008 (.05/6). As a result, the significance values (p) below .008 revealed significant results for univariate comparisons. Significant univariate *interaction effects* were found for the self-efficacy variables namely CSCS ($F(6,76) = 10.94$, $p < .008$, $\eta^2 = .13$) and SCL ($F(6,76) = 36.13$, $p < .008$, $\eta^2 = .32$). When Cohen's criteria ($\eta^2 = .01$ as a small effect, $\eta^2 = .06$ as a medium effect, and $\eta^2 = .14$ as a large effect) was employed, the univariate effect of SCL was large with the partial eta squared value of .32 and CSCS was medium with the partial eta squared value of .13. On the other hand, the goal orientation constructs did not make any significant impact on the overall interaction effect.

Table 4.9 Result of Univarite Tests for the Interaction Effect for the Motivational Variables

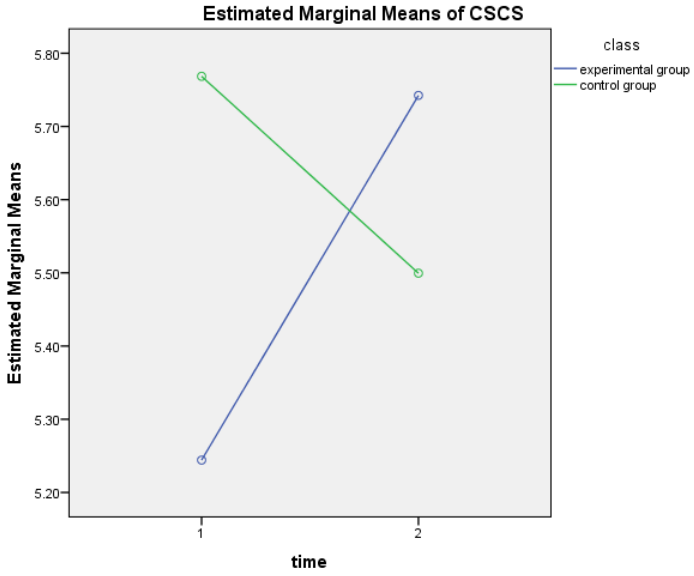
DV	*F*	Hypothesis *df*	Error *df*	Sig.	Partial η^2
Performance-approach	.593	1	76	.443	.008
Performance-avoidance	3.040	1	76	.085	.038
Mastery-approach	.006	1	76	.936	.000
Mastery-avoidance	2.958	1	76	.090	.037
CSCS	10.942*	1	76	.001	.126
SCL	36.131*	1	76	.000	.322

* $p<.05$

In an effort to explain the significant interaction effects, the profile plots for the vaiables SCL and CSCS were investigated (see figure 4.1). Among motivational variables, SCL made the highest contribution to the overall interaction effect with the partial eta squared value of .32. Figure 4.1.a indicated that although the mean of control group on the SCL measurement was higher at Time I, it increased slightly from 5.81 to 6.08 over time. On the other hand, a sharp increase occurred in the mean of experimental group from Time I (*M*=3.85) to Time II (*M*=6.54). The crossing lines in figure 4.1.a supported this interaction effect. As a result, the treatment was found to cause an increase in the mean of SCL in both groups with the higher degree in the experimental group. For the CSCS, there was a slight decrease in the mean of control group over time (from 5.77 to 5.50); while, there was a little increase in the mean of experimental group (5.24 at Time I and 5.74 at Time II) (see Figure 4.1.b).



(a)



(b)

Figure 4.1 Profile Plots for (a) SCL and (b) CSCS

4.1.3.3 Hypothesis Testing for Cognitive Variables

The second mixed-MANOVA was conducted for the linear combination of five cognitive variables: rehearsal, elaboration, organization, metacognitive self-regulation, and achievement in Solubility Equilibrium and Acids and Bases. Similarly, treatment was the between-subject factor and time was the within-subject factor. Table 4.10 presents the results of the mixed-MANOVA for cognitive variables. The multivariate test of "Pillai Trace" was non-significant for the *interaction effect* (Pillai Trace = .08, $F(5,70) = 1.24$, $p > .05$, $\eta^2 = .08$). Therefore, the main effects were interpreted. The *time main effect* was found to be significant (Pillai Trace = .81, $F(5,70) = 58.84$, $p < .05$, $\eta^2 = .81$), indicating that the mean difference on the linear combination of DVs was significant between two testing periods. 81% of the multivariate variance in the combined DVs was explained with the time main effect. With respect to Cohen's criteria ($\eta^2 = .01$ as a small effect, $\eta^2 = .06$ as a medium effect, and $\eta^2 = .14$ as a large effect), it was a quite large effect size. Likewise, the *treatment main effect* was also significant (Pillai Trace = .23, $F(5,70) = 4.17$, $p < .05$, $\eta^2 = .23$). It also had a large effect size, but with a smaller degree compared to the time main effect. It explained 23% of the multivariate variance in the combined DVs. This result indicated that the mean difference on the linear combination of DVs was significant among experimental and control groups. In addition, the observed power was found to be 1.00 for the time main effect and .94 for the treatment main effect. Both values were above the pre-determined power of .80.

Table 4.10 Result of Mixed-MANOVA for the Cognitive Variables

Source	Pillai Trace	*F*	Hypothesis *df*	Error *df*	Sig.	Partial η^2
Between-subjects treatment group	.229	4.168*	5	70	.002	.229
Within-subjects time	.808	58.835*	5	70	.000	.808
Interaction group*time	.082	1.243	5	70	.299	.082

* p<.05

In order to understand which DVs contributed to the overall main effects, univariate tests for between-subject (treatment group) and within-subject (time) factors were performed. Table 4.11 shows the results of univarite tests for the between-subject and within-subject effects separately. Same as the analysis for motivational variables, the *Bonferroni adjustment* was done to control Type 1 error while testing univariate effects. Again, the alpha (α=.05) was divided by the number of DVs in the analysis (5) and the adjusted alpha was .01 (.05/5). Consequently, the p values below .01 were accepted significant. For the time main effect, initially sphericity assumption was checked before interpreting univariate statistics. The Epsilon values for *Mauchly's Test of Sphericity* were 1.000. Accordingly, the assumption was met and the *sphericity assumed* line of the univariate tests was reported in Table 4.11. Only the achievement variable ($F(1,74) = 279.97$, $p < .01$, $\eta 2 = .80$) changed significantly from Time I to Time II. The estimated marginal means showed that the mean of achievement measurement increased from Time I (4.09) to Time II (14.28). As for the treatment main effect, the univariate tests were examined. Similarly, only the mean of achievement was significantly different among groups ($F(1,74) = 15.72$, $p < .01$, $\eta 2 = .17$). When the estimated marginal means was checked, the experimental group (*M*=10.21) had higher mean than the control group

(*M*=8.16). Since the learning strategies did not make any significant contribution to the overall treatment and time main effects, only the profile plot for the achievement was displayed in Figure 4.2. It showed that the means of groups were very close both at Time I (4.70 for experimental group and 3.47 for control group) and Time II (15.71 for experimental group and 12.84 for control group). Additionally, both at Time I and Time II, the means of experimental group was a little higher than the control group. Since the means of both groups increased in the same way over time, the interaction effect was non-significant. In sum, the treatment main effect favoured experimental group and the time main effect was in favour of Time II.

Table 4.11 Result of Univarite Tests for the between-subject and within-subject Effects for the Cognitive Variables

Source	DV	*F*	Hypothesis *df*	Error *df*	Sig.	Partial η^2
Between-subjects treatment group	Rehearsal	.117	1	74	.734	.002
	Elaboration	.572	1	74	.452	.008
	Organization	.301	1	74	.585	.004
	Metacognitive self-regulation	.405	1	74	.527	.005
	ASEAB**	15.723*	1	74	.000	.175
Within-subjects time	Rehearsal	.025	1	74	.874	.000
	Elaboration	2.285	1	74	.135	.030
	Organization	1.972	1	74	.164	.026
	Metacognitive self-regulation	2.213	1	74	.141	.029
	ASEAB**	297.969*	1	74	.000	.801

* p<.05

**ASEAB: Achievement in Solubility Equilibrium and Acids and Bases

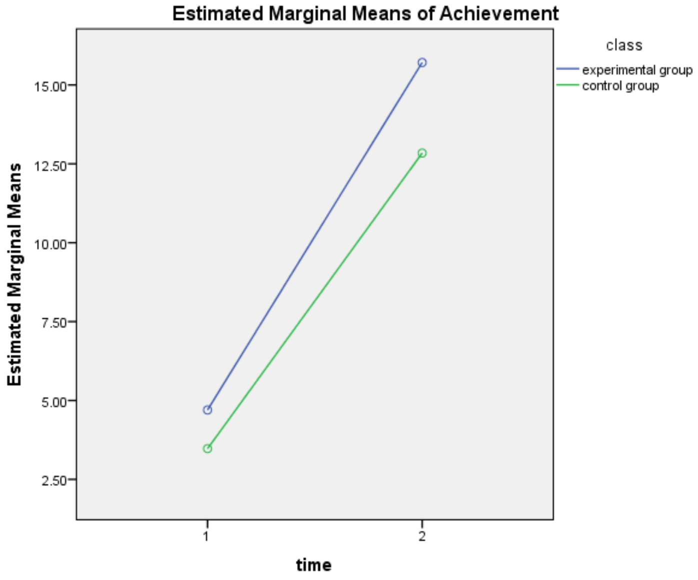


Figure 4.2 Profile Plot for Achievement in Solubility Equilibrium and Acids and Bases

4.2 Results of Qualitative Analyses

In the present study, the case study method was employed as a qualitative approach. Since students in the both groups employed self-regulatory processes to some degree while studying for the Solubility Equilibrium and Acids and Bases Units, each group was accepted as a case. Accordingly, results coming from different qualitative sources were presented separately for two cases: "self-regulatory practice in the experimental group" and "self-regulatory practice in the control group". In sum, each classroom was defined as a separate case and four focal students at varied achievement levels and gender groups were selected as typical examples to describe their cases.

4.2.1 Case 1: Self-Regulatory Practice in the Experimental Group

To explain self-regulatory practice in the experimental group, the analyses of interviews, journals, and think aloud protocols are presented seperately for Mete, Fatma, Berat, and Ayşe as the typical examples of their cases.

4.2.1.1 Mete

Mete was the low achieving student in the experimental group. Based on interviews conducted before the intervention, his self-regulatory practice could be described as follows. Mete was not planning his study beforehand, rather he was studying occasionally. He studied for the course since questions from chemistry course were asked at the university entrance examination. He was mostly using rehearsal and highlighting task strategies in the performance phase. As self-reflection practices, he evaluated his chemistry performance in terms of understanding the topic, attributed success to his effort, and gave up after experiencing failure.

4.2.1.1.1 Analyses of Interview

In the interview, Mete reported that he was not using strategic planning process in the forethought phase; rather he was studying for the course irregularly. In terms of motion, he employed mastery-approach type goals as a forethought motivation process. He expressed it very obviously in the following quote: "*They say the indicator of being a successful student in chemistry is getting good grades but I believe the one who understands chemistry better is a more successful student, I think the grade is not important* [Interviewer: But how do we know if we understand the topic?] *If we understand the chemistry we can solve the problems by ourselves. We can make small mistakes and the answer might be incorrect, but I think that is not important. The important thing is to conceptualize* [the topic]" Besides, he possessed value beliefs for chemistry course. According to Mete, learning chemistry was important to do well in the university entrance examination and after he would enroll in a university program.

In the performance phase, he used the following task strategies: rehearsal, highlighting, note taking, solving additional problems on studying chemistry. For example, while studying for the course he memorized how the teacher had solved the questions in the classroom and then solved additional questions from different tutoring books.

As for the self-reflection phase, Mete evaluated the effectiveness of his learning process by using the criteria whether he could solve the chemistry problems: "*when you solve the [chemistry] problems you know whether you understand the [chemistry] topic or not*". Additionally, he attributed his success in chemistry course to his effort, listening to the teacher carefully in the classroom, type of questions in the exams, and his emotional status during the exams: "*I cannot solve the question. The questions about the chemistry are too long; I cannot comprehend the question... I feel under the stress in the chemistry class especially when I don't understand and when I am confronted by a long problem. Unfortunately, in general, teachers ask long questions*." Furthermore, Mete showed self-reaction process in defensive form; he gave up when he was unsuccessful as a consequence of studying for an exam.

4.2.1.1.2 Analyses of Journals

Table 4.12 provides the analyses of journals belonged to the group in which Mete worked. Journal 1 was the first laboratory experience for most of the students in class. Therefore, Mete's group was so excited in their first activity as well as other groups and struggled in writing their experiences. Similarly, Journal 3 (Let's Examine Solubility at Micro Level) included another novel activity for students. That activity was done as a demonstration by the cooperative teacher; the students filled their journals themselves in view of whole class discussions rather than in view of group discussions. Mete did not bring his journal back at the end of the third activity.

Regarding Journal 2, the group which Mete worked in only made a plan to record the data; in other words, they prepared a table for data recording in the forethought phase but it was not at a satisfactory level. The group used all processes for the performance phase. While the observation of data and the inference based on observations were at a satisfactory level, the procedure was not stated satisfactorily. As seen in Table 4.12, Mete did not use or report any process regarding the self-reflection phase throughout all journals, indicating low self-regulation skills. Similarly, he did not report any processes in Journal 3 which could be attributed to low self-regulatory skills of Mete.

However, following Journal 3, a development in the use of the self-regulatory processes for the forethought and performance phases was observed in the group. For example, in Journal 4 (Does it precipitate?), the group again only planned data recording but this time at a satisfactory level. Additionally, the group used all the processes satisfactorily in the performance phase. When reporting their predictions in Journal 4, Mete stated that "*We decided by experience, by mixing two liquids together, we observed whether it precipitate or not*". This quote did not include any prediction; rather he explained the process they employed. However, he reported the process that they employed in the performance phase at a satisfactory level as given in Figure 4.3. Similarly, while reporting the unexpected results he observed during "Does it precipitate?" activity, he reported that "*The colors were interesting, different colors when two liquids mixed together*". This statement could be used as an evidence for student's increased motivation; however it did not include any reflection for unexpected result (see Table 4.12). The table taken from the same journal and given in figure 4.3 also belonged to this group. Since the table included all the solutions used in the activity and summarized all the observations, it was at a satisfactory level. In the inference below the table in figure 4.3, the students reported whether they observed any precipitation as a result of mixing two salt solutions, identified the precipitating compound if they observed any, and explained the reason if they did not observe. Accordingly, they made *inference based on observations* and *procedure* satisfactoryly (see Table 4.12). In summary, with respect to Journal 4 (Does it precipitate?) Mete's group did not report their plan of what they would do before the activity and their prediction was not acceptable. On the other hand, the group prepared the data table, and employed the performance phase processes "*satisfactorily*". Finally, Mete reported an irrelevant statement in *unexpected outcomes* process in the self-reflection phase and did not report anything in the remaining self-reflection phases. Therefore, self-reflection phase processes were not observed.

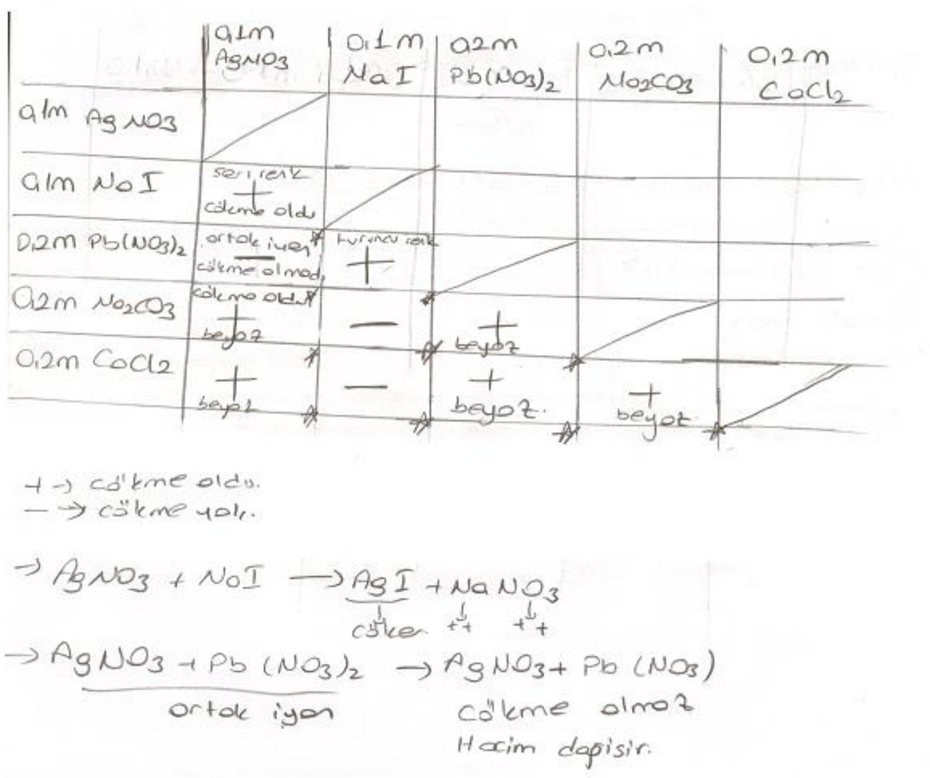


Figure 4.3 Table of results and related inference belonged to Mete's group with respect to Journal 4 (Does it precipitate?)

As seen in Table 4.12 in Journal 5, the group which Mete worked in used all the processes regarding the forethought and performance phases at a satisfactory level except for the inference based on observation process. Moreover, the group started to report their predictions for the first time in

Journal 5. In Journal 6, the group used all the processes except for the predictions process regarding forethought and procedure phases. The group again reported their predictions in Journal 7 which was not at a satisfactory level. Their observation notes were also not satisfactoryly stated in Journal 7. Finally, in Journal 8, the same processes as in Journal 6 was observed. Throughout the intervention, Mete did not report any processes in the self-reflection phase. He mostly reported the processes regarding the performance phase. Additionally, it was observed a development in using the processes regarding the forethought phase throughout the journals.

Table 4.12 The Self-Regulatory Processes reported by Mete

Process	**Phase**	Journal 1 Solutions	Journal 2 The Effect of Temperature on Solubility	Journal 3 Let’s Examine Solubility at Micro level	Journal 4 Does it precipitate?	Journal 5 Acid or base?	Journal 6 How much acidic or how much basic?	Journal 7 Acid-Base Reactions with Metals	Journal 8 Acid-Base Titration
Planning activity	Forethought	**X**	**X**	**X**	**X**	✓✓	✓✓	**NA**	**NA**
Planning data recording	Forethought	**X**	✓	**X**	✓✓	✓✓	✓✓	**NA**	✓✓
Predictions	Forethought	**X**	**X**	**X**	**X**	✓✓	**X**	✓	**X**
Procedure	Performance	**X**	✓	**X**	✓✓	✓✓	✓✓	**NA**	✓✓
Observation Data	Performance	**X**	✓ ✓	**X**	✓✓	✓✓	✓✓	✓	✓✓
Inference based on observations	Performance	**X**	✓✓	**X**	✓✓	✓	✓✓	**X**	✓✓
Unexpected outcomes	Self-reflection	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Assessing learned material	Self-reflection	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Experienced difficulties during activity	Self-reflection	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Evaluation /Elaboration	Self-reflection	**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**
Assessing the activity	Self-Reflection	**X**	**X**	**X**	**X**	✓	**X**	**X**	**X**

* **X**: non-existent, ✓: not satisfactory, ✓✓: satisfactory, **NA**: not applicable

4.2.1.1.3 Analyses of Think Aloud Protocols

According to Table 4.13, Mete even did not think on the cases in the Solubility Equilibrium Unit. For example, in Episode 1, he put the paper on the desk and even did not think on it. When the researcher asked for the reason, he said that he did not like numbers, he preferred interpretation type questions. Actually, the task did not require any calculation, the Ksp value of the salt was given to interpret that the salt was slightly soluble. This quote showed that, since he experienced failure in solving algorithmic questions, he gave up quickly and did not think on the cases. However, in the Acids and Bases Unit, there was an improvement in terms of his strategy use and achievement. For example, in Episode 2, similar to Faruk (high achiever in the control group) he defined equivalance point as the point where pH value got 7 (rehearsal), and he checked the given table for the point of pH=7 (elaboration), however he could not find the equivalance point. Next, to monitor the consistency between his existing knowledge and the given table, he calculated the point where the pH was 7 (metacognitive monitoring). He explained his reasoning and came up with the conclusion that the equivalence point was when 49.45 mL of NaOH added and that was not given on the table. Although he employed monitoring strategy effectively, he could not provide full explanation and his response was graded as wrong response with poor/insufficient (scientific) explanation in terms of achievement.

EPISODE 1:

Mete: Let me put it here.

R: You even do not want to read?

Mete: Yes.

R:Why?

Mete: I do not like numbers; I would do if it requires interpretation.

R:Do you think you can’t do numerical questions?

Mete: I think I can’t do, I don’t do. I tried once or twice, I tried, I skimmed the content, I couldn’t do then I gave up.

EPISODE 2:

R: Where is the equivalence point?

Mete:7.

R: I mean, whether you could show me on the table?

Mete: But there is no “7” on the Table, it should have been over here

R: Okay then, what does exist in the environment?

Mete: Then there is…forty nine mL OH, 50ml de HA.

R:49?

Mete:A...

R: Do you think that it is 49?

Mete: No, 49.90.

R: But then it does not make it 7

Mete: 49.50.

R: Okay.

Mete: Let me think a second, and calculate. 49.00 6.45; 49.90 7.46; there is 90 in between. Hıımmmm, no. there is no 90, but it is 89... Is that wrong? 46 from here and 45-55 from there, Oh, sorry it was 100, I am a little confused today.

R: What did you do? I did not understand how you calculated.

Mete: No, I.. I used my own method.

R: Okay, well… That is why I want you to compute, I would like to understand your method.

Mete: Nothing, do not ask me... Hımmm... let's make it 90%, and 49.45. See, I found it !

R: How did you find it,that is a good question?

Mete: You would not find it.

Table 4.13 The Use of Cognitive and Metacognitive Strategies and the Achievement of Mete with respect to Think Aloud Protocols

	Solubility Equilibrium						**Acids and Bases**					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Rehearsal	✓			✓				✓	✓			✓
Elaboration							✓					
Organization												
Metacognitive Awareness										✓		
Metacognitive Monitoring										✓		✓
Metacognitive Evaluation												
Achievement	1	A) 1 B)1	A) 1 B) 1	A) 2 B) 2	1	1	3	A)1 B) 1	3	7	A) 1 B) 1	A)2 B) 3 C) 2 D) 3 E) 1 F) 1

* ✓**:** The process is existent.

* 1: Wrong response; 2: Wrong response with poor/insufficient (scientific) explanation; 3: Partially correct response; 4: Correct response without (scientific) explanation; 5: Correct response with irrelevant (scientific) explanation; 6: Correct response with poor/insufficient (scientific) explanation; 7: Correct response with (scientific) explanation

4.2.1.2 Fatma

Fatma was the medium achiever in the experimental group. Based on interviews, she was not a strategic planner either. Her motivational orientations included performance-approach goals, value beliefs, and high self-efficacy beliefs. In the performance phase, she was employing attention focusing strategy, different task strategies such as rehearsal and imagery strategies. She assessed effectiveness of her study in terms of her ability in employing the learnt material in daily life, attributed success to her effort, and continued studying even after experience of success.

