EXPLORATION OF PRESERVICE TEACHERS' REFLECTIVE JUDGMENT AND ARGUMENTATION SKILLS REVEALED IN A SOCIOSCIENTIFIC ISSUES-BASED INQUIRY LABORATORY COURSE

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

DİLEK KARIŞAN

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
THE DEPARTMENT OF ELEMENTARY EDUCATION

APRIL 2014

Approval of the Graduate School of Social Sciences

Prof. Dr. Meliha ALTUNIŞIK
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy.

Prof. Dr. Ceren ÖZTEKİN
Head of Department

This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.

Prof. Dr. Dana L. ZEIDLER
Co-Supervisor

Assoc. Prof. Dr. Özgül YILMAZ-TÜZÜN
Supervisor

Examining Committee Members

Assoc. Prof. Dr. Ahmet KILINÇ	(İBU, ELE)	
Prof Dr. Jale ÇAKIROĞLU	(METU, ELE)	
Assoc. Prof. Dr. Yezdan BOZ	(METU, SSME)	
Assoc. Prof. Dr. Gaye TEKSÖZ	(METU, ELE)	
Assoc. Prof. Dr. Özgül YILMAZ-TÜZÜN	(METU, ELE)	

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

Name, Last name: Dilek KARIŞAN

Signature

ABSTRACT

EXPLORATION OF PRESERVICE TEACHERS' REFLECTIVE JUDGMENT AND ARGUMENTATION SKILLS REVEALED IN A SOCIOSCIENTIFIC ISSUES-BASED INQUIRY LABORATORY COURSE

Karışan, Dilek
Ph.D., Department of Elementary Education
Supervisor : Assoc. Prof. Dr. Özgül Yılmaz-Tüzün
Co-Supervisor: Prof. Dr. Dana L. Zeidler

April 2014, 235 pages

This study aimed to explore preservice teachers' (PTs) reflective judgment skills and determine the argumentation pattern used during argumentation in socioscientific issues (SSI) based Inquiry Laboratory Course (ILC). The association between reflective judgment skills and argumentation pattern was also investigated in SSI-based ILC. The participants of the study were 20 PTs from the Department of Elementary Education at a large, research oriented public university in Turkey. Qualitative research method was used in this study. During SSI-based ILC five socioscientific issues (transportation issue, food additives, alternative energy sources, climate change, and the industrial revolution) were used. PTs' laboratory manuals, interviews and classroom discussions were analyzed qualitatively. In addition to qualitative analysis, quantitative analysis by using chi square, fisher exact test on what correlations were presented to address hypothesized relationships between reflective judgment stages and argumentation levels within five different socioscientific issues. Results of the study showed that PTs' Reflective Judgment Model (RJM) scores tended to increase from the first experiment to last experiment. In that, the class average scores of RJM increased from first experiments to last experiments In addition to class average scores, number of reflective PTs also increased from three to nine. Being reflective on SSI, PTs' also used different levels of argumentation. Their use of evidence to support conflicting ideas tended to increase as their use of incorrect or insufficient use of evidence decreased. Finally, the association between reflective judgment skills and argumentation pattern revealed that reflective PTs tend to have of highest level argumentation whereas prereflective PTs tend to have lowest level argumentation skills across different SSI.

Keywords: Reflective judgment, Argumentation, Preservice teachers, Inquiry laboratory, Socioscientific issues

ÖZ

ÖĞRETMEN ADAYLARININ REFLEKTİF MUHAKEME VE ARGÜMANTASYON YETENEKLERİNİN SOSYOBİLİMSEL KONULARA VE SORGULAYICI ÖĞRETİME DAYALI LABORATUVAR DERSİNDE İNCELENMESİ

Karışan, Dilek
Doktora, İlkogretim Bölümü
Tez Yöneticisi : Doç. Dr. Özgül Yılmaz-Tüzün
Ortak Tez Yôneticisi: Prof. Dr. Dana L. Zeidler