4.2.1.2.1 Analyses of Interview

Based on the interview analyses, Fatma did not employed strategic planning process in the forethought phase. She possessed performance-approach type goals as a motivational orientation: "*The formulas confuse my mind and I am not interested in chemistry much. I study just from exam to exam to get a good grade.*" She also had value beliefs to learn chemistry because chemistry had daily applications and it was important for her future career: "*I would say chemistry is a very important course because it involves things from daily life. We learn the symbols and formulas of the things that we use in our everyday lives*". Moreover, Fatma possessed high self-efficacy beliefs that she felt confident that she could learn chemistry.

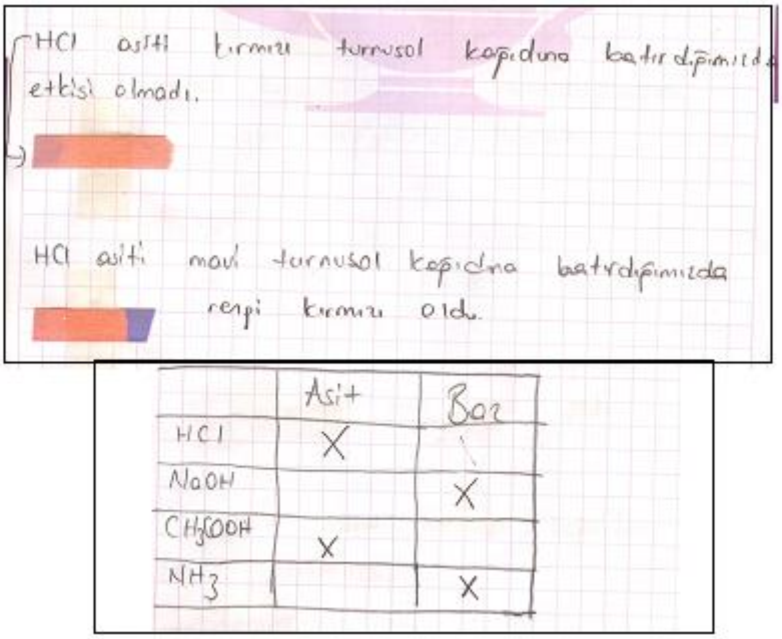
In the performance phase, Fatma used three sub processes namely attention focusing, task strategies, and imagery. As example for attention focusing Fatma stated that she revised what the teacher taught at the course and took short notes indicating for important points on the small papers. Later on, she reread these notes again and again. Moreover, as a task strategy she highlighted the studying material and made imagination to understand the chemistry concepts. For instance she said: "*I try to conceptualize my readings in my mind. For example, what happens when water is boiling? Or, what happened when I mixed the sugar in the tea? I drank tea at that day and sugar did not melt, why did it not melt? Sugar precipitated. I tried to remember these phenomena and* *to relate with the concepts that I learned in the chemistry course*". In addition, she resolved the questions which solved at the classs to get prepared for the chemistry exam which was an indicator of rehearsal strategy.

Fatma also used self-evaluation process to assess the effectiveness of her learning. She decided whether her study was effective or not in terms of applying the learned subject into daily life. For example she stated: "*I have a lot on my mind with what I studied, anyway those things haunt me all day. For example, when I see the vinegar bottle in the kitchen, I think that I learned it yesterday, the characteristics of acids are like that and the bases act like that etc. If I can do this, I say myself that I understood the subject*". She attributed her success to her effort. In addition, she was an adaptive learner because she said that she continued studying even in the instances of she could solve the problems.

4.2.1.2.2 Analyses of Journals

The analyses of journals submitted by Fatma indicating their group performance are given in Table 4.14. Her group either did not report their experiences in Journal 1 or she did not bring Journal 1 back. In Journal 2 and Journal 3, her group only reported the procedure they employed and the data they observed for the performance phase. In both journals, while the observation data process was stated at a satisfactory level, the procedure process was not satisfactory. In Journal 4, a progression with respect to using the processes of the forethought and performance phases except for the planning activity process was observed. All these processes were at satisfactory level. Furthermore, Fatma started to report her predictions for the first time in Journal 4. She used the evaluation/elaboration process at a satisfactory level and assessed the activity imprecisely.

In journal 5, her group used all the processes regarding the forethought and performance phases. Except the inference based on the observation process, all processes were at a satisfactory level. Figure 4.4 displays the observation notes and data report of Fatma's group with respect to Journal 5 (Task: Acid or base?). In this task, the students explored the acidic or basic characteristics of different chemicals and households. The observation notes given above included the description of the group's observations and the litmus paper they used. They had two trials for each chemical; one with blue litmus paper and the other with red litmus paper. The observation above was worded as "*When we plunged HCl acid into red litmus paper, it did not affect.*" and the observation below was worded as "*When we plunged HCl acid into blue litmus paper, it turned into red*". The table below was the data table in which students recorded their findings, the chemicals were listed in the rows and the acidic and basic property was reported in the columns. Although wording was not representing what students actually did, taking into account the whole journal, it was attributed to lack of writing skills rather than observation skills and this data was accepted as satisfactory in terms of observation notes. Additionally, preparing a table for data recording was also satisfactory. Although the group came up with the decision that HCl was an acidic solution, they did not explain their reasoning. As a result, they did not make inference at a satisfactory. In this journal, Fatma's progression regarding using or reporting the processes for the self-reflection phase was observed. She used all processes except the unexpected outcomes process and her report was at a satisfactory level.



HCl asiti kırmızı turnusol kağıdına batırdığımızda etkisi olmadı.

HCl asiti mavi turnusol kağıdına batırdığımızda rengi kırmızı oldu.

	Asit	Baz
HCl	X	
NaOH		X
CH_3COOH	X	
NH_3		X

Figure 4.4 Observation notes and data report of Fatma’s group with respect to Journal 5 (Task: Acid or base?)

Journal 6 was the first journal in which both the group used all processes regarding the forethought and performance phases and Fatma used all processes regarding self-reflection phases. Except the experienced difficulty during activity process, all processes used were at *satisfactory* level. Figure 4.5 presents the observation notes and inference of Fatma’s group with respect to Journal 6 (Task: How much acidic or how much basic?). In this task, the students worked with the same chemicals they had used in the previous task and several households they brought, and compared how much acidic or basic they were. The observation notes given in Figure 4.5 included what students did, the description of their observations, and the Universal pH indicator they used while they were working with drain opener. They wrote “*We plunged Universal pH indicator into drain opener*”; since it explained the processes accurately, it indicated a satisfactory description of the method they employed. The observation notes consisted of the Universal pH indicator they used and worded as “*pH value is 14*” which indicated a satisfactory observation process.

The observation note also included their inference in addition to inference section. They reported that "*In conclusion, the solutions with a pH value bigger than 7 showed a basic property. The drain opener has a strong basic property since its pH value was 14; pH > 7*". Since the students explained their reasoning with respect to their observations, it was accepted as a satisfactory inference. When Figure 4.4 was compared to Figure 4.5, it was also evident that students improved their reasoning and writing. They might be more careful while writing or more confident while conducting the experiments.

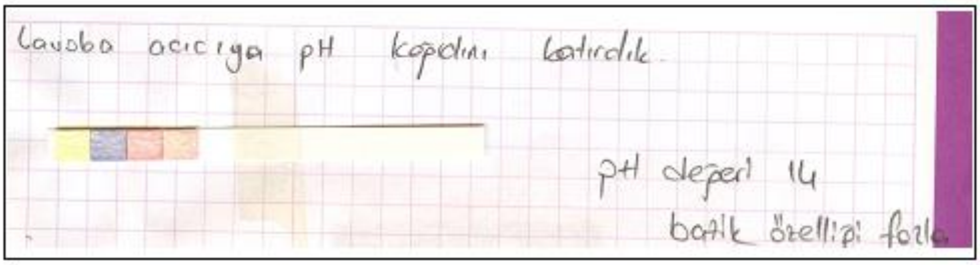


Figure 4.5 Observation note and inference of Fatma's group with respect to Journal 6 (Task: How much acidic or how much basic?)

Figure 4.6 shows the drawing of the students' observation with respect to Journal 5 (Task: Acid or base?). Although they were not requested, the students preferred to draw their observations and use colorful pens which were a satisfactory representation of her group's observations. When Figure 4.4, Figure 4.5, and Figure 4.6 were evaluated together, it could be said that the students were engaged the activity motivationally as well as cognitively.

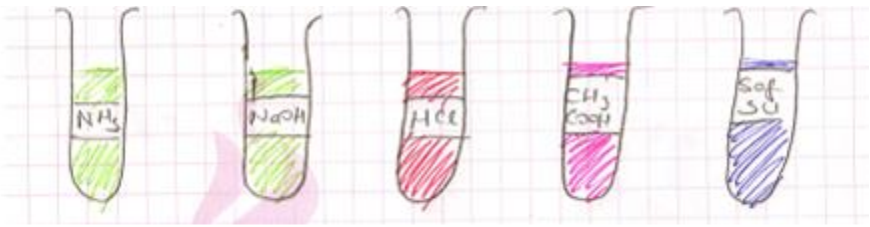


Figure 4.6 Observation notes Fatma's group with respect to Journal 5 (Task: Acid or base?)

Until Journal 7, it is obvious that both the group and the Fatma increased their use of self-regulatory processes. However, in Journal 7 and Journal 8, Fatma only used or reported the evaluation/elaboration and the assessing the activity processes regarding the self-reflection phases while the group continued to use all processes for the forethought and performance phases.

Table 4.14 The Self-Regulatory Processes reported by Fatma

Process	**Phase**	Journal 1 Solutions	Journal 2 The Effect of Temperature on Solubility	Journal 3 Let's Examine Solubility at Micro level	Journal 4 Does it precipitate?	Journal 5 Acid or base?	Journal 6 How much acidic or how much basic?	Journal 7 Acid-Base Reactions with Metals	Journal 8 Acid-Base Titration
Planning activity	Forethought	**X**	**X**	**X**	**X**	✓✓	✓✓	**NA**	**NA**
Planning data recording	Forethought	**X**	**X**	**X**	✓✓	✓✓	✓✓	**NA**	✓✓
Predictions	Forethought	**X**	**X**	**X**	✓✓	✓✓	✓✓	✓✓	✓
Procedure	Performance	**X**	✓	✓	✓✓	✓✓	✓✓	**NA**	✓✓
Observation Data	Performance	**X**	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
Inference based on observations	Performance	**X**	**X**	**X**	✓✓	✓	✓✓	✓✓	✓✓
Unexpected outcomes	Self-reflection	**X**	**X**	**X**	**X**	**X**	✓✓	**X**	**X**
Assessing learned material	Self-reflection	**X**	**X**	**X**	**X**	✓✓	✓✓	**X**	**X**
Experienced difficulties during activity	Self-reflection	**X**	**X**	**X**	**X**	✓✓	✓	**X**	**X**
Evaluation /Elaboration	Self-reflection	**X**	**X**	**X**	✓✓	✓✓	✓✓	✓	✓✓
Assessing the activity	Self-Reflection	**X**	**X**	**X**	✓	✓✓	✓✓	✓✓	✓✓

* **X**: non-existent, ✓: not satisfactory, ✓ ✓: satisfactory, **NA**: not applicable

4.2.1.2.2 Analyses of Think Aloud Protocols

According to Table 4.15, Fatma showed an improvement in the Acids and Bases Unit compared to the Solubility Equilibrium Unit with respect to strategy use and achievement. In Solubility Equilibrium Unit, she used only rehearsal and elaboration strategies and all her responses were wrong. However, in the Acids and Bases Unit, she started to use metacognitive processes. For example, in Episode 3, she was aware of the processes she employed in the laboratory (metacognitive awareness) and linked it to the given case (elaboration). Her response was correct with scientific explanation. In Episode 4, she explained the experiment they did in detail (metacognitive awareness). However, she could not explain how an indicator was choosen in titration and gave wrong response; accordingly, it was accepted as a wrong response with poor explanation.

EPISODE 3:

Fatma: Starting Ph value is 10 … at first when water is added to the detergent, pH gets close to neutral.

R: Why?

Fatma: That is because water will dilute the pH value of detergent. For example, pH is given as 10 here, however it might go down to 9 or 8 as it will be in a diluted state. Because we did the same.

R: What did you do?

Fatma: When we plunged litmus paper into the bleach, the paper got white. The teacher told us that if we had added more water, it would have diluted it and we might get better results.

R: Yeah.

Fatma: Based on that, pH value gets close to neutral such as 8, however it will not become neutral.

EPISODE 4:

Fatma: pH color change range is 4,4-6,2. It has changed here as I said. If we mix it somewhere around here, we observe that color change disappears. Can we use Methyl red as an indicator? Methyl red? Indicator? Yes we can, because we had used in in our experiments but how did we use it? When we put some Methyl red indicator in it, we had observed the color change. That is what I think but I am not sure about the indicator.

R: Why is the color change important for titration?

Fatma: Because it is the color change. In the moment that the color starts changing, in my opinion strong acid loses its acidic characteristic, and it starts becoming basic. As a result of this, at the point that color changes, we find the equivalence point.

Table 4.15 The Use of Cognitive and Metacognitive Strategies and the Achievement of Fatma with respect to Think Aloud Protocols

	Solubility Equilibrium						**Acids and Bases**					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Rehearsal	✓	✓		✓	✓	✓		✓	✓		✓	✓
Elaboration	✓			✓		✓	✓			✓	✓	✓
Organization												
Metacognitive Awareness							✓				✓	✓
Metacognitive Monitoring									✓			✓
Metacognitive Evaluation												
Achievement	1	A) 2 B) 1	A) 1 B) 1	A) 1 B) 1	1	2	7	A)1 B) 1	2	7	A) 3 B) 1	A)2 B) 3 C) 3 D) 3 E) 2 F) 2

* ✓**:** The process is existent.

* 1: Wrong response; 2: Wrong response with poor/insufficient (scientific) explanation; 3: Partially correct response; 4: Correct response without (scientific) explanation; 5: Correct response with irrelevant (scientific) explanation; 6: Correct response with poor/insufficient (scientific) explanation; 7: Correct response with (scientific) explanation

4.2.1.3 Berat

Berat was the other medium achiever in the experimental group. He was stuying once in a while to pass the exams. He also possessed performance-approach goals and utility value beliefs. In the performance phase, he mainly used rehearsal strategy. In the self-reflection phase, he evaluated success in terms of high grades, attributed success to effort, and had maladaptive reflection that is he decreased effort after experience of success.

4.2.1.3.1 Analyses of Interview

None of the focal students used strategic planning as a forethought self-regulation process indicating that students did not choose a strategy considering the demands of the task and organize implementation of that strategy intentionally. The following statement which belonged to Berat clearly indicated lack of strategic planning: "*I do not study a lot but when I study; the reason is that I want to get good grades in this semester. I do not study reguarly like everyday; I study once in a while to pass the course this semester... sometimes I just study one week before the exams*". This quato also indicated that Berat possessed performance-approach type goals; that is, he studied for the course to get high grades. Additionally, he studied for the course to achieve in the university entrance examination. The following quote included staments indicating that he possessed performance-approach type goals and value beliefs as forethought motivation process: *"...after graduating the high school we will take the university entrance exam, then what will chemistry come in handy? For this reason, I think chemistry is not important. However, the other areas like biology are significant in the life because they give us the useful things such as the structure of human organs. These necessitate the daily life knowledge for example, the numbers in mathematics. What is chemistry? Just mixtures, solutions this and that, therefore it is not such important course... I do not study a lot but when I study; the reason is that I want to get good grades in this semester.*" Moreover, his self-efficacy belief was low on basic calculations and exponential numbers when solving chemistry problems.

In the performance phase, Berat did not employ different strategies; rather he mainly used rehearsal strategy as a task strategy "*I study through taking notes... I study from my notebook; the teacher solves different type of questions and she emphasizes some questions, I resolved those ones. In addition I resolve the questions that are solved at the private course*."

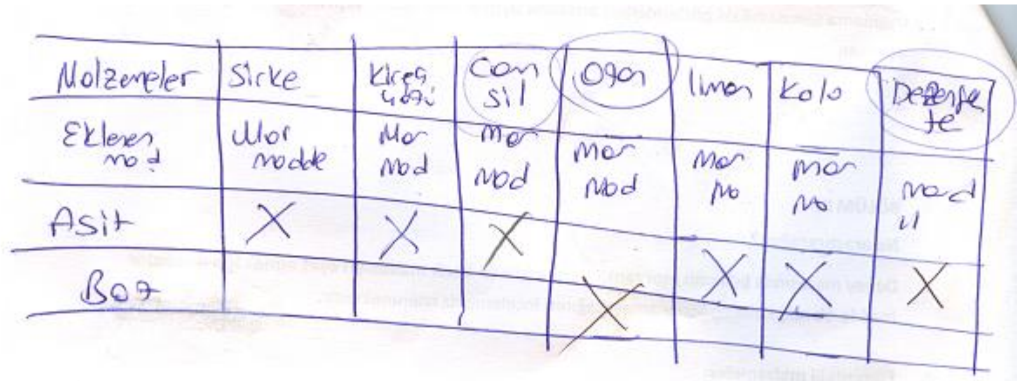
Berat evaluated the effectiveness of his learning in the chemistry with high grades in the exams. He thought that he was successful when he got high grade in the chemistry course. Moreover, Berat reported maladaptive reflection to success; that is, he decreased effort after experience of success. Berat stated that he studied less for the second exam after getting a good grade in the first exam: "I *studied first midterm. I started studying a week ago. And I got 80. Then, I did not study for the second midterm, I thought it would be easy. I thought I knew the topic. Then I took the exam. Actually, I knew the questions; however I got confused during the exam. Thinking of what to do, then I did wrong*." Accordingly, he attributed success to effort.

4.2.1.3.2 Analyses of Journals

Table 4.16 includes the analyses of journals submitted by Berat. In Journal 1, the group reported their predictions in the forethought phase however it was not at a satisfactory level. The group also reported the procedure they employed and the data they observed in the performance phase. Berat also reported the evaluation/elaboration and assessing the activity processes for the self-reflection phases. In this journal, the observation data reported by the group and the assessment of the activity written down by Berat were at satisfactory level. In Journal 2, the group used only the planning data recording process in the forethought phase, and it was employed adequately. The group used all processes for the performance phase but only the procedure was reported at a satisfactory level. Berat also assessed the activity regarding the self-reflection phase. Actually, he used this process in all journals except for Journal 3 and Journal 8 at satisfactory level. Journal 3 was the journal in which both the group and Berat showed a low performance in using or reporting self-regulatory processes. In this journal, Berat only wrote down his observations for the performance phase in the simulation activity and did not use or report any processes regarding forethought phase; Berat only stated his experienced difficulties during the task for the self-reflection phase.

However, as from Journal 4, there a progres was observed both in his group's and Berat's performance. The group used all processes for the forethought and performance phases from Journal 4 to Journal 8; and all processes except for the planning activity process was at satisfactory level. When reporting what they would do Berat stated that "*I want to investigate basic and acidic matter [and] their effect on turnusole paper. To learn what would the medium be when I mixed HCl acid and distilled water. Which matter shows which property and acidic properties*☺". He explained the purpose and the process together. Since the information included irrelevant data and incomplete explanation of the process, it was not satisfactory. Moreover, Berat used all processes except the unexpected outcomes for the self-reflection phases in Journal 4, and only the assessing the activity process was at a satisfactory level. Berat explained the unexpected results he experienced in Journal 4 (Does it participate) as follows: "*I was of the opinion that, my thoughts before the practice of participation of matter was wrong compared to my thoughts after the practice*". It provides information that there was an unexpected result he had; however, he did not provide information about which observation he experienced it. Consequently, the process was not observed.

Figure 4.7 includes the observation notes of Berat's group with respect to Journal 5 (Task: Acid or base?). In this part, they tested the acidic or basic property of several households. In the table, they reported the households on the first row, the inserted matter which was a purple liquid used as an indicator and their decisions based on their observation. This table was a well prepared table and accepted as satisfactory in terms of planning data recording table, observation notes, engaged procedure, and inference based on observations.



Malzemeler	Sirke	Kireç suyu	Camsil	Ogon	limon	Kolo	Deterjan
Eklenen mod	Mor modde	Mor Mod	Mor Mod	Mor Mod	Mor Mo	Mor Mo	Mod ıl
Asit	X	X	X				
Baz				X	X	X	X

Figure 4.7 Table of observations belonged to Berat’s group with respect to Journal 5 (Task: Acid or base?)

In Journal 6 he reported the unexpected outcomes and the assessing the activity processes. The unexpected outcomes process was used only in this journal throughout all journals. In Journal 7, Berat used the assessing learned material, experienced difficulties during activity, and assessing the activity processes for the self-reflection phase. In Journal 8, Berat showed a low performance in using processes for self-reflection phase. While he used at least three self-reflection processes in previous journals, he only used the experienced difficulties during the last activity.

Table 4.16 The Self-Regulatory Processes reported by Berat

Process	**Phase**	Journal 1 Solutions	Journal 2 The Effect of Temperature on Solubility	Journal 3 Let's Examine Solubility at Micro level	Journal 4 Does it precipitate?	Journal 5 Acid or base?	Journal 6 How much acidic or how much basic?	Journal 7 Acid-Base Reactions with Metals	Journal 8 Acid-Base Titration
Planning activity	Forethought	**X**	**X**	**X**	✓	✓	✓	**NA**	**NA**
Planning data recording	Forethought	**X**	✓ ✓	**X**	✓ ✓	✓ ✓	✓ ✓	**NA**	✓ ✓
Predictions	Forethought	✓	**X**	**X**	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓
Procedure	Performance	✓	✓ ✓	**X**	✓ ✓	✓ ✓	✓ ✓	**NA**	✓ ✓
Observation Data	Performance	✓ ✓	✓	✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓
Inference based on observations	Performance	**X**	✓	**X**	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓
Unexpected outcomes	Self-reflection	**X**	**X**	**X**	**X**	**X**	✓ ✓	**X**	**X**
Assessing learned material	Self-reflection	**X**	**X**	**X**	✓	✓ ✓	**X**	✓ ✓	**X**
Experienced difficulties during activity	Self-reflection	**X**	**X**	✓ ✓	✓	**X**	**X**	✓ ✓	✓ ✓
Evaluation /Elaboration	Self-reflection	✓	**X**	**X**	✓	✓	**X**	**X**	**X**
Assessing the activity	Self-Reflection	✓ ✓	✓ ✓	**X**	✓ ✓	✓ ✓	✓ ✓	✓ ✓	**X**

* **X**: non-existent, ✓: not satisfactory, ✓ ✓: satisfactory, **NA**: not applicable

4.2.1.3.3 Analyses of Think Aloud Protocols

Although Faruk, the high achiever in the control group, was accepted as the highest achiever among all participants before the study started, during the think aloud protocols Berat showed better performance. He used both cognitive and metacognitive strategies in both units (see Table 4.17). When he got confused, he did not give up, by the help of the clues given by the researcher, he continued to think on the cases. For example, in Episode 5, initially he explained the case with neutralization reaction since the Acids and Bases Unit had already started. Then the researcher gave a prompt and Berat started to monitor the process. Different from Tolga (see Episode 15) he did not give up, continued working on the case, recalled the formula (rehearsal), employed the case to the formula and calculated solubility of the salt (metacognitive monitoring), and evaluated whether the result was reasonable (metacogntitive evaluation). At the end, he reached correct response with scientific explanation. Similarly, in Episode 6, 7, and 8, Berat thought on the clues given by the researcher, evaluated his exsting ideas whether pH could take a value bigger than 14, monitored process and reached correct response with scientific explanation. Since Berat provided information rich data, more episodes reflecting his metacognitive monitoring and metacognitive evaluation processes were given here.