Nisan 2014, 235 sayfa

Bu çalışma öğretmen adaylarının sosyobilimsel konuların incelendiği sorgulayıcı öğretime dayalı laboratuvar dersinde kullanmış oldukları reflektif muhakeme becerilerini ve argümantasyon yeteneklerini araştırmayı hedeflemiştir. Çalışmanın katılımcıları, Ankara’da araştırma odaklı büyük bir üniversitede öğrenim görmekte olan 20 öğretmen adayından oluşmaktadır. Farklı sosyobilimsel konuların (hava kirliliği, gıda katkı maddeleri, alternative enerji kaynakları, iklim değişikliği, endüstri devrimi) dahil edildiği bu araştırmada nitel araştırma yönteminin yanısıra nicel data analiz yöntemi de kullanılmıştır. Öğretmen adaylarının kendi hazıramış oldukları laboratuar kılavuzları, mülakat görüşmeleri ve sınıf tartışmaları nitel olarak analiz edilmiştir. Nitel araştırma sonuçlarına ek olarak, reflektif muhakeme ve argümantasyon becerileri arasındaki hipotetik ilişki nicel olarak incelenip sonuçlar ki-kare testi ve fischer exact test korelasyonları ile sunulmuştur. Çalışmanın sonuçları öğretmen adaylarının reflektif muhakeme becerilerinin ilk incelenen sosyobilimsel konu ile son incelenen sosyobilimsel konu arasında artma eğiliminde olduğunu göstermektedir. Reflektif muhakeme modeline göre hesaplanan sınıf ortalaması ilk uygulamadan son uygulamaya doğru bir artış göstermiştir. Sınıf ortalamasının yanı sıra, reflektif muhakeme düzeyindeki öğretmen adaylarının sayısı da üç'ten dokuz'a yükselmiştir. Reflektif muhakeme yeteneğindeki artışın yanında adayların argümantasyon becerilerinde de farklılık görülmüştür. Bu laboratuvar deneyimi boyunca adayların yetersiz ya da eksik delil kullanma eğilimlerinin azaldığı ve kendi fikirlerini savunurken kullandıkları kanıtların nitelik ve nicelik yönünden zenginleştiği gözlemlenmiştir. Son olarak, iki sonuç değişkeni (reflektif muhakeme ve argümantasyon) arasındaki ilişki incelenmiş olup değişkenler arasında anlamlı bir ilişki olduğu tespit edilmiştir.

Anahtar Kelimeler: Reflektif muhakeme, Argümantasyon, Öğretmen adayları, Sorgulayıcı öğretime dayalı laboratuvar, Sosyobilimsel konular

To My Mother

Pakize İPİN

ACKNOWLEDGMENTS

First, I would like to thank the preservice teachers who selected inquiry laboratory course as an elective course and who voluntarily participated in this course. Your enthusiasm and interest in the learning SSI in the laboratory confirmed my purpose conducting this study.

I especially would like to thank Mr. Nihat Zeybekçi for his everlasting support. Mr. Zeybekçi, you were the only person who had faith in me during my tough times.If you weren't there to back me up, I could not be a Ph.D. candidate right now. I appreciate your all contributions to my life. Thank you for providing me full support even when everything deteriorates.

I also would like to thank the course assistants Bahar Yılmaz-Yendi, Murat Aydemir, Volkan Atasoy, Ali Sağdıç, and Mehmet Şen who contribute to this work as an independent evaluator. This study would not have happened without their' numerous guidance while conducting experiments.

I have been extremely fortunate to share offices with some of the best people Dilek Altun, Gamze Çetinkaya, Berna Sicim, and Simge Alkuş. You always support me when my feelings were up and down throughout this process. Ayşe Yenilmez-Türkoğlu, it is my pleasure to have a "bestie" as you. Your friendship has no exchange of payment; it looks like our paths has changed as life goes on, but I am sure the bond between us remains ever strong.