EPISODE 5:

Berat: Barium sulfate… but it says solely barium ion is very dangerous, sulfate came next to it, because sulfate ion cames next to it, might it make the toxic substance neutralize? Make the toxic substance harmless for the patient?

R: Well, Ksp value is given there.

Berat: Yes.

R: Why do you think it is given?

Berat: Ksp value? 1,8 x 10^{-10}*... Iiii... x, x Ksp value, is it because it is strong or week, is that the reason?*

R: What have you done?

Berat: I separated the Barium SO_4 *into its ions.*

R: Yeah.

Berat: let it be x, x^2*... but I do not understand how it is related to that.*

R: What are you trying to find, what will you find then?

Berat: I find solubility of one of those…

R: Yeah., do you think you can use solubility?

Berat: Now it is x and x.

R: Yeah.

Berat : x^2 *is equal to 1 point...*

R: It is 1.

Berat: Is it 1 multiply 10^{-10}*?*

R: Yeah.

Berat: Now what is x, is x equal to 10^{-5}*? Yes. x is equal to* 10^{-5}*.*

R: What does 10^{-5} mean?

Berat: Isn't that a very small number?

R: Yeah.

Berat: Is that the reason why its effect decreases?

R: So?

Berat: Very small number… Probably, it has not got any effect because solubility is very small…when it goes to the stomach, it won't dissolve, it does not when it goes through stomach path because its solubility is so small…

EPISODE 6:

Berat: "Does its pH take negative value?" "(a) Does pH take negative value? Is pH=15 possible? Explain briefly your comprehension."

pH can be 15, why can't it be, it is 10-15 (6). O, what was it, emm… 1 second, o pH cannot be 14, doesn't pH take value together with pOH in interval of 14?

R: I'm asking it to you.

Berat: One second?... [s/he is writing…] In my opinion it cannot be 15, it says pH equals to 14, if it is 10-15, can't H+ be found as 15? It can, why can't it? Isn't it possible?"

R: I'm asking it to you…

Berat: Now give me a hint (copy) teacher, now I have never seen such a question where it is 15.

R: Can it be?

Berat: If pH value of H^+ ion is 10^{-15}, for example pH can be calculated as 15(10).

R: Yeah.

Berat: Why can't it be?

R: If that’so, then could it be negative (minus)? (03:20)

Berat: Can it be negative, it can’t be, I have never seen, it can’t be negative.

R: Yeah.

Berat: No, it can’t be negative.

R: Why do you think that it can’t be negative?

Berat: Emm…One second… [Silence…] I don’t know, when 10s are simplified from logarithm (then it is found) 15, it is not minus 15, I think it is found 15.

R: As you said minus pH, what is it for example? Could pH be -1?

Berat: It couldn’t be, teacher in fact pH value is between 1 and 14, isn’t it? Can it be -1, -2? Never seen such pH (value).

R: Can it be? I’m also asking to you.

Berat: Okay see, pH is from 1 to 14.

R: But you have said it could be 15?

Berat: Emm, okay, 15 but it is a high value. Hmm, from 14, there is logic as can it be lower than 1 (and) higher than 14? Can it be, as I said I haven’t seen (such things) in questions but for example if H^+ ion concentration is 10^{-15}, to calculate pH, when we use logarithm of H+, pH is found, eee pH is being 15 then. But it is not found negative.

EPISODE 7:

R: Let’s continue according the question. Normally, if there was not a tampon in the blood, and the amount of lactic acid increases, how would pH change? (Prompt)

Berat: If lactic acid comes???

R: Yeah.

Berat: (mumbling) it is more acidic

R: How?

Berat: It is acidic, pH decreases.

R: You would expect that it would decrease, but it would not.

Berat: Yes.

R: The reason for not decreasing is these two substances. How does this tampon solution work?

Berat: How does it work? For example, if we add basic it decreases the alkaline. When we add acidic… or it could be that neither it decreases nor it does not decrease… this could be a substance that gives reaction to both acidic and basic, it makes them ineffective. It could be it.

R: Ok, is there any substance that could make the acid ineffective?

Berat: Here it is teacher, bicarbonate bicarbonic acid, this brings the acid, and bicarbonate brings the bases.

R: Ok, now think about lactic acid's acidic characteristic, think about all the information, all the comments we have made so far, rethink the question again. How would you comment?

Berat: About what??? Can you write the chemical reaction of this?

R: Not the reaction …

Berat: Ok, let me read the question again. (reads the question loud) Look teacher, like we said, this tampon solution might affect the change of pH. (read *the question loud, not clear) It causes diseases, for example this bicarbonic acid, it might prevent the increase of acidity.*

R: How does this carbonic acid work in the tampon system?

Berat: In fact, now, for example, came up with something that makes sense, bicarbonic acid can go into the reaction with acids. I think bicarbonic acid might go into reaction with bases.

R: Yeah.

Berat: Because if acids go into reaction with acids, bicarbonate can go into the reaction with bases and it might equal them. Now, you already know, 7.4 is something close to neutral, is not it?

R: Yeah.

Berat: Because it is close to neutral, the acid will go into reaction with the base, so that it becomes neutral. The base will go into reaction with the acid, so that it becomes neutral. That is what I thought.

R: Ok then, what makes lactic acid neutral?

Berat: "However we don't observe any change in blood's pH". Lactic acid neutralizes with bicarbonate, because it is acidic, and it is not effective any more. That is it.

EPISODE 8:

Berat: Ok. pH change range is from 4,4 to 6,2. Can we do a logic like, if we look at the change range, if we look at the change range of these things, between these two things, for example it says from 4,4 to 6,2. Our change range is between 7,46 to 10,00. We might not be able to observe this. Can we do a logic like this, teacher?

R: How do you interpret the next one then?

Berat: This is between 8,3 and 10,0. Is it 8,3??? 8,3 to 10,0, it could be.

R: Yeah.

Berat: We can use this one because this has range of 8,3 to 10,0, we sad equivalence point, I think this works.

R: If I use the one on top, what happens?

Berat: If I use the one on top, it will change color at pH, 4,4.

R: Yeah.

Berat: So, it changes the color quickly.

R: what happens, if color changes quickly?

Berat: We find the wrong equivalence point wrong.

Table 4.17 The Use of Cognitive and Metacognitive Strategies and the Achievement of Berat with respect to Think Aloud Protocols

	Solubility Equilibrium						**Acids and Bases**					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Rehearsal	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓
Elaboration		✓	✓	✓	✓	✓				✓	✓	✓
Organization												
Metacognitive Awareness	✓		✓	✓			✓	✓			✓	✓
Metacognitive Monitoring	✓	✓		✓				✓			✓	✓
Metacognitive Evaluation	✓							✓			✓	✓
Achievement	7	A) 1 B) 1	A) 7 B) 7	A) 2 B) 6	7	3	2	A) 7 B) 1	2	7	A) 7 B) 1	A) 2 B) 3 C) 2 D) 3 E) 7 F) 7

* ✓**:** The process is existent.

* 1: Wrong response; 2: Wrong response with poor/insufficient (scientific) explanation; 3: Partially correct response; 4: Correct response without (scientific) explanation; 5: Correct response with irrelevant (scientific) explanation; 6: Correct response with poor/insufficient (scientific) explanation; 7: Correct response with (scientific) explanation

4.2.1.4 Ayşe

Ayşe was the high achiever in the experimental group. She was not a strategic planner either; however, she was studying for the course repeatedly. In terms of motivation, she had mastery-approach goals, high self-efficacy beliefs, and utility value beliefs. In the performance phase, she used diverse strategies such as help seeking, underlining, and note-taking. She evaluated her performance in terms of number of correct questions, and attributed success to her effort, teacher characteristics, and question types.

4.2.1.4.1 Analyses of Interview

Ayşe was not planning purposefully while she was studying for chemistry course. In terms of motivational beliefs, she reported use of mastery-approach type goals as stated in the following quote: "*the thing that motivates me to study for chemistry is my teacher. I like chemistry. It is fun and exciting, and I have curiosity to learn chemistry*". Additionally, Ayşe possessed high self-efficacy belief that she was capable of learning the content of chemistry. For example, she stated that "*I am, for example, very good at Solubility Equilibrium. I mean, I believe that I can solve all the problems*". Besides, she had the value belief that the chemistry course was important in order to succeed in university entrance examination: "*Actually grade is not important. Understanding the topic is more important for me. Actually, while stuying for chemistry exam, I pretend like I do not study for the course exam. I study for university entrance examination. When I study for the university entrance examination, in fact I study for the course examination.*"

In the performance phase, Ayşe used several task strategies when studying for the course such as rehearsal, resolving questions, help seeking, underlining, and taking notes. She talked about her studying techniques as: "*what am I doing today? For example, we solved questions at the class and then I am resolving these questions at home. Next I am taking short notes from what the teacher made us written during the course. After that, I am solving new* *questions about the subjects. Of course, I ask the questions that I cannot solve at home either to the teacher at the private course or our classroom teacher*."

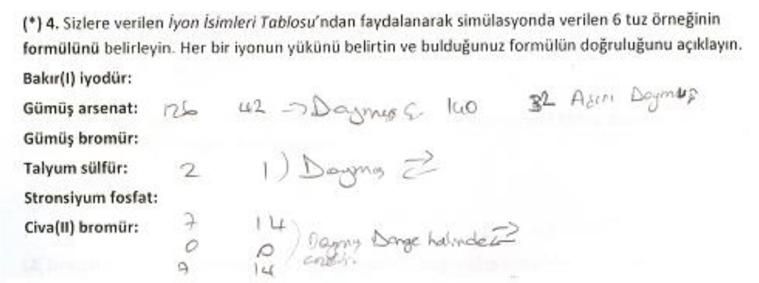
Ayşe decided whether she understood chemistry subject or not in terms of the number of the correct answers she gave to the questions at the tutoring books. She explained it as follows: "*After understanding the subjects, I solve the questions. If I solve the 9 questions correctly out of 10, I believe that I am sure that I understood. If I did 4 mistakes I definitely did not understand that subject*." Moreover, she attributed her success to different factors such as the teacher, question type, and her effort. In the following quote she described how the teacher and question type affected her performance in the exam: "*I had good grade last semester on chemistry but this semester it is better because last semester there was a different teacher. The teacher could not teach well.... For example I got 70 from the exam. Actually, I believe that I did all questions and I was sure of myself. The reason might be it was a multiple choice test. If it was a writen examination, I would get good grade*."

4.2.1.4.2 Analyses of Journals

Table 4.18 provides the analyses of journals submitted by Ayşe. In Journal 1, the group did not use or report any self-regulatory processes but Ayşe used only evaluation/elaboration process for self-reflection phase. In Journal 2, while the group did not use or report any process regarding the forethought phase, they engaged in all the processes regarding the performance phase. Among these processes, the observed data and inference based on observations were given at a satisfactory level; however, the procedure process was not at satisfactory level. In this journal Ayşe reported only her unexpected outcomes for the self-reflection phase.

In Journal 3, she again did not use any self-reflection processes. The group also showed a low performance in this journal because they did not use or report any process for the forethought phase and they only reported their observations in the performance phase which was not satisfactory. The data given in Figure

4.8 was belonged to Journal 3 “Let’s Examine Solubility at Micro level” in which a simulation was used to investigate the water solutions of slightly soluble salts at micro level. In this part, the students were asked to identify formulas of given ionic compounds using the simulation. Although the students took notes during the activity including number of ions and type of solution such as saturated solution, the notes were not organized and not clear; therefore, it was not accepted *satisfactory* in terms of observations and the inference based on observations process was not observed.


(*) 4. Sizlere verilen *İyon İsimleri Tablosu*'ndan faydalanarak simülasyonda verilen 6 tuz örneğinin formülünü belirleyin. Her bir iyonun yükünü belirtin ve bulduğunuz formülün doğruluğunu açıklayın.

Bakır(I) iyodür:

Gümüş arsenat: 126 42 → Doymuş Ç. 140 32 Aşırı Doymuş

Gümüş bromür:

Talyum sülfür: 2 1) Doymuş ⇄

Stronsiyum fosfat:

Civa(II) bromür: 7 0 9 14 0 14 Doymuş Denge halinde ⇄

Figure 4.8 Data belonged to Ayşe’s group with respect to Journal 3 (Examine Solubility at Micro level)

As from Journal 4, both the group and Ayşe indicated an improvement in using self-regulatory processes. The group used all processes regarding both the forethought and performance phases at satisfactory level. Similarly, Ayşe used all the processes except the assessing learned material process for the self-reflection adequately. In Journal 5, again the group used all processes regarding the forethought and the performance phases while Ayşe used only the unexpected outcomes process for the self-reflection phase. Actually, from as Journal 4, the group started to use all processes at satisfactory level and Ayşe increased use of self-reflection processes except the experienced difficulties during activity process. She only reported her experienced difficulties in Journal 4 “Does it precipitate?” This might indicate that Ayşe did not experience much trouble during the study.

The students were asked to draw pOH scale in order to practice the pH and pOH concepts at home. However this was not an assignment or compulsory work. Among the focal students in the experimental group, Ayşe was the only student who worked on the task. Figure 4.9 belonged to her work. Above the scale, she translated the pH values of the chemicals she investigated in Journal 6 (Task: How much acidic or how much basic?) into pOH values. Next, she marked the pOH values of these chemicals on the scale. The task was completely authentic to students, to complete this task Ayşe assumed to use cognitive and metacognitive strategies effectively. However, her inference was not correct. Most probably, it happened because of her wrong use of “>” and “<” signs. For example, she marked pOH value of NaOH solution as 1, and defined it as a base solution. From the drawing, she reported that the solutions with a pOH value greater than 7 was base [pOH>7] opposing to the remaining information in the data. It was assumed that this happened because of incorrect use of mathematical signs “>” and “<”; not indicating that she misplaced the solutions on the scale.

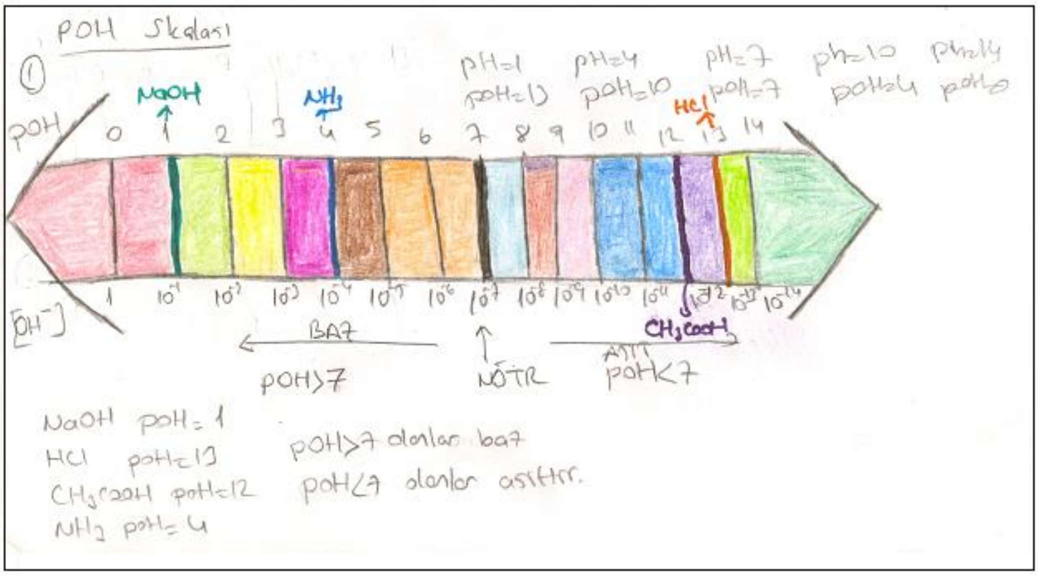


Figure 4.9 Drawing of pOH scale belonged to Ayşe

Table 4.18 The Self-Regulatory Processes reported by Ayşe

Process	**Phase**	Journal 1	Journal 2	Journal 3	Journal 4	Journal 5	Journal 6	Journal 7	Journal 8
		Solutions	The Effect of Temperature on Solubility	Let's Examine Solubility at Micro level	Does it precipitate?	Acid or base?	How much acidic or how much basic?	Acid-Base Reactions with Metals	Acid-Base Titration
Planning activity	Forethought	**X**	**X**	**X**	✓✓	✓	✓	**NA**	**NA**
Planning data recording	Forethought	**X**	**X**	**X**	✓✓	✓✓	✓✓	**NA**	✓✓
Predictions	Forethought	**X**	**X**	**X**	✓✓	✓✓	✓✓	✓✓	✓
Procedure	Performance	**X**	✓	**X**	✓✓	✓✓	✓✓	**NA**	✓✓
Observation Data	Performance	**X**	✓✓	✓	✓✓	✓✓	✓✓	✓✓	✓✓
Inference based on observations	Performance	**X**	✓✓	**X**	✓✓	✓	✓✓	✓✓	✓✓
Unexpected outcomes	Self-reflection	**X**	✓	**X**	✓✓	✓	✓	**X**	**X**
Assessing learned material	Self-reflection	**X**	**X**	**X**	**X**	**X**	✓✓	✓✓	**X**
Experienced difficulties during activity	Self-reflection	**X**	**X**	**X**	✓✓	**X**	**X**	**X**	**X**
Evaluation /Elaboration	Self-reflection	✓✓	**X**	**X**	✓✓	**X**	✓✓	✓✓	✓✓
Assessing the activity	Self-Reflection	**X**	**X**	**X**	✓✓	**X**	✓✓	✓✓	✓✓

* **X**: non-existent, ✓: not satisfactory, ✓ ✓: satisfactory, **NA**: not applicable

4.2.1.4.3 Analyses of Think Aloud Protocols

Analyses of think aloud protocols belonged to Ayşe, is presented in Table 4.19. Accordingly, she also improved her strategy use in the Acids and Bases Unit compared to the Solubility Equilibrium Unit. She used more metacognitive strategies in the second think aloud excersize. In Episode 9, she questioned herself what could equate acidic characteristic of the solution. Actually she meant that, what could neutralize the lactic acid. Then she monitored the process and provided a sufficient correct response. In Episode 10, she stated the given case in her own words (elaboration) and explained why she could not make any comparison in confidence (metacognitive awareness).

EPISODE 9:

Ayşe: Hımm, why did I think like that? Because, there should be something else to equiate this..

R: How could that be?

Ayşe: Hımm... I mean, at the end?

R: Let's say the blood is mixed with lactic acid. What, do you think, will happen?

Ayşe: lactic acid… as it is an acid,

R: Yeah.

Ayşe: It should provided with the base, or there should be an alcaa base, so that the value can be preserved.

R: Yeah.What do you think,what will help this?

Ayşe: Bicarbonate?

R: Why do you think that is bicarbonate?

Ayşe: Because this is acid, and at least we know that it is carbonic acid. There is only bikarbonat in this environment; I guess it should be basic so that it can preserve the environment.

EPISODE 10:

Ayşe: (silently reading)... The results of the experiment are given ....they are seen on the Table... What could be said about the solution before the titration? I mean, now, we have not added anything in it. The pH value is 2.88. So, this is an acid. So, is it the acid in the cup? Then we should add base.

R: It is already written over there.

Ayşe: Hı... I have not seen that. There is NaOH as a base. Then, we added 10 mL, we already said that, 25 mL.

R: Ok then, can you say anything about whether this acid is a strong or a weak one?

Ayşe: Actually, we cannot make a comparison, but it is close to 1 so it can be strong, but not exactly.

R: Why did you say that we cannot make a comparison?

Ayşe: I mean, that is because, if there were any other solutions given, or an acid given, we could have made a comparison accordingly. Let's say it's value is 3 and this one is 2.88, then I could have said that this one is stronger. But now only this one's information is given, so I cannot make any inference now.

Table 4.19 The Use of Cognitive and Metacognitive Strategies and the Achievement of Ayşe with respect to Think Aloud Protocols

	Solubility Equilibrium						**Acids and Bases**					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Rehearsal	✓		✓	✓	✓		✓	✓	✓			✓
Elaboration		✓	✓			✓	✓		✓	✓	✓	✓
Organization												
Metacognitive Awareness		✓									✓	✓
Metacognitive Monitoring	✓	✓							✓		✓	✓
Metacognitive Evaluation												✓
Achievement	6	A) B) 2	A) 7 B) 7	A) 3 B) 3	6	3	1	A) 2 B) 1	2	7	A) 7 B) 7	A) 7 B) 3 C) 2 D) 3 E) 2 F) 5

* ✓**:** The process is existent.

* 1: Wrong response; 2: Wrong response with poor/insufficient (scientific) explanation; 3: Partially correct response; 4: Correct response without (scientific) explanation; 5: Correct response with irrelevant (scientific) explanation; 6: Correct response with poor/insufficient (scientific) explanation; 7: Correct response with (scientific) explanation

4.2.2 Case 2: Self-Regulatory Practice in the Control Group

In order to describe second case, the self-regulatory practice in the control group, the analyses of interviews and think aloud protocols are given for Ege, Meryem, Tolga, and Faruk.

4.2.2.1 Ege

Ege was the low achiever in the control group. Based on results of his interview analyses, he possessed performance-approach goals, high self-efficacy beliefs and utility value beliefs as motivational orientations in the forethpught phase. However he did not report use of strategic planning process. In the performance phase, he employed Attention focusing, task strategies, and self-experimentation processes. Finally, he attributed success to his effort and teacher characteristics, and increased effort after experience of failure.

4.2.2.1.1 Analyses of Interview

Based on the interview with Ege, he reported use of performance-approach type goals in the forethought. For example, he stated that he studied for chemistry in order to compete with his classmates: "*it is a fact that it is good to compete with others. They should be even in higher level than you, because if you are at the same level then you get the same grades. But if there are people who are more successful than you, then you become more passionate and then there is a competition*". Moreover, Ege believed that he possessed high level of self-efficacy belief in learning chemistry content: "*I am especially interested in chemistry because I can be successful in this course.*" In addition, he possesed value beliefs in chemistry; that is, learning chemistry was important to do well in the university entrance examination, and when he would enroll in a university program. For instance, he mentioned that "*chemistry will be important in the future, because I will be asked chemistry questions in university entrance exam, also when I start my university education I will learn chemistry. So now my chemistry courses are actually affecting my future, and* *my future career*." However, he did not make any strategic planning while studying for the course.

In the performance phase, Ege reported use of attention focusing and task strategies as self-control processes. He mainly implemented rehearsal strategy and solved additional questions. In addition, he mentioned that he employed self-experimentation process. For example, once he experimented taking an exam with and without much studying: "*I have already tested it. I did not study an exam, I did not think I would succeed in that, in fact I understood the topic, but I did not study. I got "4" from that exam. Then, I understood the topic, but I studied the exam. In that exam, I did not miss any questions and I got 5. In other words, I increased (my grade), then I understood the importance of studying an exam*."

As for self-reflection phase, Ege attributed his success in chemistry course to his effort and hard work, careful listening of his teacher, and the characteristics of the teacher. When he was asked the reasons of becoming successful in chemistry, he replied as "*First of all, of course, 'the studying'. The teacher is another factor since we don't know the subject and we learn it when s/he teaches us so the teacher role is important. Also if you try, you will be successful*". He reported that he was changing his learning goals or study strategies after experience of failure and continued working on the task which indicated an adaptive reaction to learning process. He stated that "*When I get a low grade, then I did not get the topic. And I really get sad. Then I will try to overcome it. Then I will focus on the coming exams and continue studying*."

4.2.2.1.2 Analyses of Think Aloud Protocols

Table 4.20 presents the analyses of think aloud protocols of Ege with respect to the use of cognitive and metacognitive strategies and the achievement. It is evident that, he did not use much strategy in both units. He only used "rehearsal" and "elaboration" strategies, but did not use any metacognitive strategies. Additionaly, his achievement scores were mostly 1 or 2, indicating that his responses were totally wrong or including inaccurate explanations. Accordingly, he did not show much progress in both units in terms of strategy use and achievement. In Episode 11, Ege tried to explain whether pH value could get a negative value or be 15. In Episode 12, he compared two conditions of the George Washington's marble sculpture in New York, a picture taken in 1944 and a more recent picture. In both episodes, he tried to provide some explanation. In the first one, he recalled the information given in the class but did not criticize it. In the second one, he restated the case in his own words. Accordingly, he used rehearsal strategy in the first one and elaboration strategy in the second one. Although he could not get correct response, he provided incomplete scientific explanation in the first episode. Therefore, the achievement category was considered as "2". However, he only restated the case and did not provide any relevant explanation in episode 12; as a result it was accepted completely wrong response and the achievement category was 1.

EPISODE 11:

R: Can pH get a negative value or can it be 15?

215: *pH cannot get a negative value because it is always positive. It's value changes from 1 to 14, so it cannot be 15 neither.*

EPISODE 12:

Ege: Picture below… (continued mumbling)…So, it shows the latter condition of the marble sculpture which stayed here for a long time. So, deterioration is happening.

R: How can I explain this?

Ege: This, calcium carbonate, so, as the day goes by, its vitality disappears.

R: What could the reason be?

Ege: The reason is due to staying too long, it has deteriorated. How about the pieces falling? What could be reason? What else? Nothing.

Table 4.20 The Use of Cognitive and Metacognitive Strategies and the Achievement of Ege with respect to Think Aloud Protocols

	Solubility Equilibrium						Acids and Bases					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Rehearsal	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
Elaboration		✓					✓			✓	✓	✓
Organization												
Metacognitive Awareness												
Metacognitive Monitoring												
Metacognitive Evaluation												
Achievement	2	A) 1 B) 1	A) 7 B) 1	A) 2 B) 1	3	3	1	A)1 B) 1	1	1	A) 1 B) 1	A)2 B) 2 C) 2 D) 2 E) 2 F) 6

* ✓**:** The process is existent.

* 1: Wrong response; 2: Wrong response with poor/insufficient (scientific) explanation; 3: Partially correct response; 4: Correct response without (scientific) explanation; 5: Correct response with irrelevant (scientific) explanation; 6: Correct response with poor/insufficient (scientific) explanation; 7: Correct response with (scientific) explanation

4.2.2.2 Meryem

Meryem was the medium achiever in the the control group. She possessed performance approach goals and value beliefs as motivational orientation in the forethought phase. However, she did not make strategic planning same as other focal students. In the performance phase, she commonly employed imagery and rehearsal strategies. In the self-reflection phase she assessed her performance in terms of number of correct responses, attributed success to interest in the topic and listening to the teacher, and showed defensive reaction (gave up) after experience of failure.

4.2.2.2.1 Analyses of Interview

Meryem was not a strategic planner either. She was studying occationally to get high grades. She was motivated by grades indicating performance-approach goal orientation. She also had value beliefs to study for chemistry. She stated that chemistry was important for her future career and in daily life: "*chemistry is important because we learn about different substances inside us*".

In the performance phase, she employed imagery strategy; she created mental images to code given information. Meryem explained one of the reasons for her to like chemistry was that she could imagine the material: "*another reason is that it is easy… it is practical... I mean everything is obvious. For example periodic table, everything is clear, 8 elements in group A, 8 elements in group B, than group D and F, all of it…It is useful because I can imagine it. It is very different [interesting]. For example, I can compare it to something else; this is why it is practical. I mean, according to me*." Moreover, she mostly used rehearsal as task strategy. She stated that she repeated what the teacher talked about during the lesson at home. Her rehearsal technique was based on studying the easy subjects initially and then continuing with the more difficult subjects.

Meryem evaluated her learning in the chemistry regarding to the number of correct responses given to the questions. In the following statement it was obvious: "*If I solve problems, it is effective, if I don't, it is not*." Moreover, she attributed her success to interest in the subject and listening to the teacher. She explained it as: *"...if I like the topic, I listen to the teacher. If the subject was not interesting, I don't listen to her.....If I listened to the chemical equilibrium topic, I would not get a bad grade.*" Finally, she gac-ve up studying in the event of failure.

4.2.2.2.2 Analyses of Think Aloud Protocols

Similar to Ege, the low achiever in the control group, Meryem also used rehearsal and elaboration strategies frequently. However, she used monitoring strategies in two tasks in the Solubility Equilibrium Unit. Additionally, she performed better in terms of achievement compared to Ege (see Table 4.21). In Episode 13, use of rehearsal and metacognitive monitoring strategies was evident. Initially she listed ions from her memory which was an indicator of rehearsal strategy. After she completed the task, the researcher gave a clue by asking the reason of giving the Ksp values of two salts in the task. Then, she monitored the consistency between her response and the information given in the task, and changed her response. However, she could not reach correct response. In Episode 14, she recalled the color change in titration experiment demonstrated by the teacher. She mentioned color change but did not explain its relation to equivalance point. Therefore, question 6 part (e) was a wrong response with poor/insufficient (scientific) explanation; while, question 6 part (f) was a correct response with poor/insufficient (scientific) explanation.

EPISODE 13:

Meryem: hımm ok.(reading silently)… First, Mg will be in the precipitate.

R:Yeah.

Meryem: Because it dissolves slightly.

R: Yeah.

Meryem:Also there will be lead.

R:Why?

Meryem: It also dissolves slightly.

R: Yeah.

Meryem: What is given here, it is mentioning salts. Ca will not be. Ca will be in the solution.

R: Yeah.

Meryem:...(writing) ...

R: Can you write it down, what they will be in the solution, which ions are going to be in the solution?

Meryem: Hı hı, I shall write them too but first I shall write these. Ca is going to be here, Mg is going to be in this, Lead is going to be in this. Then, this, NH_4, I mean ammonium,…it is going to be in the precipitate, NH_4... Yes now it is the most critical question Ag?...Ag is going to be here. OK

R: OK?

Meryem:Ok. It is asking them.

R:Finished?

Meryem:Finished.

R: Ksp values of two substances are given to you. What might be the reason?

Meryem: I didn't read it, for example, it is excellent, isn't it?

R:Hı now, what are you thinking when you read it, what is the reason to give it?

Meryem:...

R:Why are the Ksp values of those two substances given?

Meryem:...

R:What does Ksp of a substance mean?

Meryem:...Something has changed right now. Its Ksp is bigger than its Ksp that it dissolves… it dissolves more, it precipitates.

R:You said, $PbCl_2$ dissolves more, AgCl precipitates

Meryem: It precipitates. Because of the Ksp.

EPISODE 14:

Meryem: It makes change at the condition of 4,4 -6,2. Which means…

R: So what?

Meryem: By this, in this interval, I mean in this interval, I mean between 25 mL and 40 mL, its color changes.

R: Yeah.

Meryem: Which means at 40 mL, when 25 mL is added it change color.

R: Then, can I use this matter as indicator?

Meryem: Yes, you can use because you know the value that its color changes.

R: Yeah.

Meryem: So it can be used (writing)… pH color change… Then this one also can be used. (Because) it is in this interval.

R: Yeah.

Meryem: If we can observe color change. For example, we… It has already given the value, so we can use it.

Table 4.21 The Use of Cognitive and Metacognitive Strategies and the Achievement of Meryem with respect to Think Aloud Protocols

	Solubility Equilibrium						**Acids and Bases**					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Rehearsal		✓	✓		✓	✓	✓		✓			✓
Elaboration	✓	✓	✓								✓	✓
Organization												
Metacognitive Awareness												
Metacognitive Monitoring				✓		✓						
Metacognitive Evaluation												
Achievement	7	A) 2 B)1	A)7 B) 7	A) 3 B) 3	2	1	7	A)1 B) 1	2	1	A) 1 B) 1	A)2 B) 2 C) 3 D) 2 E) 2 F) 6

* ✓**:** The process is existent.

* 1: Wrong response; 2: Wrong response with poor/insufficient (scientific) explanation; 3: Partially correct response; 4: Correct response without (scientific) explanation; 5: Correct response with irrelevant (scientific) explanation; 6: Correct response with poor/insufficient (scientific) explanation; 7: Correct response with (scientific) explanation

4.2.2.3 Tolga

Tolga was the medium achiever in the control group. In the forethoughtnphase, he did not use strategic planning either. He was also motivated by performance-approach type goals and utility value beliefs. In the performance phase, he employed note-taking and rehearsal strategies. Finally, in the self-reflection phase, he used grades as a standard for success, attributed success to effort and listening to the teacher, and showed defensive reflections.

4.2.2.3.1 Analyses of Interview

Tolga did not employ strategic planning, rather he was studying irregularly. Same as other focal students he had performance-approach type goals and utility value beliefs as forethought motivation processes. He stated that he studied for the chemistry course to get high grades, which would in turn help him for university entrance examination: "*there is no other reason. I study because I want to pass the course*". In the following statement, he explained the importance of university entrance examination in his study: "*I try to understand the topic, if I don't understand it..... When I examine the general exams, I mean the items in the university exam, if enough items related to the topic haven't been asked, I do not care about the topic and I don't study much*."

Tolga used note taking and rehearsal techniques frequently in the performance phase to understand the chemistry concepts; "*First of all, I summarize the entire topic, and then resolve the solved questions, and next I solve questions which are similar to the previous ones.*"

Tolga evaluated his learning by means of solving problems and getting high grades on the exam: "*When I get a high grade on the exam, I accept I achieved it*". Moreover, he attributed his success to his effort or hard work, and listening to their teacher carefully. For example, he stated that "*If there was not an outside factor, I would attribute it to my study.*" Finally, he reported that he experienced procrastination and/or cognitive disengagement in order not to experience disappointment in future performance which were indicating defensive strategies. He reported that, he quit studying when he felt frustration: "*Actually it depends, sometimes I got bored studying chemistry and I quit studying*".

4.2.2.3.2 Analyses of Think Aloud Protocols

The results of the analyses with respect to the use of cognitive and metacognitive strategies and the achievement for Tolga are presented in Table 4.22. According to Table 4.22 he also used rehearsal and elaboration strategies more often; however, all his responses were wrong. In Episode 15 while explaining the first task in the Solubility Equilibrium Unit, referring to the arithmetic questions solved in the classroom, he figured out that there should be a calculation. Actually, this question did not require any calculation; rather, students were expected to interpret the meaning of Ksp. After he stated that he could not explain the case, the researcher gave him a prompt and asked whether the Ksp value could help. However, he did not try and he gave up. On the other hand, there was a slight improvement in his strategy use and achievement level in the Acids and Bases Unit. For example, he used all metacognitive strategies in Question 1 while explaining how woud the pH value change, when the same amount of water was added to the detargant with a pH value of 10. As seen in Episode 16, initially he stated the main point of the question which was the pH value of water was required to solve the case. In this instance, elaboration strategy was marked. Next, he figured it out based on the pH value of drinking water at home which indicated the awareness of everyday applications of the topic. To find the answer, he added both pH values and gave the response as 18 which was a wrong response. At that moment he remembered that the pH values range between 0 and 14 which indicated use of rehearsal strategy. This forced him to evaluate his initial response comparing to the pH range where metacognitive evaluation was obvious. At that moment, he stated to monitore the consistency between his existing idea (pH ranged between 0 and 14) and his initial response. Finally, he came up with the conclusion that there was a decomposition which formed a new mixture and decreased the pH value. Although the decrease of pH value was the correct response, existence of a reaction was also related to the response, the reaction was not decomposition reaction but neutralization reaction. As a result although his response was correct response, his explanation was poor/insufficient. He used mostly rehearsal and elaboration strategies while explaining the remaining five cases in the Acids and Bases Unit.

EPISODE 15:

Tolga: Now here, is this is a question to solve or is it an interpretation?

R: What's your opinion?

Tolga: If Ksp was given here, it means that again, emmm, there should be a calculation.

R: Yeah.

Tolga: To make the calculation, what was it like? (Murmuring, chemical equilibrium unit… can you explain it?) Yes. Are you asking if I can explain it?

R: Yeah.

Tolga: But I, I think I can't explain it.

R: Ok.

Tolga: Yes.

R: Will you try?

Tolga: … I haven't studied chemistry for two weeks, I should say that.

R: Ok.

Tolga: Emm right now, emm

R. Yeah

Tolga: It seems like I can't do it.

R: You think you can't do it.

Tolga: Yes.

R: Do you want me to pass?

Tolga: Yeah.

R: Would you like to try? Is there a reason that Ksp is given?

Tolga: *The reason that Ksp is given…*

R: Why was it given? Eh?

Tolga: The reason why Ksp is given… emm… (murmuring, X-rays…) I won't be able to solve it.

R: Okay.

EPISODE 16:

Tolga: Now here, to conclude last situation,

R: Yeah.

Tolga: We have to know pH of water.

R: Yeah.

Tolga: pH of water is…

R: What do you expect?

Tolga: …, pH of water is, the water we drink at home its pH was 8, yes it was 8. Drinkable water's pH was 8, but what was it, the pH of water?

R: Okay, I'm expecting an approximate value, I don't expect an exact numerical value.

Tolga: Okay, then it means, approximately,

R: Yeah yeah.

Tolga: it can be 18 in my opinion.

R: 18.

Tolga: Yes.

R: How did you calculate?

Tolga: Well now, detergants's pH is already given as 10.

R: Yeah.

Tolga: And as we added water, its pH will rise.

R: Yeah.

Tolga: Otomatically.

R: Okay.

Tolga: But how can its pH value be 18?

R: How it can be?

Tolga: I'm thinking it too.

R: What makes you conflicted here?

Tolga: Now, the pH values are between 0 and 14.

R: Yeah.

Tolga: Acid-bases. But can pH exceed 14? Yeah it is another issue, this question is very conflicting… Yes … it askes what will be the pH, it doesn't mention to acid or base.

R: What do you expect about pH, increasing or decreasing?

Tolga: Hmm… I expect it is increasing when we add water… also there is a probablity of decrease… I mean it becames a new mixture…. se it may decrease or increase…. but in this case I think it can decrease.

R: Why?

Tolga: Why, becuase of water... In my opinion, pH decrease.

R: Why did you think like this now, why?

Tolga: Why did I think like that?

R: Yeah.

Tolga: When we add water to the detergant, a new mixture is formed; i think water can take a role of decomposer.

R: Yeah.

Tolga: When it decompopses… it deacreases the pH of surrounding, like this.

Table 4.22 The Use of Cognitive and Metacognitive Strategies and the Achievement of Tolga with respect to Think Aloud Protocols

	Solubility Equilibrium						**Acids and Bases**					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Rehearsal	✓	✓		✓	✓	✓	✓	✓	✓			✓
Elaboration		✓		✓		✓	✓			✓	✓	✓
Organization												
Metacognitive Awareness							✓					
Metacognitive Monitoring						✓	✓					
Metacognitive Evaluation							✓					✓
Achievement	1	A) 1 B) 1	A) 1 B) 1	A) 1 B) 1	2	1	6	A)1 B) 1	2	6	A) 1 B) 1	A)2 B) 2 C) 6 D) 2 E) 2 F) 6

* ✓**:** The process is existent.

* 1: Wrong response; 2: Wrong response with poor/insufficient (scientific) explanation; 3: Partially correct response; 4: Correct response without (scientific) explanation; 5: Correct response with irrelevant (scientific) explanation; 6: Correct response with poor/insufficient (scientific) explanation; 7: Correct response with (scientific) explanation

4.2.2.4 Faruk

Faruk was the high achiever in the control group, and he was the highest achiever among the all participants in the current study with respect to the teacher's judgment. Although he was studying regularly for the course, he was not making an intentional plan. However, different from other focl students he acknowledged the importance of planning. He possessed performance-approach type goals and value beliefs as motivational orientation. In the performance phase, he reported use of task strategies, and self-recording and self-expermentation subprocesses. As for self-reflection, he accepted solving questions correctly as an indicator for success, attributed his success to his effort, and continued studying in the cases when he did not understand the topic.

4.2.2.4.1 Analyses of Interview

In the forethought phase, Faruk did not make a purposeful plan for his study. However, he reported that he studied for the course repeatedly. He was motivated by performance-approach type goals, the influence of his family, and the university entrance examination. In the following piece he explained the family influence and the importance of university entrance examination: "*...chemistry is important because items are asked from the field of chemistry in the university exam...I have studied it because my family has made a sacrifice for me so I have to study and be successful at the university exam...*" Accordingly, he had utility value as a value belief for chemistry course. In addition to university entrance examination, he also thought that he would need chemistry if he would be an engineer in the future.

Faruk used task strategies under the self-control process and self-recording and self-experimentation subprocesses under the self-observation process in the performance phase. He stated that he reviewed the chemistry content at home, if he did not understand it at school. He also stated that he would ask for help from teachers or peers, if he had problems with understanding the topic or the solution of the problems. Moreover, among focal students, only Faruk used self-recording process. He expressed that "...*I can only study alone, because my concentration is broken if anybody is with me....I made a plan and tried to follow it but I couldn't. Then I went to the school counselor and we did a new plan....I will start studying according to theat plan on the coming Monday.... Actually, I started to make a plan this year. I heard from someone who enrolled the university and he advised me to study with a plan. Everybody* [who passed the university exam] *studied systematically, so I thought that it should be right and I decided to try it* [make a study plan]... *For example, I study today physics then mathematics, tomorrow I will study Turkish literature. If I study regularly, I can manage all of them* [the courses]. " In addition, as it was seen obviously from the fragment of the transcript, Faruk used self-experimentation process as well as self-recording process.

Faruk judged his understanding of chemistry topic according to the number of correct responses: "*If I solve all of the problems correctly or make just one mistake at the test, I say myself I understood this chemistry subject and then I continue solving questions from different test books*." Moreover, he attributed his success to his effort. Furthermore, Faruk can be classified as an adaptive learner, because he stated that he continued to study even after he did not understand the subject matter: "*I review the subject if I don't understand. I look and study from another source and I try to solve additional problems to understand it*".

4.2.2.4.2 Analyses of Think Aloud Protocols

During the course of the study, the cooperative teacher mentioned Faruk as the most successful student not just among the control group students but also among the experimental group students. The results of the analyses with respect to his use of cognitive and metacognitive strategies and his achievement are presented in Table 4.23. Accordingly, he used diverse strategies and achieved more in the Solubility Equilibrium Unit. However, his performance decreased in the Acids and Bases Unit. In Episode 17, while comparing two conditions of the George Washington's marble sculpture in New York, he tried to recall and link his prior knowledge to the given task. He explained it with the acids in the air which could be formed by bacteria existed in the air. Therefore, he used elaboration strategy but could not reach the correct response. In Episode 18, initially he gave the definition of equivalence point memorizing the material presented in class (rehearsal), next checked the given table but could not find the pH value 7. At that point he was confused. By the help of the prompt given by the researcher he recalled the formula (rehearsal) and employed it to given case (elaboration). Since he explained why he employed that formula, he was aware of what he learnt, this indicated metacognitive awareness. Then he evaluated whether his response (the point when 50 mL NaOH added, pH=8.73) was reasonable or not (metacognitive evaluation), to reach a decision he monitored the consistency between the definition he gave (pH=7) and the the result of his calculation (pH=8,73) (metacognitive monitoring). As a result of this monitoring, he reached the conclusion that equivalence point should be the point when 50 mL base added. However he was not provide full explanation, therefore his response acceppted as a correct response with poor/insufficient (scientific) explanation".

EPISODE 17:

Faruk: O acid, as acid remains longer, it wears away that part by time, it dissolves, I say like this.

R: What is the soruce of acid? When I say acid..?

Faruk: Calcium carbo… (silence)

R: Is calcium carbonate an acid?

Faruk: Acid, no ☺ (silence)…. Acids, in my opinion, may be formed by the microbes and bacteria in air, acid. The hydrogen in air, so-and-so.

R: Well what did you say about how the acid affects?

Faruk: The acid in air… I don't know… is rust made from iron?

R: From marble.

Faruk: Marble.

R: Sculpture made from marble.

Faruk: Is it getting rotten? O marble… calcium carbonate…

EPISODE 18:

Faruk: Equivalence point. O, isn't it the point where it is exactly neutralize? It is 7.

R: You remember like that.

Faruk: It is like…

R: By looking at this information, where is the equivalence point? How do we find it?

Faruk: There was something like M. V.TD, we were using formula; we were writing acid at one side and base to other. Then we equalize them. When we make the m equal, so you want me to make calculation? Emm one of them is 0.1-50 and the other one is 0.1-50 and their things are 1. Directly 50 mL, But it was here again, that is equivalence point. (it is marked on paper, says 50 mL)

R: Why do we write this equation, what was it used for?

Faruk: To equate the mole number, the number of the Hidrogen and the Oxygen of the acid and base… That's the reason we write mol numbers…

R: Okay at that point, you have just said you expected it to be 7, written as 8,73, why did it happen like this?

Faruk: We might have added more base.

R: 50 mL is added.

Faruk: Therefore, I don't know really.

R: Then what do you think now?

Faruk: I'm not sure but, if 7 is in the alternatives I would say it may happen, but there is no 7. 50 mL doesn't fit also. I don't think so. But this is the most logical one.

Table 4.23 The Use of Cognitive and Metacognitive Strategies and the Achievement of Faruk with respect to Think Aloud Protocols

	Solubility Equilibrium						**Acids and Bases**					
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**
Rehearsal		✓	✓	✓	✓			✓			✓	✓
Elaboration	✓	✓	✓	✓	✓	✓	✓			✓		✓
Organization												
Metacognitive Awareness												✓
Metacognitive Monitoring		✓	✓	✓							✓	✓
Metacognitive Evaluation		✓	✓									✓
Achievement	7	A) 7 B) 1	A) 7 B) 7	A) 7 B) 6	7	3	7	A) 1 B) 1	2	1	A) 2 B) 1	A) 2 B) 3 C) 6 D) 3 E) 1 F) 6

* ✓**:** The process is existent.

* 1: Wrong response; 2: Wrong response with poor/insufficient (scientific) explanation; 3: Partially correct response; 4: Correct response without (scientific) explanation; 5: Correct response with irrelevant (scientific) explanation; 6: Correct response with poor/insufficient (scientific) explanation; 7: Correct response with (scientific) explanation

4.3 Summary of Results Coming from Quantitative and Qualitative Sources

➢ Results of mixed-MANOVA revealed significant treatment by time interaction for the motivational variables.

- ■ Univariate tests revealed significant change for SCL and CSCS variables with higher effect size for SCL but not for goal orientation constructs.
- ■ The treatment resulted with an increase in the mean of SCL in both groups with the higher degree in the experimental group. On the other hand, for the CSCS, there was a slight decrease in the mean of control group; while, there was a little increase in the mean of experimental group over time.

➢ Mixed-MANOVA did not indicate significant treatment by time interaction for the cognitive variables. However, both treatment and time main effects were found to be significant with higher effect size for the time main effect.

- ■ Results of Univariate tests showed significant change only for achievement in Solubility Equilibrium and Acids and Bases not for cognitive and metacognitive strategies.
- ■ The means of achievement increased for both groups over time. At both testing occasions, the means of experimental group was slightly higher than the control group.