I would like to express my gratitude to the members of my thesis committee. Dr. Ahmet Kılınç, Dr. Gaye Teksöz, Dr. Jale Çakıroğlu, and Dr. Yezdan Boz your guidance and feedback were seminal to the completion of this study.

My deepest appreciation for the love and support from Pakize İpin, the most powerful mum I have ever seen. Mum, your dedication to your children can not be explained with any word. You are my life mentor. May this gift be used to honor and glorify you. Thank you for the work you have done in me. I also would like to thank my brother Murat Karışan who has encouraged me every step of the way.

For a Ph.D. candidate there is no easy walk to graduate, sometimes it was like passing through the valley of the shadow of death again and again (have to reorganize chapters again and again according to the feedbacks) before I reach the mountaintop of my desires (final draft of the thesis). I was lucky during this journey, since my travelling companions were Dr. Yılmaz-Tüzün and Dr. Zeidler. A good head and a good heart are always a formidable combination. I am truly fortunate to have been able to enjoy and benefit from such a combination you have. I truly think, look at, and act in the world differently due to your influence as being a good "human" before being a good advisor. This work would not have been possible without the amazing work of you. Your patience and grace through the challenging moments did not go unnoticed.

Dr. Yılmaz-Tüzün, thank you for your countless hours of shaping, editing, and motivating! Your insights and a keen eye for how to arrange a well-organized thesis have been priceless. I am thankful to you not only for benefiting from your intelligence, and wit, but also your humanity, and companionship.

Dr. Zeidler, thank you for being my co-advisor, the best friend, mentor, teacher, and companion. I am grateful for your support, encouragement, and belief in me. The time I spent at the University of South Florida with you was one of the best efficacious educational act of my life. Thank you for always being by my side despite the oceans that lie between us.

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ABBREVIATIONS

AAC	Association of American Colleges
CC	Climate Change
DBR	Design Based Research
ECE	Early Childhood Education
ESE	Elementary Science Education
ESA	European Space Agency
GMF	Genetically Modified Food
HEP	Hydro Electric Power Plant
ILC	Inquiry laboratory course
IPCC	Intergovernmental Panel on Climate Change
MoNE	Ministry of National Education
MENR	Ministry of Energy and National Resources
METU	Middle East Technical University
NRC	National Research Council
NSES	National Academy of Sciences
NGSES	Next Generation Science Education Standards
NOS	Nature of Science
OECD	Organization for Economic Co-operation and Development
PCK	Pedagogic Content Knowledge
PST	Preservice Science Teachers
PT	Preservice Teachers
PPT	Power Point Presentation
PRJI	Prototypic Reflective Judgment Interview
PISA	Program For International Student Assessment

RJM	Reflective Judgment Model
RCI	Reasoning about Complex Issues
SL	Scientific Literacy
STS	Science Technology Society
STS-E	Science Technology Society Environment
SPS	Science Process Skills
SMK	Subject Matter Knowledge
SSI	Socioscientific issues
TAP	Toulmin Argument Pattern
TAEA	Turkish Atomic Energy Authority
OECD	Organization for Economic Co-operation Development
UN	United Nations
UNEP	United Nations Environment Program
WISE	Web-Based Inquiry Science Environment
WHO	World Health Organization

CHAPTER 1

1. INTRODUCTION

Almost every aspect of human life are affected by science and technology; thus there is an urgent need for citizens to have ability to read and understand basic scientific concepts (National Research Council [NRC], 2012). The overarching goal of science education is to ensure that students have some recognition of the beauty and wonder of science; to obtain adequate knowledge of science and engineering, to enroll in public discussions on relevant issues (NRC, 2012) and, to understand the effects of scientific and technological developments to their everyday lives (Osborne & Dillon, 2008). In order to attain this goal, science education should be a part of contemporary life by engaging students and community members in meaningful activities related to their own lives (Tal & Kedmi, 2006).