➢ Interviews, which were conducted before the intervention started, revealed similar study patterns for both groups:

- ■ Focal students in both groups did not make strategic planning.
- ■ Students were mostly possessed performance approach type-goals and utility value beliefs for chemistry course.
- ■ In the performance phase, they generally employed task strategies such as rehearsal. Students possessed limited number of strategies.

■ Students commonly evaluated their success in terms of grades and number of correct responses and attributed success to their effort.

- Journals were analyzed for four different study groups in the experimental group. Focal students reported no or very limited information regarding their group work in Journal 1 and Journal 3. For the remaining journals, there was an improvement in the use of self-regulatory processes; explicitly, groups used more self-regulatory processes in the Acids and Bases Unit.
- Think aloud protocols revealed that students in the control group engaged in less metacognitive thinking and achieved less compared to their peers in the experimental group.
- According to think aloud protocols, all students in the experimental group used cognitive and metacognitive strategies at higher degree compared to their peers in the control group. Additionally, they engaged in more metacognitive thinking in the Acids and Bases unit compared to Solubility Equilibrium Unit.

CHAPTER 5

DISCUSSION AND IMPLICATIONS

There are three sections in this chapter. First, results coming from different data sources are gathered and the meaning of and possible reasons for these results are discussed. Then, implications of results for practice are given. Finally, some suggestions are presented for future research.

5.1 Discussion of the Results

In this study, the effectiveness of SRI based on guided inquiry approach on 11th grade students' achievement in Solubility Equilibrium and Acids and Bases Units, motivation, and learning strategies over time was investigated. Additionally, how students employed the self-regulatory processes while learning chemistry concepts in these two chemistry units and how these processes developed over the course of the study were explored. Accordingly, two research strands were employed at parallel times; that is, both quantitative and qualitative methodologies were merged together to get better understanding of SRL phenomenon. When the findings coming from two approaches were compared and contrasted, they provided convergent results for students' self-efficacy beliefs, supplementary results for their goal orientations, and divergent results regarding achievement and learning strategies.

With respect to students' *self-efficacy beliefs*, the results of quantitative analyses yielded that SRI caused a significant increase both for cognitive and laboratory skills, with a higher effect size for laboratory skills. Students in both groups had laboratory practice: in the control group, the experiments were cook-book type, in which concepts related with the laboratory work were not discussed. On the other hand, in the experimental group, the instruction mainly consisted of laboratory tasks based on guided inquiry approach, in which students discussed both their learning processes and outcomes within their group members and later as a whole class. Students in the control group were behaviorally active while students in the experimental group were active both behaviorally and cognitively, which accounts for the development of CSCS in favor of experimental group (from M=5.24 to M=5.74) and a slight decrease in the mean of CSCS in the control group (from M=5.77 to M=5.50). Another factor affecting the development of self-efficacy beliefs might be the amount of exposure to the laboratory tasks: specifically, the control group had five class hours in chemistry laboratory while the experimental group spent 17 class hours for laboratory tasks. This might explain why the experimental group showed more improvement in SCL (from M=3.85 to M=6.54) compared to the control group (from M=5.81 to M=6.08).

These findings can be supported with the results of qualitative analyses. The journals, which were designed as an instructional tool for the experimental group, were examined and the results revealed that students in the SRI classroom improved their use of self-regulatory processes over the course of the study (i.e., they used more self-regulatory processes in the Acids and Bases Unit than in the previous unit, Solubility Equilibrium). These findings can be explained with the Bandura's (1986) Triadic Reciprocal Determinism Model, which proposes a bi-directional relationship among behavioral and personal factors affecting learning (Bandura, 1986). In other words, experience of success after high effort leads to an improvement in students' self-efficacy beliefs (Schunk & Zimmerman, 1997). On the other hand, learners with high level of self-efficacy beliefs prefer challenging tasks, use different strategies, and persist after experience of failure (Linnenbrink & Pintrich, 2003).

When the findings coming from both qualitative and quantitative sources were considered, it was found that they were in agreement with each other, which implied the convergence of results for self-efficacy beliefs. As a result, SRI was superior to the traditional teaching in terms of self-efficacy beliefs both in cognitive skills and laboratory skills. These results are parallel to the findings of other studies in the existing literature (e.g., Arsal, 2009; Yetkin, 2006). This was an expected outcome, since *mastery experiences* which provides feedback to the learner about his/her performance are the main source of self-efficacy beliefs (Bandura, 1986; Schunk, 2001). In the SRI classroom, students followed three phases of SRL and journals were the main source of feedback for students about their own learning. Students initially made a plan to achieve their learning goals, next employed strategies to accomplish these goals, and finally evaluated their learning processes and learning outcomes. They wrote down their experiences onto the journals. By this way, students had conscious criticism about their learning and used this feedback loop to set learning goals for their further study (Zimmerman, 2000). Additionally, when they had trouble, the teacher gave informative feedback about the task rather than making general conclusions and guided students to monitor their learning. In addition to students' mastery experiences, *peer (coping) models* might also enhance their self-efficacy beliefs since students who possess similar experiences are supportive in developing self-efficacy beliefs (Schunk & Hanson, 1985). In the present study, students worked in groups and therefore, they had the opportunity to observe each other's work and discuss together on the tasks, which in turn could bring about the feeling that they possessed the capability necessary to complete the task, similar to their peers.

As for *students' goal orientations*, results of mixed-MANOVA analyses revealed no significant difference among groups. The findings of the interviews conducted before the intervention suggest that students in both groups study chemistry course for the same purposes. Students in both groups reported use of performance-approach type goals; that is, they studied chemistry to perform better in exams in school than their classmates. Moreover, they emphasized that the chemistry course was important for them to achieve in the university entrance examination which was an indicator of utility value. These results could be attributed to the exam-oriented transition system among different educational levels in Turkey. During the placement of an undergraduate program, students' scores on the university entrance examination and their high school GPA scores are influential. Therefore, there is a competition among students, which promotes setting performance-approach goals. Previous studies also supported this claim: students experience exam-oriented pressure during their transition from elementary school to secondary school (Kutlu & Kumandaş, 2012; Özerman, 2007) and this stress increases with grade level; more precisely, students at 8^{th} grade level experience more exam-oriented pressure (Kutlu & Kumandaş, 2012). Thus, it is assumed that high school students might experience more exam-oriented pressure, and therefore employ learning strategies in order to do get high scores on the university entrance examination. Since the exam was not a manipulated variable in this study, its influence continued over students in both groups, and no change was observed in terms of students' goal orientations. These results were contradicting with an earlier study which indicated that students getting problem-based biology instruction started to set mastery type goals such as learning new strategies rather than focusing on rewards or grades (Sungur & Tekkaya, 2006).

In terms of *students' chemistry achievement in Solubility Equilibrium and Acids and Bases Units*, the results of quantitative analysis provided improvement in both groups, but slightly at higher degree in the experimental group. The means of groups on SEABT were found to be very close both at pre-tests (4.70 for the experimental group and 3.47 for the control group) and post-tests (15.71 for the experimental group and 12.84 for the control group). Since the mixed-MANOVA did not provide a significant interaction effect, it is hard to say that SRI results in an expected outcome in terms of students' achievement, and the treatment type was not as much influential as it was predicted according to the quantitative analyses.

On the other hand, think aloud protocols as a qualitative approach yielded that students in the experimental group performed considerably better than the students in the control group in terms of achievement. Students in the experimental group showed higher achievement in the given tasks during think aloud sessions. In addition, qualitative data provided valuable evidence for the relationship between self-regulatory skills and achievement. For example, Ayşe, the high achiever in the experimental group, worked on the extra coursework (drawing pOH scale) on voluntary basis. This could be interpreted as a sign of high motivation, which would encourage the learner to engage in challenging tasks (Schunk & Pintrich, 2002). However, Mete, the low achiever in the experimental group, did not even bring his journals back at the end of the each activity, which could be accepted as an indicator of low self-regulation.

With respect to *students' learning strategies,* the results of quantitative analysis (mixed-MANOVA) revealed that SRI did not foster change in cognitive and metacognitive strategies. This finding was opposing to the related literature in that in the current study no significant change was observed in terms of students' learning strategies. Earlier studies revealed that students exposed to self-regulatory intervention possessed more varied learning strategies and used them more frequently (Pape & Wang, 2003).

However, the results of quantitative analysis (think aloud protocols) pointed out that students in the experimental group were engaged in more metacognitive thinking process and achieved more compared to their peers in the control group. Students in experimental group, regardless of their achievement level, showed an improvement in the metacognitive thinking strategies, whereas students in the control group did not show much change over time. For instance, Mete, the low achiever in the experimental group, refused to think on the cases in the Solubility Equilibrium Unit, but he used metacognitive thinking strategies in a few occasions in the next unit which was

Acids and Bases. While explaining the reason for the deterioration in the sculpture as a result of acid rain, he gave the example of deterioration of marble sink in the kitchen when lemon was left on it. This was an example of his awareness of everyday applications of the topic. Similarly, Berat, the medium achiever in the experimental group, used the cognitive and metacognitive thinking strategies more than the high achievers both in the control group and experimental group. This could be accepted as supportive effect of SRI in the use of cognitive and metacognitive strategies. On the other hand, Ege, the low achiever in the control group, did not use any metacognitive processes in either unit. Moreover, Faruk, the high achiever in the control group, did not show much change in terms of strategy use.

The high level of use of learning strategies may be affected by various factors. First of all, students who were exposed to SRI needed to use various learning strategies to accomplish given tasks. For example, they discussed each step of inquiry such as designing the experiments, reporting their observations, inferences based on their observations etc. with their group members. Additionally, they wrote down the ideas they agreed onto the journals. Furthermore, students made revisions in their inquiry based on the feedback coming from the teacher that in turn required monitoring strategies. Finally, tasks in the SRI classroom also required use of various resources and management of information coming from different resources. These factors might reinforce use of various cognitive and metacognitive strategies.

The divergent results regarding achievement and learning strategies may stem from students' not using all the self-regulatory phases in the Zimmerman's SRL model (2000), which consisted of three cyclic phases (forethought, performance and self-reflection). Although the journals were designed to help students plan their study according to Zimmerman's model, it was found that focal students' study groups did not engage much in forethought or self-reflection processes. Non-existent information in the journals does not ensure that students did not use those processes, rather it indicates that the group did not report whether they used that particular self-regulatory process or not. This might occur because of not conscious engagement in the learning process, difficulty in reading comprehension, or unwillingness in writing. All these possible reasons were accepted as an indicator of low level of self-regulation. In an effort to improve students' use of SRL strategies, Winne and Perry (2000) employ the term "strategic action" suggesting that students should determine their goals, and based on these goals, they should manage resources and employ learning strategies. Teachers, at this point, can give more feedback during the implementation of SRL phases and through modeling they can guide their students on how to use SRL processes. Although the SRI in the present study revealed some gains in terms of SRL processes, students may require more practice to become independent learners.

5.2 Implications for Practice

The present study provides considerable information about the classroom tasks that support development of SRL. In that sense it has implications for teachers and policy makers. In terms of practical applications, the present findings have clear implications for chemistry teaching and learning. The suggestions of the present study are as the following:

When both quantitative and qualitative results are considered together, SRI is found to support both students motivational and cognitive development. Therefore, it can be used by teachers in chemistry classes while teaching chemistry concepts. However, teachers should put emphasis on all three phases of SRL. This study revealed that students did not engage in the processes in the forethought and self-reflection phases as much as the processes in the performance phase. Teachers should encourage their students to engage in all phases. Effective use of components of SRL is found to help students develop effective learning practices, and in turn improve their achievement.

Considering the cyclic model of SRL, teachers should encourage their students to evaluate the efficiency of their learning outcomes and learning experiences and use this information to set new learning goals for their further study.

SRI can be utilized to increase students' chemistry self-efficacy beliefs because it provides students challenging tasks which allow them to put effort and experience success, at the end.

Guided-inquiry approach can be utilized to help students actively participate in their learning process and gain control on it gradually. Teachers can design authentic and challenging tasks for their students which would in turn activate their curiosity and motivate them. Additionally, in inquiry classes, students think about the procedure they employ and increase their metacognitive skills through discussion with their group members.

Teachers should initially check the cognitive and/or metacognitive strategies that their students possess and then design tasks to support use of different learning strategies. They can explain how to employ those strategies by modeling. It should be kept in mind that students who possessed a repertuare of strategies would monitor them easily.

Within group discussions and whole class discussions were found to improve students' cognitive and metacognitive engagement in the task. Teachers, therefore, should employ discussion technique in chemistry/science classrooms in order to help students think on their learning process and products. Teachers should give time to students to think on, discuss and reflect on their learning. By this way they can support development of their students' SRL skills.

5.3 Recommendations for Further Research

Based on my experiences in the current study, the following recommendations are listed for the researcher to be considered in the future studies:

The mixed-method design is employed in the present study in line with the suggestions of Winne and Perry (2000) and Greene (2007). To do so, the quantitative and qualitative methods with nonoverlapping weaknesses and complementary strengths were employed together for the pupose of comparing findings. Although the quantitative analyses did not yield significant results in the use of cognitive and metacognitive strategies, think aloud protocols indicated an improvement over the course of the study. Accordingly, use of mixed-method approach is recommended to study SRL phenomenon. Different qualitative and quantitative instruments can be developed to investigate three components of SRL.

This study fills a gap in SRL literature and improves its ecologic validity by employing the SRL principles to a less frequently studied context, high school chemistry classroom. In further studies, researchers can investigate different chemistry topics at different grade levels.

In this study, think aloud protocols were employed after the implementation of the topic. However, researchers could benefit from think aloud protocols as a teaching tool while students are learning the topic in order to detect in which tasks students struggle and give prompts to students to continue working on the task and monitor their learning.

In further studies, researcher could videotape students while learning a task, and request students to explain their thinking verbally in the course of the task.

In further studies, researchers can train the teachers about the SRL strategies and can develop classroom tasks in cooperation with them.

In the current study, in order to minimize threats to internal validity, all the activities were completed within class hour. It was found that students struggle in the use of forethought phase processes. To overcome this problem, researchers can distribute journals to the students a week before the implementation of the task in order to give time to investigate the journals, search for the activities, and think more on the task to make more accurate plans.

In further studies, researchers could focus different SRL processes in different tasks and disciplines and employ additional curricular activities especially for the students with lower self-regulation level taking in consideration the threats to internal validity.

The present study covered the third and fourth units in 11^{th} grade national chemistry curriculum. In order to minimize the novelty effect, researchers can start implementation at the beginning of the semester which could also be advantageous to conduct a longer investigation.

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APPENDIX A

OBJECTIVES FOR SOLUBILITY EQUILIBRIUM UNIT

Students will able to

1. describe what a solution is in their own words.
2. identify the components of a solution.
3. classify solutions based on the state of solution.
4. give examples from daily life to each solution category.
5. distinguish between ionic and molecular solutions.
6. draw the representation of ionic and molecular solutions at the microscopic level.
7. illustrate under which conditions saturated, unsaturated and supersaturated solutions occur at the microscopic level.
8. explain under which conditions saturated, unsaturated and supersaturated solutions occur at the macroscopic level.
9. write down a dissolving reaction for salts.
10. identify anions and cations when a salt dissolved in water.
11. make a discussion on differences between soluble salts and slightly salts at the microscopic level.
12. make a discussion on differences between soluble salts and slightly soluble salts at the macroscopic level.
13. compose a dissociation equation for soluble salts.
14. compose a dissociation equation for slightly soluble salts.
15. calculate the concentration of a solution in terms of molarity and percent by mass and volume.
16. define molar solubility in their own words.

17. determine the chemical formula of a substance using the ionic ratios in a given solution.
18. explain the effect of temperature on solubility
19. interpret solubility-temperature curves.
20. clarify the solubility equilibrium that exists in a saturated aqueous salt solution.
21. define the solubility product constant, Ksp in their own words.
22. describe the Ksp as a specialized form of equilibrium constant (Keq).
23. write down ionization equation/reaction and the solubility product constant's formula of different salts dissolved in water.
24. calculate the Ksp value for different salts.
25. compare solubility of different salts based on Ksp.
26. discover the relationship among saturated solution, solubility of a salt, and Ksp.
27. calculate the Ksp value for the salts with different anion/cation ratios when the solubility of the compound is given and vice versa.
28. give at least three examples for a complete ionic equation and a net ionic equation that represent a precipitation reaction.
29. predict whether a precipitate will occur when two solutions are mixed and identify the precipitate.
30. predict the formation of a precipitate by comparing the trial ion product (Qsp) to the Ksp value
31. explain how selective precipitation is used as an analytical technique.
32. illustrate the changes that occur in a solubility equilibrium when a common ion is added.

APPENDIX B

OBJECTIVES FOR ACIDS AND BASES UNIT

Students will able to

1. define acids and bases based on the Arrhenius/ Bronsted-Lowry/Lewis models.
2. identify acids and bases using the applicable definition of acids and bases (the Arrhenius/ Bronsted-Lowry/Lewis models).
3. recognize acids and bases in daily life.
4. identify conjugate acid-base pairs in an acid-base reaction.
5. state the definition of an "amphoteric" substance in their own words.
6. define the strength of an acid/base solution
7. test for the difference between strong acids/bases and weak acids/bases.
8. define the concentration of an acid/base solution.
9. explain the difference between concentrated acids/bases and dilute acids/bases.
10. make a distinction between the strength and concentration of acids/bases.
11. explain a neutralization reaction (an acid-base reaction).
12. Experiment with acids and bases to form a neutralization reaction.
13. explain the dissociation of pure water.
14. calculate the concentration of H_3O^+ and OH^- ions using the dissociation of pure water.
15. convert $[H_3O^+]$ and $[OH^-]$ to pH and pOH values.

16. calculate the pH, pOH, $[H_3O^+]$ and/or $[OH^-]$ values for a solution when any of these values is given.
17. compare the acidity and/or alkalinity of solutions based on pH value.
18. measure the pH of a solution in the laboratory.
19. apply the use of acid–base indicators
20. test for a group of substances (chemicals in the laboratory or household substances) as an acid/base using different acid-base indicators in the laboratory.
21. inspect the acidity and/or alkalinity of solutions in the laboratory.
22. relate the dissociation of pure water and the equilibrium constant expression (Kw).
23. formulate the equilibrium constant expression for the reaction of an acid (Ka) or a base (Kb) with water.
24. explain the meaning of Ka and pKa.
25. compare the strength of acids/bases using its equilibrium constant value (Ka/Kb).
26. compare the relative strengths of the conjugate bases/acids of a series of acids/bases based on the Ka/Kb values.
27. interpret whether an aqueous solution of a salt will be acidic, basic or neutral using Ka and Kb values for conjugate acid-base pairs.
28. decide on whether any reaction occurs between different type of metals (active, semi-precious, and amphoteric metals) and acid/base solutions.
29. explain the principles of buffers solutions.
30. give examples to buffer solutions from real life.
31. explain how acid rain occurs
32. explain how titration is used as an analytic method.
33. take part in conducting a titration experiment in the laboratory.
34. apply the use of acid/base indicators in the titration reaction.
35. interpret the chemical change(s) that occurs during a titration process, by the help of acid base reactions.

36. identify the equivalence point using an acid/base indicator in the lab.
37. draw titration graphs.
38. identify the equivalence point in an acid-base titration from the titration graph.
39. calculate the concentration of an unknown acid/base using titration method.
40. work safely with acids and bases in the laboratory.

APPENDIX C

RESULTS OF ITEM ANALYSES FOR 45-ITEM PILOTED TEST

Table C.1 Results of item analyses for the 45-item piloted test

Item # in the Pilot test	Item # in the final test	Item Dif.: Pro. of Correct Response N=154	Conc. for Item Dif.	Item Disc. Index: Point Biserial N=154	Conc. for Item Disc.	Decision
1	item1	0.805	Easy	0.302	Little or no revision	No Revision
2	item2	0.818	Easy	0.333	Little or no revision	No Revision
3	item3	0.526	Moderate	0.314	Little or no revision	No Revision
4	item4	0.481	Moderate	0.462	No revision	No Revision
5	item5	0.636	Moderate	0.341	Little or no revision	No Revision
6		0.299	Difficult	0.158	Not well discriminating	Removed: The item was difficult and not well discriminating
7	item7	0.175	Difficult	0.371	Little or no revision	No Revision
8	item8	0.539	Moderate	0.505	No revision	No Revision

Item #: Item number; Item Dif.: Item Difficulty; Pro. of Correct Response: Proportion of Correct Response; Conc. for Item Dif.: Conclusion for Item Difficulty; Item Disc.: Item Discrimination; Conc. for Item Disc.: Conclusion for Item Discrimination

Table C.1 (continued)

Item # in the Pilot test	Item # in the final test	Item Dif.: Pro. of Correct Response N=154	Conc. for Item Dif.	Item Disc. Index: Point Biserial N=154	Conc. for Item Disc.	Decision
9	item9	0.740	Easy	0.380	Little or no revision	No Revision
11		0.766	Easy	0.443	No revision	Removed: The item was easy and the subject matter was covered in another item
12		0.169	Difficult	0.415	No revision	Removed: The item was difficult and the subject matter was covered in another item
13	item13	0.506	Moderate	0.369	Little or no revision	No Revision
14	item15	0.506	Moderate	0.235	Needs Revision	Revised and Used
15		0.077	Difficult	-0.164	Not well discriminating	Removed: The item was difficult and not well discriminating
16		0.538	Moderate	0.338	Little or no revision	Removed: The subject matter was covered in another item with better item discrimination index

Item #: Item number; Item Dif.: Item Difficulty; Pro. of Correct Response: Proportion of Correct Response; Conc. for Item Dif.: Conclusion for Item Difficulty; Item Disc.: Item Discrimination; Conc. for Item Disc.: Conclusion for Item Discrimination

Table C.1 (continued)

Item # in the Pilot test	Item # in the final test	Item Dif.: Pro. of Correct Response N=154	Conc. for Item Dif.	Item Disc. Index: Point Biserial N=154	Conc. for Item Disc.	Decision
17	item11	0.635	Moderate	0.321	Little or no revision	No Revision
18	item6	0.429	Moderate	0.415	No revision	No Revision
19	item14	0.314	Difficult	0.213	Needs revision	Revised and Used
20		0.244	Difficult	0.198	Not well discriminating	Removed: The item was difficult and not well discriminating
21		0.154	Difficult	0.183	Not well discriminating	Removed: The item was difficult and not well discriminating
22	item12	0.590	Moderate	0.596	No revision	No Revision
23	item16	0.597	Moderate	0.529	No revision	No Revision
24	item17	0.779	Easy	0.455	No revision	No Revision
25	item19	0.437	Moderate	0.320	Little or no revision	No Revision
26	item18	0.571	Moderate	0.503	No revision	No Revision
27	item20	0.714	Easy	0.258	Needs revision	Revised and Used
28		0.266	Difficult	0.194	Not well discriminating	Removed: The item was difficult and not well discriminating
29	item22	0.351	Difficult	0.263	Needs revision	Revised and Used

Item #: Item number; Item Dif.: Item Difficulty; Pro. of Correct Response: Proportion of Correct Response; Conc. for Item Dif.: Conclusion for Item Difficulty; Item Disc.: Item Discrimination; Conc. for Item Disc.: Conclusion for Item Discrimination

Table C.1 (continued)

Item # in the Pilot test	Item # in the final test	Item Dif.: Pro. of Correct Response N=154	Conc. for Item Dif.	Item Disc. Index: Point Biserial N=154	Conc. for Item Disc.	Decision
30		0.065	Difficult	-0.067	Not well discriminating	Removed: The item was difficult and not well discriminating
31	item24	0.701	Easy	0.415	No revision	No Revision
32	item25	0.519	Moderate	0.433	No revision	No Revision
33		0.708	Easy	0.497	No revision	Removed: The item was easy and the subject matter was covered in another item
34	item27	0.110	Difficult	0.246	Needs revision	Revised and Used
35	item28	0.214	Difficult	0.305	Little or no revision	No Revision
36	item29	0.325	Difficult	0.274	Needs revision	Revised and Used
37	item30	0.188	Difficult	0.217	Needs revision	Revised and Used
38		0.455	Moderate	0.247	Needs revision	Removed: The subject matter was covered in another item with better item discrimination index

Item #: Item number; Item Dif.: Item Difficulty; Pro. of Correct Response: Proportion of Correct Response; Conc. for Item Dif.: Conclusion for Item Difficulty; Item Disc.: Item Discrimination; Conc. for Item Disc.: Conclusion for Item Discrimination

Table C.1 (continued)

Item # in the Pilot test	Item # in the final test	Item Dif.: Pro. of Correct Response N=154	Conc. for Item Dif.	Item Disc. Index: Point Biserial N=154	Conc. for Item Disc.	Decision
39		0.737	Easy	0.473	No revision	Removed: The item was easy and the subject matter was covered in another item
40		0.429	Moderate	0.468	No revision	Removed: The subject matter was covered in another item with better item discrimination index
41	item21	0.596	Moderate	0.418	No revision	No Revision
42		0.769	Easy	0.543	No revision	Removed: The item was easy and the subject matter was covered in another item
43	item23	0.558	Moderate	0.611	No revision	No Revision
44	item26	0.308	Difficult	0.483	No revision	No Revision
45		0.474	Moderate	0.249	Needs revision	Removed: The subject matter was covered in another item with better item discrimination index

Item #: Item number; Item Dif.: Item Difficulty; Pro. of Correct Response: Proportion of Correct Response; Conc. for Item Dif.: Conclusion for Item Difficulty; Item Disc.: Item Discrimination; Conc. for Item Disc.: Conclusion for Item Discrimination

APPENDIX D

SOLUBILITY EQUILIBRIUM AND ACIDS BASES TEST (SEABT)

ÇÖZÜNÜRLÜK DENGESİ VE ASİTLER BAZLAR TESTİ

Sevgili Öğrenciler,

Bu test 11.sınıf kimya konularından "Çözünürlük Dengeleri" ve "Asitler ve Bazlar" ünitelerindeki **kavramları ne kadar anladığınızı ölçmek** için geliştirilmiştir. Testi cevaplamanız çalışmamız açısından önemlidir. Test toplam 30 adet sorudan oluşmaktadır. Her bir soru biri doğru yanıt olmak üzere beş seçenekten oluşmaktadır. Cevap kağıdında lütfen her soru için doğru olduğunu düşündüğünüz **yalnız bir seçeneği daire içine alarak** işaretleyin. Testin yanıtlanması için size verilen toplam sure **2 ders saati/80 dakikadır**.

1) Aşağıdaki çözeltilerden hangisi diğerlerinden farklı bir fazdadır?

A) Maden suyu

B) Deniz suyu

C) Hava

D) Sirke

E) Şekerli su

2) Suda çözünmüş oksijen gazı denizlerdeki canlıların yaşaması için önemlidir. Oksijen gazının suda çözünmesi aşağıdaki gibi gösterilir:

O_2 (g) $\rightleftarrows$ O_2 (suda) + ısı

Buna göre oksijen gazının suda çözünmesiyle ilgili aşağıdaki ifadelerden hangisi doğrudur?

A) Endotermik bir olaydır.

B) Kimyasal bir olaydır.

C) Homojen bir dengedir.

D) Minimum enerjiye eğilim ürünler yönündedir.

E) Maksimum düzensizlik çözünmenin lehinedir.

3) Bir araştırmacı molar derişimleri aynı olan çözeltilerin elektrik iletkenliğini ölçüyor ve aşağıdaki sonuçları elde ediyor. Buna göre kalsiyum klorür 0.05M ($CaCl_2$) çözeltisinin elektrik iletkenliği aşağıdaki seçeneklerden hangisi olabilir?

Çözelti	Çözelti derişimi (M)	Elektrik iletkenliği (μS/cm)
NaCl (sodyum klorür)	0.05	5714
$AlCl_3$ (alüminyum klorür)	0.05	11707
CH_3COOH (asetik asit)	0.05	461
CH_3OH (metanol)	0.05	0
$C_2H_6O_2$ (etilen glikol)	0.05	0
Çeşme Suyu		684

A) 0 B) 528 C) 3624 **D) 9362** E) 13180

4)

Bir öğrenci içinde su bulunan bir behere bir miktar sodyum klorür (NaCl) tuzu ekliyor. Bir süre bekledikten sonra dibinde katısı olan şekil I'de gösterilen çözeltiyi elde ediyor. Bu çözeltinin üzerinden hacimce yarısını alıp şekil II'deki boş kaba aktarıyor. Son durumda her iki kaptaki çözeltiler ile ilgili aşağıdaki ifadelerden hangisi doğrudur?

A) Birinci kaptaki çözeltinin kütlece yüzde derişimi daha fazladır.

B) Birinci kaba dipteki tuzu çözecek kadar su eklenirse çözeltinin derişimi artar.

C) İkinci kapta çözünmüş tuz miktarı daha azdır.

D) İkinci kaba bir miktar sodyum klorür eklendiğinde çözeltinin yoğunluğu artar.

E) Her iki kaptaki çözeltilerin yoğunluğu aynıdır.

5) Az çözünen tuzların denge sabiti, çözünürlük çarpımı ($K_ç$) olarak tanımlanır. Çözünürlük çarpımı ile ilgili aşağıdaki ifadelerden hangisi doğrudur?

A) $K_ç$ değeri hiçbir zaman değişmez.

B) Molekül halinde çözünen bileşikler için hesaplanır.

C) $K_ç$ bağıntısında çöken katı türü yer almaz.

D) Çözünme hızı arttıkça artar.

E) Birimi yoktur.

6) Bir öğrenci laboratuar uygulaması sırasında AB tuzunun bir çözeltisini hazırlıyor. Bir miktar katı AB tuzunu saf suya ilave ettiğinde, çözeltinin hazırlandığı beherin ısındığını görüyor. Ders kitabından AB tuzunun çözünürlük çarpımının $4x10^{-12}$ olduğunu öğreniyor. Bu çözelti için aşağıdaki yorumlardan hangisi doğrudur?

A) İyonlaşma denklemi AB(k) $\longrightarrow A^{+}(aq) + B^{-}(aq)$ şeklinde yazılabilir.

B) Sıcaklığı artırdığında dipteki katı miktarı artar.

C) Sıcaklığı artırdığında daha fazla AB tuzu çözebilir.

D) Sıcaklığı azalttığında çözünürlük çarpımı (Kç) değeri değişmez.

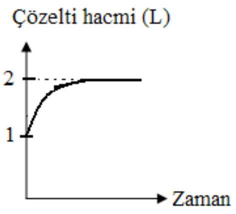
E) Sıcaklığı azalttığında çözeltideki A^{+} ve B^{-} iyon derişimleri azalır.

7) Kurşun (Pb) çevre için zararlı olan ağır metallerden biridir. Çok az miktarı bile çevre kirliliğine yol açar. Aşağıda farklı kurşun bileşiklerinin çözünürlük çarpımı ($K_Ç$) değerleri verilmiştir. Bu çözeltilerin oda sıcaklığındaki doymuş çözeltileri karşılaştırıldığında, hangisi çevreye <u>en çok</u> zarar verir?

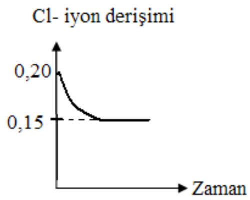
	Tuz	Çözünürlük Çarpımı ($K_Ç$)
A)	PbS	$8,4 \times 10^{-28}$
B)	$PbCrO_4$	$1,8 \times 10^{-14}$
C)	$PbCO_3$	$1,5 \times 10^{-13}$
D)	**PbI_2**	**$8,7 \times 10^{-9}$**
E)	$PbSO_4$	$1,8 \times 10^{-8}$

8) 0,2 molarlık sodyum klorür (NaCl) çözeltisinin 1 litresine aynı sıcaklıkta ve eşit hacimde 0,1 molar potasyum klorür (KCl) çözeltisi yavaş yavaş ekleniyor. Sıcaklık değişmediğine göre karışımla ilgili aşağıdaki grafiklerden hangisi yanlıştır?

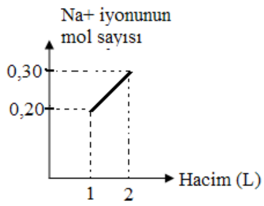
A)



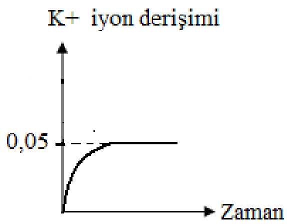
B)



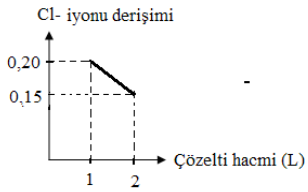
C)



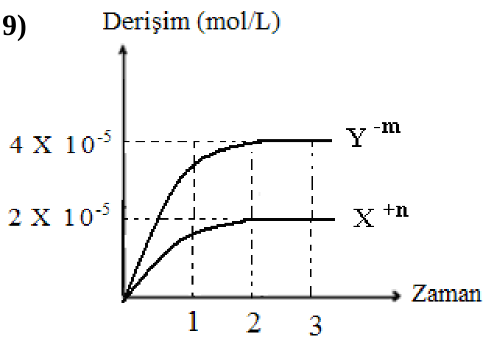
D)



E)



9)



Bir tuzun çözünürken suya verdiği iyonların derişiminde zamanla gözlenen değişim yukarıdaki grafikte verilmiştir. Buna göre, bu tuzun çözünürlük çarpımı değeri nedir?

A) $1,6 \times 10^{-14}$ **B) $3,2 \times 10^{-14}$** **C)** $1,6 \times 10^{-10}$

D) $6,4 \times 10^{-10}$ E) 8×10^{-10}

10) Aşağıdaki birinci denklem amonyum klorür (NH_4Cl) tuzunun suda çözünmesini, ikinci denklem ise ayrışmasını göstermektedir.

I. $NH_4Cl_{(k)} \rightleftharpoons NH_4^+{}_{(suda)} + Cl^-{}_{(suda)} \quad \Delta H > 0$

II. $NH_4Cl_{(k)} \rightleftharpoons NH_{3(g)} + HCl_{(g)} \quad \Delta H > 0$

Bu iki olay ile ilgili aşağıdaki ifadelerden hangisi doğrudur?

A) Her iki olayda da düzensizlik ürünler lehinedir.

B) Her iki olay da kimyasal dengeye örnektir.

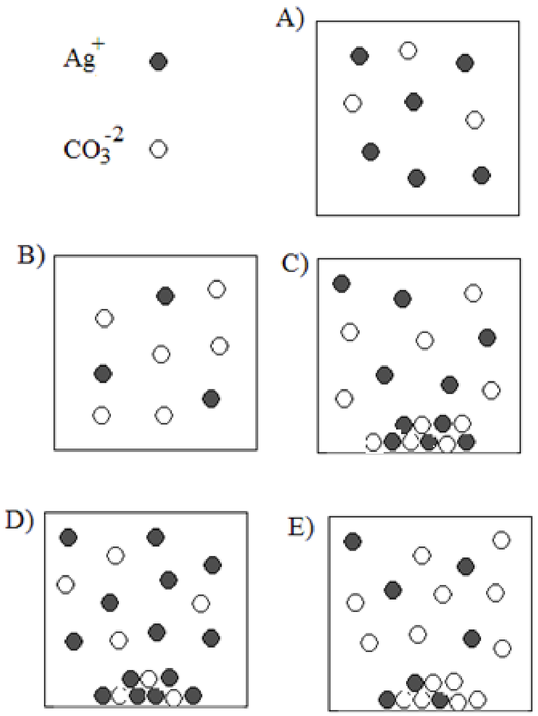
C) Her iki olay gerçekleşirken içinde bulundukları kap ısınır.

D) I. olayın gerçekleşmesi için daha fazla enerji gerekir.

E) I. olayda statik, II. olayda dinamik denge söz konusudur.

11) Bir öğrenci dipteki katısı ile denge halinde bulunan gümüş karbonat (Ag_2CO_3) çözeltisindeki iyonların tanecik boyutunda görünümünü çizmek istiyor. Aşağıdaki şekillerden hangisi gerçeğe en yakın çizilmiştir?

(Şekilde gümüş iyonları (Ag^+) içi dolu daire (●) ve karbonat iyonları (CO_3^{-2}) içi boş daire (○) ile gösterilmiştir.)



12) T°C sıcaklıkta katısı ile dengedeki doymuş kalsiyum karbonat ($CaCO_3$) çözeltisine bir miktar sodyum karbonat (Na_2CO_3) katısı ekleniyor. Buna göre aşağıdaki ifadelerden hangisi doğrudur?

A) Denge ürünler yönüne kayar.

B) Kabın dibindeki kalsiyum karbonat ($CaCO_3$) katısının miktarı artar.

C) Çözeltideki kalsiyum iyon (Ca^{+2}) derişimi artar.

D) Kalsiyum karbonat ($CaCO_3$) tuzunun çözünürlüğü artar.

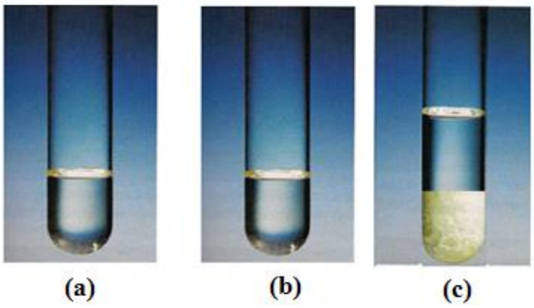
E) Çözünürlük çarpımı (Kç) değeri küçülür.

13) Bir çözeltide birden fazla katyon türü çözünmüş olarak bulunuyorsa, bu iyonlar seçimli çöktürme yöntemi kullanılarak birbirinden ayrılabilir. Bu yöntemde iyonlar, çözünürlük çarpımı değerleri arasındaki farktan yararlanılarak ayrılır. Çözeltiye çöktürücü reaktif madde azar azar ilave edildiğinde, reaktif madde çözünürlüğü daha küçük olan katyonla çökelek oluştururken diğer iyon çözeltide kalır.

Bu bilgiyi kullanarak, aşağıdaki çözeltilerden hangisi seçimli çöktürme yöntemiyle en iyi şekilde ayrılır?

	Çözeltideki Katyon Türleri	Kullanılan Reaktif Madde	Çözünürlük Çarpımı
A)	Cu, Pb	HCl	CuCl: 1,0 x 10^{-6}
			$PbCl_2$: 1,6 x 10^{-5}
B)	Ca, Sr	NaOH	$Ca(OH)_2$: 1,3 x 10^{-6}
			$Sr(OH)_2$: 3,2 x 10^{-4}
C)	**Pb, Fe**	**H_2S**	**PbS: 7,0 x 10^{-29}**
			FeS: 4,0 x 10^{-19}
D)	Ca, Ba	Na_2CO_3	$CaCO_3$: 8,7 x 10^{-9}
			$BaCO_3$: 5,0 x 10^{-9}
E)	Ca, Mg	NaF	CaF_2: 4,0 x 10^{-11}
			MgF_2: 6,4 x 10^{-9}

14)



Belli bir sıcaklıkta (a) kabında bulunan derişik baryum nitrat ($Ba(NO_3)_2$) çözeltisi ile (b) kabında bulunan derişik sodyum karbonat (Na_2CO_3) çözeltisi eşit hacimlerde karıştırıldığında (c) kabında dibinde katısı olan bir çözelti elde ediliyor. Buna göre aşağıdaki ifadelerden hangisi doğrudur?

A) Çöken madde sodyum nitrat ($NaNO_3$)'dır.

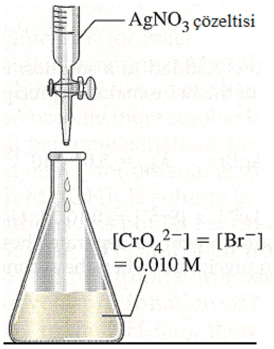
B) Son durumda çözeltide baryum (Ba^{+2}) iyonu derişimi yarıya düşer.

C) Son durumda çözeltide karbonat (CO_3^{-2}) iyonları bulunmaz.

D) Son durumda baryum karbonat ($BaCO_3$) tuzu dengededir.

E) Bu bir nötralleşme tepkimesidir.

15)



Yukarıdaki şekilde gösterilen erlende eşit derişimde Br^- ve CrO_4^{-2} iyonları içeren bir çözelti vardır. Bu erlene bir büret yardımıyla $AgNO_3$ çözeltisi damlatılıyor. Bu olay ile ilgili aşağıdaki ifadelerden hangisi doğrudur?

($K_ç$ (Ag_2CrO_4) = 1,1 x 10^{-12}; Kç (AgBr) = 5,0 x 10^{-13})

A) Ag_2CrO_4 katısı önce çökmeye başlar.

B) AgBr dengeye ulaştığında ortamdaki Br^- iyonu derişimi sıfırdır.

C) Br^- iyon derişimi yarıya indiğinde CrO_4^{-2} iyonları çökmeye başlar.

D) Ag_2CrO_4 çökmeye başladığında ortamda çok az miktarda Br^- iyonu bulunur.

E) Her iki tuzun dengeye ulaşması için eşit miktarda Ag^+ iyonu gereklidir.

16) 25ºC'de hazırlanan sulu çözelti için aşağıdaki yargılardan hangisi <u>yanlıştır</u>?

A) pH = pOH = 7 ise nötrdür.

B) $[OH^-] > 10^{-7}$ M ise pH > 7 dir.

C) $[H^+] > [OH^-]$ ise pH < 7 dir.

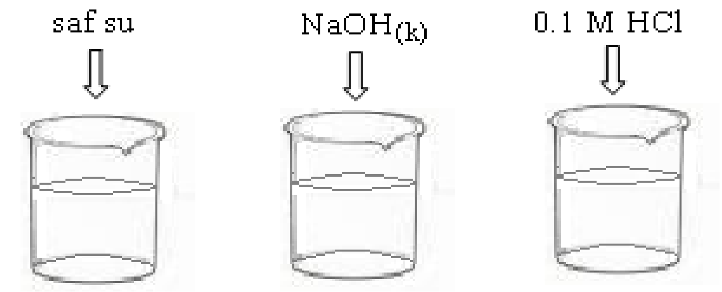
D) $[H^+] = [OH^-]$ ise pH = 7 dir.

E) $[H^+] < 10^{-7}$ M ise pH < 7 dir.

17) Aşağıdaki tepkimede yer alan molekül ve iyonlar Bronsted-Lowry asit baz tanımına göre sırasıyla aşağıdaki seçeneklerden hangisinde doğru olarak belirtilmiştir?

	NH_4^+	+	CO_3^{-2}	$\rightleftharpoons$	NH_3	+	HCO_3^-
A)	Baz		Asit		Baz		Asit
B)	Baz		Asit		Asit		Baz
C)	Asit		Baz		Asit		Baz
D)	**Asit**		**Baz**		**Baz**		**Asit**
E)	Asit		Asit		Baz		Baz

18)



Şekil I 0,1 M KOH | Şekil II 0,1 M KOH | Şekil III 0,1 M KOH

Yukarıdaki şekilde gösterilen üç özdeş kapta eşit miktarda 0,1 M derişimli potasyum hidroksit (KOH) çözeltileri vardır. Birinci kaba bir miktar saf su, ikinci kaba katı sodyum hidroksit (NaOH) ve üçüncü kaba 0.1 M derişimli hidroklorik asit (HCl) çözeltisi ekleniyor. Son durumda her üç kaptaki çözeltinin pH değeri başlangıç durumuna göre nasıl değişir?

	I. Kap	II. Kap	III. Kap
A)	**Azalır**	**Artar**	**Azalır**
B)	Artar	Artar	Azalır
C)	Artar	Azalır	Artar
D)	Azalır	Azalır	Artar
E)	Artar	Azalır	Azalır

19) Eşit hacimdeki HX ve HY çözeltilerini nötrleştirmek için gereken NaOH miktarları aynıdır. Aynı sıcaklıkta HX çözeltisindeki H^+ iyonu derişimi HY'dekinden fazla olduğuna göre, aşağıdaki yargılardan hangisi doğrudur?

A) HX çözeltisinin molar derişimi HY çözeltisinden fazladır.

B) HX çözeltisinin pH'si HY çözeltisinin pH'sinden büyüktür.

C) HX çözeltisinin elektrik iletkenliği HY çözeltisininkinden fazladır.

D) Çözeltilerin aynı sıcaklıktaki buhar basınçları eşittir.

E) Her iki çözeltinin aynı sıcaklıktaki çözünürlük değerleri eşittir.

20) Bir öğrenci her biri 100ml hacimli beş farklı baz örneğinin 0.1 M HCl çözeltisi ile nötrleşme tepkimesini inceliyor. Aşağıdaki tabloda baz çözeltilerinin derişimi ve bu çözeltileri tamamen nötrleştirmek için gerekli asit çözeltisi miktarları verilmiştir. Tesir değerliği 3 olan baz hangisidir?

	Baz	Derişim (M)	V_{asit} (ml)
A)	X	0.1	100
B)	Y	0.1	200
C)	Z	0.2	400
D)	**T**	**0.2**	**600**
E)	S	0.3	600

21) Aşağıdaki maddeler karıştırıldığında hangisinde tepkime gerçekleşmez?

A) Zn (k) + H_2SO_4 (suda)

B) CuO (k) + NaOH (suda)

C) Ca (k) + CH_3COOH (suda)

D) $MgCO_3$ (k) + HCl (suda)

E) Fe (k) + HNO_3 (suda)

22) 3. periyod metallerinden X, Y, Z' nin oksitleri X_2O, YO ve Z_2O_3'ün asitlik kuvvetleri aşağıdakilerden hangisinde doğru karşılaştırılmıştır?

A) $X_2O > YO > Z_2O_3$

B) $X_2O > Z_2O_3 > YO$

C) $YO > Z_2O_3 > X_2O$

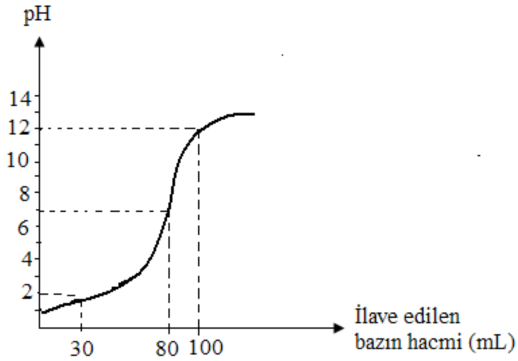
D) $Z_2O_3 > X_2O > YO$

E) $Z_2O_3 > YO > X_2O$

23) Aşağıdaki seçeneklerde 5 farklı asit çözeltisinin derişimleri ve iyonlaşma yüzdesi verilmiştir. Üniversal pH kağıdı yardımıyla her bir çözeltinin pH değeri ölçüldüğünde, hangi çözelti için pH değeri <u>en büyük</u> olur?

	Asit	Molarite (M)	İyonlaşma yüzdesi (%)
A)	HA	1.0×10^{-2}	100
B)	**HB**	$\mathbf{1.0 \times 10^{-2}}$	**10**
C)	HC	1.0×10^{-1}	100
D)	HD	1.0×10^{-1}	10
E)	HE	1.0	1

24)



Yukarıdaki grafik 50 mL'lik hidroklorik asit (HCl) çözeltisinin 0,1 M'lık sodyum hidroksit (NaOH) çözeltisiyle titrasyon eğrisini göstermektedir. Buna göre hidroklorik asit çözeltisinin derişimi kaç molardır?

A) 0,10 B) 0,12 **C) 0,16** D) 0,18 E) 0,20

25) Bir araştırmacı aşağıda verilen çözelti örneklerinin pH değerlerini ölçüyor ve her bir çözeltiye bir miktar kırmızı soğan suyu ilave ederek renk değişimlerini gözlemliyor.

Örnek	pH	Renk
Mide özsuyu	1.9	Pembe
Sirke	3.4	Soluk Pembe
Süt	6.4	Soluk Yeşil
Kabartma tozu	8.0	Yeşil
Deterjanlar	10.0	Sarı

0,4 M HX çözeltisine bir miktar kırmızı soğan suyu ilave edildiğinde oluşan karışım ne renk olur? (K_a (HX) = 2,5 x 10^{-4})

A) Pembe B) Soluk Pembe C) Soluk Yeşil

D) Yeşil E) Sarı

26) Bir araştırmacı I. ve II. sütunda verilen çözelti örneklerini karıştırarak 5 farklı numune hazırlıyor. Bu numunelerden hangisi tampon çözelti olarak kullanılamaz?

		I	II
A)	Numune 1	HF	NaF
B)	Numune 2	HCN	NaCN
C)	**Numune 3**	**HCl**	**NaCl**
D)	Numune 4	$NaHCO_3$	Na_2CO_3
E)	Numune 5	NH_3	NH_4Cl

27)

V (ml) NaOH	pH
0	1.00
10	1.37
20	1.95
22	2.19
24	2.70
25	7.00
26	11.30
28	11.75
30	11.96
40	12.36
50	12.56

Yandaki tabloda kuvvetli bir asidin NaOH çözeltisi ile titrasyonuna ait deney sonuçları verilmiştir. Kullanılan NaOH miktarı (mL) ve erlende oluşan çözeltinin pH değerleri tabloda görülmektedir. Bu titrasyon işlemi sırasında aşağıda renk değişim aralığı verilen indikatörlerden hangisinin kullanılması uygun olmaz?

	İndikatör	Renk Değişim Aralığı
A)	**Timol mavisi**	**pH, 1.2 – 2.8**
B)	Metil Kırmızısı	pH, 4.4 – 6.2
C)	Bromotimol Mavisi	pH, 6.0 – 7.6
D)	Krezol kırmızısı	pH, 7.2 – 8.8
E)	Fenolftalein	pH, 8.3 – 10.0

28) Bir araştırmacı etiketleri karıştırılan asetik asit (CH_3COOH), hidroklorik asit (HCl) ve sülfürik asit (H_2SO_4) çözeltilerini inceliyor. Her bir asidin pH değeri ve eşit miktarda örneğinin 0.1M sodyum hidroksit (NaOH) çözeltisi ile titrasyonunda kullanılan baz miktarı aşağıdaki tabloda belirtilmiştir. Buna göre, bu çözeltiler hangi seçenekte doğru olarak belirtilmiştir?

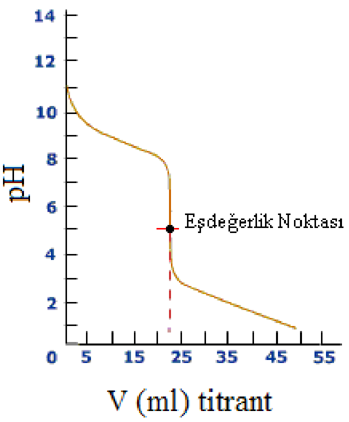
Örnek	Konsantrasyon (M)	pH	V (ml) titrant
Asit 1	0.1	3	50
Asit 2	0.1	1	100
Asit 3	0.1	1	50

	Asit 1	Asit 2	Asit 3
A)	CH_3COOH	HCl	H_2SO_4
B)	**CH_3COOH**	**H_2SO_4**	**HCl**
C)	HCl	CH_3COOH	H_2SO_4
D)	HCl	H_2SO_4	CH_3COOH
E)	H_2SO_4	CH_3COOH	HCl

29) Aşağıdaki tabloda belirtilen asit ve baz çözeltilerinin tepkimesi sonucu oluşan tuzlardan hangisi hidroliz olmaz?

	Asit	Baz	Tuz
A)	HCN	NH_3	NH_4CN
B)	CH_3COOH	KOH	KCH_3COO
C)	H_2S	NaOH	Na_2S
D)	**HNO_3**	**KOH**	**KNO_3**
E)	HCl	NH_3	NH_4Cl

30)



Yukarıda verilen titrasyon eğrisi aşağıdaki uygulamalardan hangisine ait olabilir?

A) Kuvvetli bir asidin kuvvetli bir bazla titrasyonu

B) Kuvvetli bir bazın kuvvetli bir asitle titrasyonu

C) Zayıf bir asidin kuvvetli bir bazla ile titrasyonu

D) Zayıf bir bazın kuvvetli bir asitle ile titrasyonu

E) Kuvvetli bir bazın zayıf bir asitle titrasyonu

APPENDIX E

SAMPLE ITEM FOR EACH VARIABLE

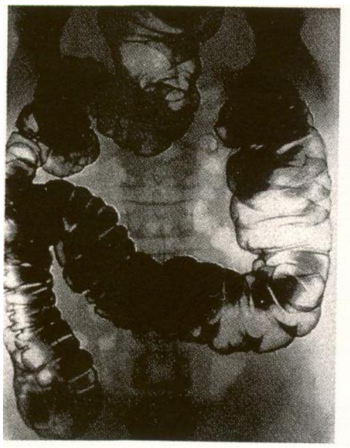
HER BİR DEĞİŞKEN İÇİN ÖRNEK MADDE

BÖLÜM I: HEDEF YÖNELİMLERİ ANKETİ **Goal Orientations Scale (GOS)**	
Kimya dersinde diğerlerine göre daha başarılı olmak benim için önemlidir.	Performance-Approach
Kimya dersinde amacım sınıftaki diğer öğrencilerden daha kötü performans sergilemekten kaçınmaktır.	Performance-Avoidance
Kimya dersinde verilen her şeyi tam olarak öğrenmek arzusundayım.	Mastery-Approach
Bazen Kimya dersinin içeriğini istediğim kadar iyi **anlayamayacağımdan** korkuyorum.	Mastery-Avoidance
BÖLÜM II: LİSE KİMYA ÖZYETERLİK ANKETİ **High School Chemistry Self-Efficacy Scale (HCSS)**	
Atomun yapısını tasvir etmede ne kadar iyisiniz?	CSCS
Laboratuvar düzeneğini ne kadar iyi kurabilirsiniz?	SCL
BÖLÜM III: BİLİŞSEL VE ÜSTBİLİŞSEL STRATEJİLER ÖLÇEĞİ **Cognitive and Metacognitive Strategies Scale (CMSS)**	
Kimya dersine çalışırken, önemli bilgileri içimden defalarca tekrar ederim.	Rehearsal
Kimya dersine çalışırken, dersten, okuduklarımdan, sınıf içi tartışmalardan ve diğer kaynaklardan edindiğim bilgileri bir araya getiririm.	Elaboration
Kimya dersi ile ilgili bir şeyler okurken, düşüncelerimi organize etmek için konuların ana başlıklarını çıkarırım.	Organization
Kimya dersinde işlenen konuları anladığımdan emin olabilmek için kendi kendime sorular sorarım.	Metacognitive Self-Regulation

APPENDIX F

SAMPLE ITEMS FOR THINK ALOUD PROTOCOL

F.1 CHEMISTRY EQUILIBRIUM UNIT



Mide-bağırsak sisteminin incelenmesinde X ışını kullanılır. Hastaya baryum sülfat ($BaSO_4$) çözeltisi içirilerek, X ışınları altında yemek borusundan mideye geçişi izlenebilir. Baryum sülfat ışın geçirmeyen bir maddedir, yani X ışınlarına direnci olan bir maddedir ve filmde ışıklı alanlar olarak görünür (Soldaki şekilde görüldüğü gibi).

Baryum (Ba^{+2}) iyonu oldukça zehirli bir iyon olmasına rağmen, baryum sülfat çözeltisi hasta için zararsızdır. Çözünürlük Dengesi ünitesinde edindiğin bilgileri kullanılarak bu durumu açıklayabilir misin?

$BaSO_4$ için $K_ç = 1,1 \times 10^{-10}$

F.2 ACIDS AND BASES UNIT

Zayıf asit çözeltisinin pH değeri, kuvvetli asit çözeltisinin pH değerinden daha küçük olabilir mi?

- Olmaz diyorsanız nedenini kısaca açıklayın.
- Olur diyorsanız hangi koşullarda olduğunu kısaca açıklayın.

APPENDIX G

SAMPLE JOURNAL FROM THE TOPIC ACIDS AND BASES

HOW JOURNALS COVER THREE CYCLIC SRL PHASES

JOURNAL 6: How much acidic? How much basic?

Group No:	Grup Name:	Student ID:

Student IDs and Roles (Supervisor, Technician, Reporter) of the Students:

1.

2.

3.

4.

WARNING: Bring your latex gloves since acids and bases are corrosive.

INTRODUCTION:

Check existing knowledge or introduce some new concepts **(Forethought Phase)**

In the previous activity, we investigated some substances for their acidity or basicity with the help of some indicators found in the lab. Can I find how much acidic or basic a substance is? To do this I can compare acidity and basicity of some substances with pure water by taking pure water as reference. Pure water is ionized, though very slightly, at 25°C. Ionization reaction of water is an equilibrium reaction and shown as $H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$. K_{eq} of this reaction is shown as below:

$$\mathbf{K_{eq}} = \frac{[H^+][OH^-]}{[H_2O]}$$

In this equation, concentration of *water* (H_2O) is constant because water is liquid. Accordingly, equilibrium constant can be written like this:

$K_{eq}[H_2O]=[H^+][OH^-]$

In this equation, $K_{eq}[H_2O]$ can be shown as K_w. So, K_w is written like this:

$K_w=[H^+][OH^-]$

Since K_w is an equilibrium constant, it is affected from temperature changes: the value of K_w is 1.0 x 10^{-14} at 25°C. The concentrations of H^+ and OH^- ions are equal in pure water. So, **$[H^+]=10^{-7}$M and $[OH^-]=10^{-7}$M at 25°C.** In aqueous solutions, since the values of $[H^+]$ and $[OH^-]$ are very small, we use the term "pH" to make it easy. The value of pH is calculated as negative logarithm of the concentration of H^+ ion.

$pH = -\log[H^+] \Rightarrow pH = -\log 10^{-7} = 7$ in pure water

Similarly, the value of pOH is calculated as negative logarithm of the concentration of OH^- ion

$pOH = -\log[OH^-] \Rightarrow pOH = -\log 10^{-7} = 7$ in pure water

So, in pure water at 25°C, pH + pOH = 14.

In pure water the concentrations of H^+ ve OH^- ions are equal and the medium is neutral. If the concentration of H^+ ions in a solution is higher than the concentration in pure water, than the solution has acidic property. If the concentration of OH^- is higher in a solution than in pure water, than the solution has basic property.

To find the value of pH in aqueous solutions, Universal Indicator Paper **is used. This paper changes its color between the pH values of 1 to 14. With the help of Universal Indicator Paper, it is possible to find pH value of a substance according to color changes.**

In the previous activity, we investigated whether a substance is acidic or basic. *In today's activity, we will examine how much acidic or basic some substances are that we see in daily life or find in chemistry lab. To do this, we will use universal indicator paper.*

WARNING: Bring your latex gloves since acids and bases are corrosive.

Safety Information / Guidance

What will I investigate? Purpose of the task **(Forethought Phase)**

You are asked to compare pH values of the substances on the laboratory desk.

NOTE: **(**Environmental Support / Scaffolding**)** We will use Universal Indicator Paper for this purpose. Universal Indicator Papers are found as strips and they will have different color for different pH's when they are immersed in a solution. The pH takes on a value between 1 to 14 when measured with Universal Indicator Paper.

Materials: (Environmental Support/ Introduce resources)

- Acidic and basic solutions (hydrochloric acid (HCl), sodium hydroxide (NaOH), acetic acid (CH_3COOH), ammonia (NH_3) solutions)

- Tap water, pure water (rain water or lake water)

- Household substances (you can bring liquids such as vinegar, soda, mineral water, lemon juice or fruits such as lemon, tomato, orange. Also, drain opener, glass cleaner, various cleaners, and skin cleanser could be possible.)

- Glass equipment (100 ml. beaker, 100 ml. erlenmayer flask, test tubes)

- Universal Indicator Paper

❒ **Explain what you will do during the practice before you start.**

Planning activity **(Forethought Phase)**

❒ **Prepare a table to write data obtained during the practice. Having prepared this table beforehand will help you save time. To draw the table, use the space below or the other side of the sheet.**

Planning data recording **(Forethought Phase)**

❒ **If you have any predictions before the beginning of the practice, take notes. For example, what pH values do you expect the chemicals in the lab to have?** Predictions / to help focusing scientific obeservations **(Forethought Phase)**

❒ **Fill the table you prepared with your observations.**

Observation Data **(Performance Phase)**

Are your predictions similar to the data obtained during practice? Did you get unexpected results? Explain. Unexpected outcomes / to improve metacognitive awareness **(Self-reflection Phase)**

NOTE: The duration to complete the tasks to this point is 40 minutes. To use your time effectively it is advised that you make a plan previously.

Planning / time management **(Forethought Phase)**

What have I learned?

Assessing learned material / to improve metacognitive awareness **(Self-reflection Phase)**

At the end of this activity, write down the **concepts** that are related to the activity and the **inferences** you draw at the end of the activity.

Inference based on observations **(Performance Phase)**

At what point did I have difficulties?

Experienced difficulties during activity / to help students think about necessary enviromental help, teacher support **(Self-reflection Phase)**

During the Activity 8, at what point did you have difficulties? What did you do in that case?

Moreover, you can write down questions you have trouble with and the points you want to investigate more.

ADDITIONAL INFORMATION: pH meter

(Extra Information for Interested Students)

In high school laboratories, **Universal Indicator Paper** is used to find pH values. These papers take different colors at different pH values between 1 to 14. In research laboratories, a device called **pH meter** is used to make precise measurement. Using this device, it is possible to measure a pH value with two significant figures after comma. Various types of this device can be found. In the figure below, the electrode of the pH meter is immersed in the solution to measure its pH value. The measurement values can be seen on the screen of the device on the right. The **pH value** is found to be **6.78**. This device also measure the temperature, it is **28.6°C**.

EXPLAIN THE EXAMPLES BELOW CONSIDERING THE KNOWLEDGE YOU LEARNED:

Evaluation (check conceptual understanding) /Elaboration (apply learnt material into different context) **(Self-reflection Phase)**

*This part will be filled after the activity is finished.

❒ **According to the results of this activity, which substances you examined are acidic and which are basic? Which pH values do they have?**

❒ **According to the results of the measurements, which substances are more acidic? Write down the pH values of those substances.**

❒ **According to the results of today's activity how did the pH values change when the acidity was increased?**

❒ **According to the results of the measurements which substances are more basic? Write down the pH values of those substances.**

❒ **According to the results of today's activity how did the pH values change when the basicity was increased?**

❒ **Indicate the pH value of one of the substances you examined and calculate its H^+ concentration.**

❒ **Indicate the pOH value of one of the substances you examined and calculate its OH^- concentration.**

❒ **Compare the acidity and H^+ ion concentration of pure water and tap water.**

❒ **Can we use the term "pH" for basic substances? Why? Explain shortly.**

❒ **Can we use the term "pOH" for acidic substances? Why? Explain shortly.**

❒ **Fill the blank cells in the table below using the given information and values.**

pH	$[H^+]$	$[OH^-]$	pOH
3			
	10^{-11}		
		10^{-6}	
			1
		10^{-10}	
	10^{-7}		
0			

❒ **Calculate pH and pOH values of a solution which has a OH^- concentration of 10M.**

EVALUATION OF ACTIVITY 6 Assesing the activity **(Self-reflection Phase)**

*This section will be filled after the activity is finished.

❒ **How challenging was today's activity?**

1	**2**	**3**	**4**	**5**
Not at All	Not Really	Medium	Somewhat	Very Much

❒ **How much were you motivated during today's activity?**

1	2	3	4	5
Not at All	Not Really	Medium	Somewhat	Very Much

❒ **How interesting was today's activity?**

1	2	3	4	5
Not at All	Not Really	Medium	Somewhat	Very Much

❒ **Do you think today's activity helped you learn the concepts?**

1	2	3	4	5
Not at All	Not Really	Undecided	Somewhat	Very Much

❒ **How efficient was the group work?**

1	2	3	4	5
Not at All	Not Really	Medium	Somewhat	Very Much

❒ **In this activity, which sources did you benefit from?**

- My teacher
- My friends in my group
- My friends in other groups
- Activity sheets
- Others: specify ……………………

❒ **In what part(s), the lecture has failed? What do you advise to fix this (those)? Please specify.**

APPENDIX H

SAMPLE LESSON PLAN FOR THE EXPERIMENTAL GROUP FOR JOURNAL 6 GIVEN IN APPENDIX G

School Level: High School

Grade level: 11th grade

Unit: Acids and Bases

Topic: Strength of Acids/Bases, Dissociation of Pure Water

Unit Outline:

A. Definition of Acids and Bases, General Properties of Acids and Bases

B. Strength of Acids/Bases, Dissociation of Pure Water

C. Equilibrium of Weak Acids/Bases, Neutralization

D. Neutralization and Titration

E. Hydrolysis and Buffer Solutions

Teaching Strategy: Self-Regulatory Instruction based on Guided Inquiry Approach

Journal 6: How much acidic? How much basic?

Link: At the previous week, In Journal 5 (Acid or Base?) which took two class hours, students initially identified the colors of different acid-base indicators (blue litmus paper, red litmus paper, methyl orange, and phenolphthalein), then tested acidic or basic property of different households, and finally explored whether the given purple liquid (purple cabbage juice as an acid-base indicator) could be used as an acid-base indicator. In the third class hour, summary of different acid-base definitions in association with their historical development, and general properties of acids and bases were discussed with the students.

Today students will explore the strength of different acid and base solutions and different households in Journal 6 (How much acidic or how much basic?).

In the following class hour, students will define the pH and pOH concepts, and the pH scale connecting with today's laboratory task; argue the difference between the strength and the concentration of any acid or base solutions; discuss the ionization of water and the equilibrium constant expression (Kw) in association with Le Chatelier's principle; describe the acid dissociation constant (Ka) and the base dissociation constant (Kb) on different examples; and solve algorithmic questions related with dissociation of pure water, pH and pOH concepts.

Then, in the following week, they will continue with the reactions of different metals [active (magnesium), semi-precious (copper), and amphoteric (aluminum)] and acid/base solutions such as hydrochloric acid, sulfuric acid, and sodium hydroxide.

Timing: Two class hours; 80 minutes

1. Groups take their places, greeting, and taking students attention to the topic (2 minutes)
2. Pre-Classroom Discussion: summarizing previous lesson (5 minutes)
3. Distribution of journal 6 to students (3 minutes)
4. Within group discussion (Meanwhile teacher walks through the groups and gives feedback and clues to guide them) (10 minutes)
5. Distribution of chemicals to technicians (5 minutes)
6. Conducting the task (20 minutes)

7. Post- Classroom Discussion: (10 minutes)
8. Evaluation and elaboration of concepts (13 minutes)
9. Classroom Discussion on the answers of step 8. (10 minutes)
10. Evaluation of the activity (2 minutes)

General Objectives:

Objectives (General Objectives (GO), Specific objectives (SO))

Students will able to

1. understand the concepts of pH and pOH. (GO)

1.1 measure the pH value of a solution in the laboratory. (SO)

1.2 compare the acidity and/or alkalinity of given solutions based on pH value. (SO)

2. explain the difference between the strength and the concentration of a given solution. (GO)

2.1 define the strength of an acid/base solution. (SO)

2.2 test for the difference between strong acids/bases and weak acids/bases. (SO)

2.3 define the concentration of an acid/base solution. (SO)

2.4 explain the difference between concentrated acids/bases and dilute acids/bases. (SO)

2.5 make a distinction between the strength and concentration of acids/bases. (SO)

3. describe the dissociation of pure water. (GO)

3.1 relate the dissociation of pure water and the equilibrium constant expression (Kw). (SO)

3.2 calculate the concentration of H_3O^+ and OH^- ions using the dissociation of pure water. (SO)

3.3 convert $[H_3O^+]$ and $[OH^-]$ to pH and pOH values. (SO)

3.4 calculate the pH, pOH, $[H_3O^+]$ and/or $[OH^-]$ values for a solution when any of these values is given. (SO)

Instructional Materials:

- Acidic and basic solutions (hydrochloric acid (HCl), sodium hydroxide (NaOH), acetic acid (CH_3COOH), ammonia (NH_3) solutions)

- Tap water, pure water (rain water or lake water)

- Household substances (the substance that students will bring: liquids such as vinegar, soda, mineral water, lemon juice or fruits such as lemon, tomato, orange. Cleaning supplies such as drain opener, glass cleaner, various cleaners, and skin cleanser can be brought.)

- Glass equipment (100 ml. beaker, 100 ml. Erlenmeyer flask, test tubes)

- Universal pH indicator papers

Presentation of the topic

- Groups take their places, the teacher greets the students takes their attention to the topic. (2 minutes)
- The following questions can be asked to open "pre-task classroom discussion" for the purpose of reinforcing students' prior knowledge and motivating them to engage in the task. (5 minutes)
    - How can you decide whether a given solution can be used as an indicator or not?
    - How can you identify whether a given solution is acidic or basic?
    - You can consume some acids as food such as lemon juice. On the other hand, other acids are very harmful for you. Can you compare acidic or basic characteristics of different acid and bases solutions?

The teacher writes down all the answers coming from the students on the board, asks the class whether they agree or not to others' answers. At the end, with respect to the answers coming from the class the teacher goes over the main points on the board.

- Distribution of Journal 6 to students (3 minutes) (See Appendix G for Journal 6)
- The introduction section of Journal 6 explains the ionization of pure water at 25°C and the equilibrium equation for this reaction. Than pH scale ranging from 1 to 14 is given. Finally, the universal pH indicator paper is introduced.
- Next, the teacher demonstrates how to measure pH value of a solution using universal pH indicator papers.
- Groups perform within group discussion on how to accomplish the given task under the direction of the group's supervisor. Meanwhile, the teacher walks through the groups and gives feedback about their work and clues to guide them. The reporter writes down the procedure they plan to employ and how to report the data. (10 minutes)
- After getting approval from the teacher for the procedure to be employed, the chemicals will be distributed to the technicians by the teacher. (5 minutes)
- Next groups will conduct the task under the guidance of the teacher (20 minutes)

  Initially, the students will report their predictions.

  Then, they will work with different chemicals that they explored in the previous journal.

  Next, they will work with the household materials.

  Meanwhile students will discuss whether their predictions and observations supported each other, and they make inferences based on their observations. The teacher will provide feedback to groups on how accurately they conduct the planned procedure and ask open-ended questions to guide them.

- After groups completed the task, "post-classroom discussion" will be conducted to talk over students' observations and the inferences they come up. The following questions can be asked: (10 minutes)
  - Why does the pH scale range between "1 and 14", instead of "1 and 10" or "1 and 20"?
  - What would you expect to happen to the pH of an acid solution with a pH value of 2 when you dilute it with the same amount of distilled water?
  - What would you expect to happen to the pH of an acid solution with a pH value of 2 when you slowly add some amount of base solution with a pH value of 12?
- At the end of the journal, the "Explain the examples below considering the knowledge you learned" section includes exercises for students to evaluation their conceptual understanding and apply learnt material into different context. (13 minutes)

  While working on the exercises, initially students will discuss on the answers within group then the reporter write down their final decision onto the journals.
- After students completed the previous step, the teacher will conduct a classroom discussion on their answers. (10 minutes)
- Students will complete the evaluation form for the activity. (2 minutes)

If time activity:

If time is left, students can measure pH values of various solutions that they will prepare with the chemicals/salts available at the laboratory.

APPENDIX I

THE PRECIPITATION EXPERIMENT AT STUDENTS' TEXTBOOK

Deney 3.1: Bazı Bileşiklerin Sulu Çözeltileri Arasındaki Tepkimeler

Amaç : 1. Verilen çözeltilerdeki iyonları belirleyerek iyonlaşma denklemlerini yazmak

2. Çözeltilerin karıştırılmasıyla oluşan çökeltilerin, hangi maddeler olduğunu bulmak

Araç ve Gereç

1. Deney tüpü (5 adet) 2. Tüplük 3. Etiket

4. Aşağıda gruplar hâlinde verilen maddelerin damlalıklı şişelerdeki çözeltileri:

	I. GRUP	II. GRUP	III. GRUP
1.	0,1 M K_2CrO_4	0,2 M $Fe(NO_3)_2$	0,1 M $BaCl_2 . 2H_2O$
2.	0,1 M $Ba(NO_3)_2$	0,1 M Na_2SO_4	0,1 M Na_2CrO_4
3.	0,1 M $FeCl_3 . 6H_2O$	0,2 M KCl	0,1 M $Ca(NO_3)_2 . 6H_2O$
4.	0,1 M $Sr(NO_3)_2$	0,2 M NaOH	0,07 M $Al_2(SO_4)_3$
5.	0,2 M $NaNO_3$	0,07 M $AlCl_3$	0,2 M KOH

		1	2	3	4	5
		$NaNO_3$	$Sr(NO_3)_2$	$FeCl_3.6H_2O$	$Ba(NO_3)_2$	K_2CrO_4
1	K_2CrO_4					
2	$Ba(NO_3)_2$					
3	$FeCl_3.6H_2O$					
4	$Sr(NO_3)_2$					
5	$NaNO_3$					

Çizelge 3.1

Deneyin Yapılışı

1. Çizgisiz kâğıda veya defterinize Çizelge 3.1'i her grup için ayrı ayrı çiziniz.

2. Size verilen çözeltilerin ikişer ikişer karışmasını sağlamak için:

a. Tüplükteki beş tüp üzerine 1. çözeltiden her birine 5 damla damlatınız. Sonra bu damlalar üzerine, 5. çözeltiden başlayarak 4, 3, 2 ve 1. çözeltilerden ikişer damla damlatınız.

b. Bu işlemi diğer çözeltiler için de tekrar ediniz.

c. Tabloda çökelti verenleri "+", vermeyenleri "-" işaretiyle gösteriniz. Çökelti vermesini beklediğiniz hâlde, gözleyemediğiniz tepkimeleri çözeltilerin damla sayısını artırarak tekrarlayınız.

Deney Sonu Soruları

1. Kullandığınız her bir çözeltideki iyonlaşma denklemini yazarak, karıştırıldıklarında çökelti oluşturan tepkimelerin iyon ve net iyon denklemlerini, aşağıda verilen örnekten yararlanarak yazınız.

Örnek: $Pb(NO_3)_2$ ve Na_2CO_3 çözeltilerini karıştıralım. $Pb(NO_3)_2$ çözeltisinden Pb^{2+} ve NO_3^- iyonları, Na_2CO_3 çözeltisinden ise Na^+ ve CO_3^{2-} iyonları gelmektedir. Çözeltiler karıştırıldığında, iyonlar karşılıklı olarak yer değiştirir. Yani oluşan çökeltiler $PbCO_3$ veya $NaNO_3$ olmalıdır. $NaNO_3$ çözeltide Na^+ ve NO_3^- iyonları hâlinde bulunur. Çökelen maddenin $PbCO_3$ olduğu anlaşılır.

$$Pb(NO_3)_{2(suda)} \longrightarrow Pb^{2+}_{(suda)} + 2NO^-_{3(suda)}$$

$$Na_2CO_{3(suda)} \longrightarrow 2Na^+_{(suda)} + CO^{2-}_{3(suda)}$$

Çökelmeye ait toplam iyon denklemi:

$$Pb^{2+}_{(suda)} + 2NO^-_{3(suda)} + 2Na^+_{(suda)} + 2CO^{2-}_{3(suda)} \rightleftharpoons PbCO_{3(k)} + 2Na^+_{(suda)} + 2NO^{2-}_{3(suda)}$$

Net iyon denkleminde, sadece çökelen maddelerin iyonları bulunur:

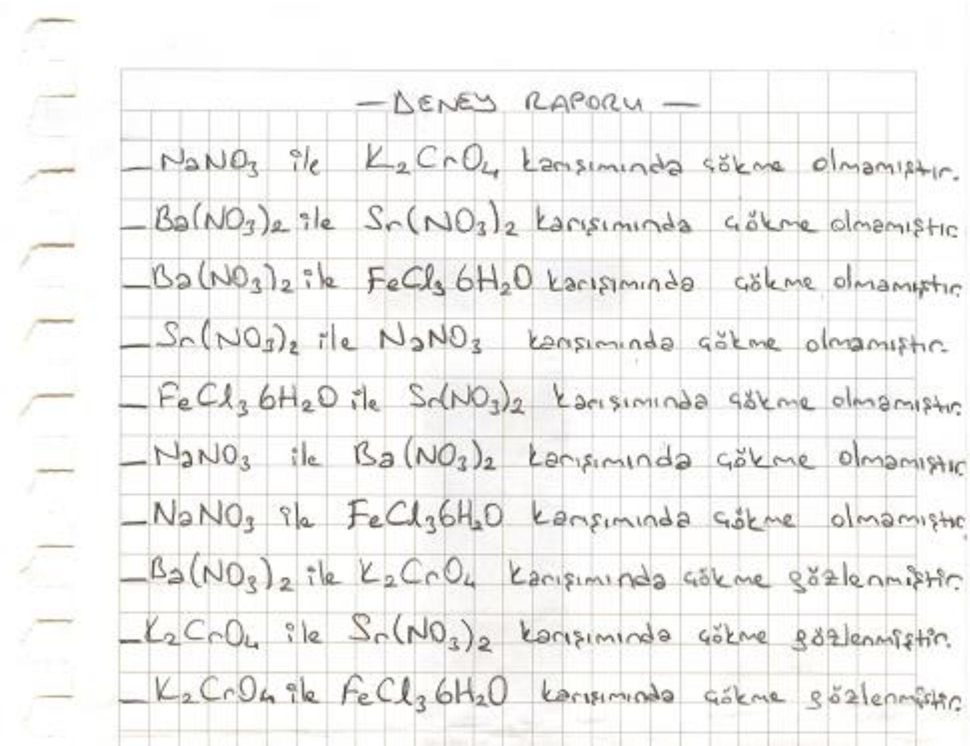
$$Pb^{2+}_{(suda)} + CO^{2-}_{3(suda)} \rightleftharpoons PbCO_{3(k)}$$

2. Deneylerde çökelti oluşmasının nedenini, Tablo 3.2'deki $K_ç$ değerlerinden yararlanarak açıklayınız.

APPENDIX J

SAMPLE LABORATORY REPORTS FOR THE CONTROL GROUP

APPENDIX J.1 Sample Report from Precipitation Activity



— DENEY RAPORU —

— $NaNO_3$ ile K_2CrO_4 karışımında çökme olmamıştır.

— $Ba(NO_3)_2$ ile $Sr(NO_3)_2$ karışımında çökme olmamıştır

— $Ba(NO_3)_2$ ile $FeCl_3 6H_2O$ karışımında çökme olmamıştır

— $Sr(NO_3)_2$ ile $NaNO_3$ karışımında çökme olmamıştır.

— $FeCl_3 6H_2O$ ile $Sr(NO_3)_2$ karışımında çökme olmamıştır

— $NaNO_3$ ile $Ba(NO_3)_2$ karışımında çökme olmamıştır

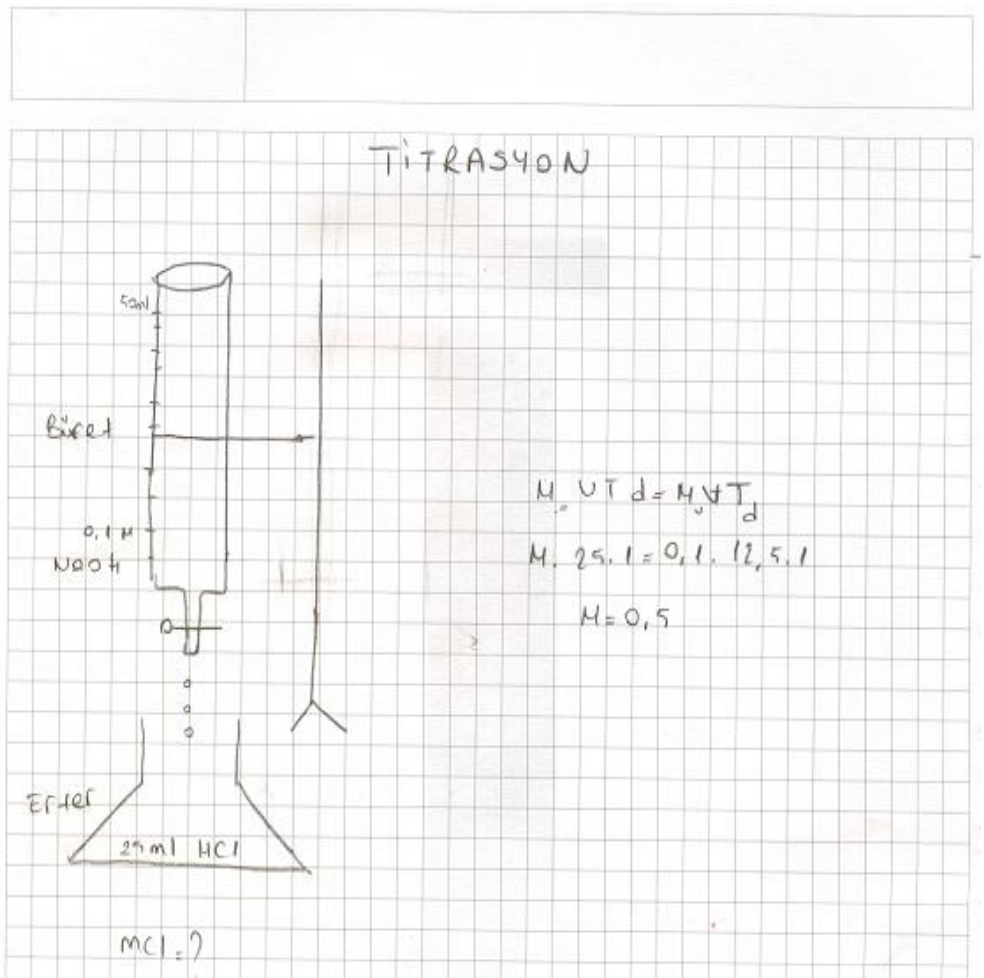
— $NaNO_3$ ile $FeCl_3 6H_2O$ karışımında çökme olmamıştır

— $Ba(NO_3)_2$ ile K_2CrO_4 karışımında çökme gözlenmiştir

— K_2CrO_4 ile $Sr(NO_3)_2$ karışımında çökme gözlenmiştir.

— K_2CrO_4 ile $FeCl_3 6H_2O$ karışımında çökme gözlenmiştir

APPENDIX J.2 Sample Report from Titration Activity



APPENDIX K

SUGGESTIONS FOR EFFECTIVE GROUP WORK

ETKİLİ GRUP ÇALIŞMASI İÇİN ÖNERİLER

Grup çalışmasının verilen sürede etkili bir şekilde tamamlanabilmesi için grup üyelerinin belli görevleri kendi aralarında paylaşmaları gerekmektedir. Aşağıdaki görev dağılımı örnek alınabilir.

Grup içi rol dağılımlarıyla ilgili olarak; önce her bir grup üyesi için görev dağılımlarını okuyun. İlk olarak **lideri** atamakta fayda var. Bunun için aranızdan biri gönüllü olabilir ya da diğer arkadaşlarınız bir aday önerebilir. Önerdiğiniz aday bu görev için istekli değilse bir grup tartışması yoluyla ya da oylayarak grup liderini belirleyebilirsiniz. Lider belirlendikten sonra, lider grup üyelerinden birini **teknisyen**, diğer bir arkadaşı da **raportör** olarak belirleyecek. Her bir etkinlikte bu rol dağılımları değişecektir. Grup çalışmasının etkili olabilmesi ve kısa surede daha fazla araştırma yapabilmek için lidere yardımcı olalım.

Her bir görev ve o göreve ait görev dağılımı size yardımcı olmak için tavsiye amaçlı hazırlanmıştır. Görev dağılımlarında gerekli düzenlemeleri yapabilir, grup sayısının üçten fazla olduğu durumlarda bazı görevleri (örneğin teknisyen) iki kişi arasında paylaşabilirsiniz.

O etkinlik için olan görev dağılımını öğrenme günlüklerinde belirtin.

Grup içi Görev Dağılımı

1. Lider

a. Grup üyelerinin toplanmasını, çalışmaya hazırlanmasını sağlar.

b. Zamanı ve yeri etkili kullanmak için gerekli düzenlemeleri yapar.

c. Laboratuar uygulamalarını takip edebilmek için öğrenme günlüklerini kontrol eder.
d. Soruları yüksek sesle okur, grup tartışmalarını yönetir.
e. Her bir grup üyesinin tartışmaya eşit şekilde katılımına yardımcı olur.
f. Grup üyelerinin görevlerini yerine getirip getirmediklerine dikkat eder.

2. Teknisyen (4 kişilik gruplarda iki kişi bu görevi üstlenebilir)

a. Lider öğrenme günlüğündeki yönergeleri okurken, deney düzeneğindeki malzemeleri kontrol eder.
b. Grup tartışması sonucunda belirlenen deney düzeneğini hazırlar, gerektiğinde grup arkadaşlarından ya da öğretmenden yardım alır.
c. Kullanılan kimyasal malzemelerdeki güvenlik uyarılarını grup arkadaşlarına açıklar.
d. Deney sırasında oluşabilecek kazaları önlemek için malzemelerin masa üstünde düzenli şekilde olmasını sağlar.
e. Deney sonrasında grup arkadaşlarının yardımıyla cam malzemeleri ve deney masasını temizler.
f. Deney sonrasında cam malzemeleri ve kimyasal maddeleri yerine yerleştirir.

3. Raportör (5 kişilik gruplarda iki kişi bu görevi üstlenebilir)

a. Laboratuarda notu, soruyu ya da cevapları kaydeder, bunların dosyalanmasını sağlar.
b. Tabloları, grafikleri hazırlar.
c. Deney ve tartışma sonuçlarını kaydeder.

APPENDIX L

SUGGESTIONS FOR EFFECTIVE GROUP/CLASSROOM DISCUSSIONS

ETKİLİ GRUP/SINIF TARTIŞMALARI İÇİN ÖNERİLER

Grup içi tartışmalar, eksiklerinizi görmeniz ve onları gidermeniz için büyük bir fırsattır. Söyleyeceğiniz bir cümlenin önemsiz olduğunu düşünmeyin, unutmayın saçma ya da anlamsız soru/fikir yoktur. Düşüncelerinizi arkadaşlarınızla paylaşmaktan çekinmeyin. Düşüncenizi ifade ederken eksik kalan bir nokta olursa arkadaşlarınız bunu telafi edecektir, etkili bir tartışma bunu gerektirir.

Sınıf içi tartışmaların etkili olabilmesi ve arkadaşlarınızın görüşlerinden faydalanabilmek için dinleme, kritik düşünme ve konuşma becerilerine ihtiyaç vardır. Grup tartışmalarının etkili olabilmesi için aşağıdaki önrilerden faydalanabilirsiniz.

Diğerlerinin iddia, tartışma ve açıklamalarını <u>dinlerken</u> şunları göz önünde bulundurun:

1. Katılan herkes tartışmaya bir katkı sağlar.
2. Diğerlerinin fikir ve düşüncelerine saygı gösterin.
3. Diğerlerinin söylediklerini dikkatlice değerlendirin.
4. Aktif dinleme, söylenen ifadeleri kendi görüşümüzle kıyaslamayı, konuşmacının söylediklerine bir soru ya da yorumla karşılık vermeyi, ya da söylenen düşünceyi test etmeyi gerektirir.

5. Başkalarının söylediklerine cevap vermek araştırma yapmayı, derinlemesine düşünmeyi, çatışan fikirleri değerlendirmeyi ve söylenen bir ifadeyi genişletmeyi gerektirir.
6. Bir konuşmaya katırken karşındakinin sözünü kesmemek ve diğer konuşmacılara baskın bir rol almamak önemlidir.

Diğerlerinin ve kendi iddia, tartışma ve açıklamalarımızı <u>düşünürken</u> ve <u>söylerken</u> şunları göz önünde bulundurun:

1. Söyleyeceğiniz noktaların ve iddiaların anlaşılır olmasına dikkat edin. Diğer katılımcılar konuşurken gerektiğinde netleştirmesini isteyin.
2. Konuşmacılardan daha fazla açıklamada bulunmasını ya da örnek vermesini isteyebilirsiniz.
3. Diğerleri tarafından yöneltilen iddiaları anlamak için destekleyici kanıtlar isteyebilirsiniz.
4. Belirtilen görüşler arasındaki ilişkileri belirten ya da aynı görüşün farklı ortamlarda örneklerini/uygulamalarını içeren yorumlarda bulunabilirisiniz.
5. Belli bir konuyu detaylandırmak için görüş belirtebilirsiniz.
6. Alternatif açıklama ya da teori sunabilirsiniz.
7. Fikirleri ve açıklamaları değerlendirirken mantıklı gelip gelmediğine dikkat edin.
8. Açıklamaların sunulan kanıtlarla tutarlı olup olmadığına dikkat edin.
9. Yapılan açıklamaların ya da sunulan fikirlerin doğruluğunu değerlendirin.
10. Yapılan açıklamaların ya da sunulan fikirlerin konuyla ilgili olup olmadığını değerlendirin.

APPENDIX M

APPROVAL LETTER FOR THE USE OF PhET SIMULATION

"SALTS AND SOLUBILITY"

University of Colorado at Boulder

Department of Physics

390 UCB
Boulder, Colorado 80309-0390
PHONE: (303) 492-6952
FAX: (303) 492-3352

February 9, 2010

Cansel Kadioglu
Collaborator from Department of Secondary Science and Mathematics Education at Middle East Technical University
kcansel@metu.edu.tr

Dear Cansel Kadioglu,

Thank you for your interest in using PhET!

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If your use includes redistribution of the simulations, please send us updates about the number of simulations your have posted and how much web traffic they are getting by writing phethelp@colorado.edu! This type of information is useful when writing proposals for future funding.

Enclosed is a copy of the PhET Software Agreement which provides additional details. Please contact me if you have any questions.

Best Regards,

Katherine K. Perkins

Katherine K. Perkins
Co-Director of PhET, University of Colorado
Katherine.Perkins@colorado.edu, 303-492-6714

APPENDIX N

ETHICAL PERMISSION

EĞİTİM
FAKÜLTESİ DEKANLIĞI
Ev. Arş. Md. Saat:

T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

BÖLÜM : İstatistik Bölümü
SAYI : B.B.08.4.MEM.4.06.00.04-312/107242
KONU : Araştırma İzni
Cansel KADIOĞLU

02/11/2009

ORTA DOĞU TEKNİK ÜNİVERSİTESİNE
(Orta Öğretim Fen ve Matematik Ana Bilim Dalı)

İlgi : a) MEB Bağlı Okul ve Kurumlarda Yapılacak Araştırma ve Araştırma Desteğine Yönelik İzin ve Uygulama Yönergesi.
b) Üniversiteniz Orta Öğretim Fen ve Matematik Ana Bilim Dalının 20/11/2009 tarih ve 16293 sayılı yazısı.

Üniversiteniz Ora Öğretim Fen ve Matematik Alanlar Eğitimi Anabilim Dalı Doktora Öğrencisi Cansel KADIOĞLU' nun **"Kimya derslerinde öğretmen rehberli sorgulayıcı araştırma yönteminin uygulanması"** konulu tez ile ilgili çalışma yapma isteği Müdürlüğümüzce uygun görülmüş ve araştırmanın yapılacağı İlçe Milli Eğitim Müdürlüğüne bilgi verilmiştir.

Mühürlü anketler (19 sayfadan oluşan) ekte gönderilmiş olup, uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde iki örneğinin (CD/disket) Müdürlüğümüz İstatistik Bölümüne gönderilmesini rica ederim.

Gülçin UYSAL
Müdür a.
Müdür Yardımcısı

EKLER :
Anket (19 sayfa)

07.12.09 020991

7/12
OÖFMAEB'ne Rehelim. G.S.

İl Milli Eğitim Müdürlüğü-Beşevler
Strateji Geliştirme Bölümü
Bilgi İçin: Kamil COŞGUN

Tel : 215 15 43- 413 36 66- 212 66 40/110
Fax: 215 15 43
strateji06@meb.gov.tr

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name : Kadioglu, Cansel
Nationality : Turkish (TC)
Place of Birth : Karabük
e-mail : canselkadioglu@gmail.com

EDUCATION

Degree	Institution	Year of Graduation
BS and MS	Dokuz Eylul University, Faculty of Education, Department of Secondary Science and Mathematics Education, Chemistry Education	2003
High School	Karabük 75th Year Anatolian High School, Karabük	1998

WORK EXPERIENCE

Year	Place	Enrollment
2005 – Present	Middle East Technical University, Faculty of Education, Department of Secondary Science and Mathematics Education	Research Assistant
2008 – 2009	The University of British Columbia, Faculty of Education, Department of Educational and Counselling Psychology, and Special Education	Visiting Researcher

SELECTED PUBLICATIONS

Kadioglu, C., Uzuntiryaki, E., & Capa-Aydin, Y. (2011). Development of Self-Regulatory Strategies Scale (SRSS). *Education and Science,* 36 (*160*), 11-23.

Perry,N., Thauberger, C., Hutchinson, L., Kadioglu, C., Lau, C. & Rahim, A. (2011, August). Elementary school students' regulation of science learning while solving a fictional murder mystery. Paper presented at the European Association for Research on Learning and Instruction (EARLI) 2011 Conference, Exeter, UK.

Kadioglu, C., Uzuntiryaki, E., & Capa-Aydin, Y. (2011,September). How are high school students' epistemological beliefs related to their goal orientations? Paper presented at the European Science Education Research Association (ESERA) Conference, Lyon, France.