To prepare the students as participant citizens is one of the primary goals of science education (Lee et al., 2013). School science should be personally meaningful and strongly connected to students lives, it should be situated in contexts where students have the opportunity to improve their reflective reasoning ability and become enmeshed in collective evidence-based decision-making experiences and other forms of social engagement (Sadler & Zeidler, 2005). Teachers have a central role in enhancing students' social engagement.

Students' active engagement promotes Scientific Literacy (SL), which is a long standing goal of science education (Fowler, Zeidler & Sadler, 2009). The term SL has been used in the literature for more than three decades; at the same time it is well known in science education community that there is no consensus about the definition of SL (Roberts, 2007). There are two competing visions about the SL simply referred as Vision-I and Vision-II that complement one another. The former emphasize the products and process of science itself. On the other hand, the latter emphasizes a broader scope that students are likely as citizens, involving in personal decision makings, and that assumes science for specific social purposes. In this study, I followed Vision II approach as it provides an opportunity for contextualized learning of science content as well as an opportunity for moral development. For this purpose, that approach being embedded in a social constructivist framework of sorts, the following definition of is congruent with the purposes of this study.

> Developing an ability, to creatively utilize appropriate evidence-based scientific knowledge and skills, particularly with relevance for everyday life and a career, in solving personally challenging yet meaningful scientific problems as well as making, responsible socio-scientific decisions, collective interaction skills, personal development and suitable communication approaches as well as the need to exhibit sound and persuasive reasoning in putting forward socio-scientific arguments. (Halbrook & Rannikma, 2009, p. 286)

Achieving SL is asserted to be a long standing goal of science education (Baybee & DeBoer, 1994; Eijkelhof, 2001). As well as international research, national research is also highlighted the importance of scientific literacy (Köseoğlu, Tümay, & Buda, 2008; Ministry of National Education (MoNE), 2005; Özdemir, 2010; Yetişir, 2007). Turkish Education System, theoretically framed by constructivist learning, explicitly stated the SL as one of the goals of Turkish Science Curriculum (MoNE, 2005). The curriculum aims to educate each student as scientifically and technologically literate persons. In this curriculum, MoNE explicitly reported the importance of scientific literacy, and listed major issues to related to enhancing students' SL by developing their ability to understand: (a) the Nature of Science (NOS) and technology; (b) key scientific concepts; (c) Science Process Skills (SPS); (d) the relation of science, technology, society, and the environment,; (e) scientific and technical psychomotor skills; (f) the values constructing the importance of science; and, (g) attitude and values toward science. The curriculum, revised in 2013, aimed to increase students' (a) critical thinking skills; (b) problem solving skills; (c) decision making skills; (d) collaborative learning skills. MoNE (2013) also integrated SSI in the revised curriculum.

SSI are controversial social issues which relate to science (Zeidler & Keefer, 2003). They are ill-structured and open-ended problems; there are multiple solutions to each problem. "Ill structured problems cannot be solved by the mechanical application of an algorithm; they require making judgments based on the strength of available evidence and the adequacy of argument (King & Kitchener, 2002, p.37)". Ill structured problems mirror real world problems which are explored in some SSI research such as gene therapy, Genetically Modified Foods (GMF), Climate Change (CC), and animal testing for medical purposes. These issues are commonly used as a teaching tool in argumentation studies or reflective judgment research for their being ill-structured. SSI are usually investigated in science education literature and found to be consistent with progressive aims of science education (Zeidler, Applebaum, & Sadler, 2011). The place of controversial issues in science education emphasized as follows:

> It is now a commonplace in science education that the study of socioscientific issues by students constitutes a prime avenue for fostering scientific literacy of a kind that will prompt young people to familiarize themselves with science in action, to develop their capacity for evaluating the information made available to them on a daily basis, to make decisions concerning controversial sociotechnical issues, and to take part in debates and discussions on sociotechnical controversies of concern to them. (Pouliot, 2008, p. 545)

According to Turkish new science curriculum (MoNE, 2013), the SSI is expected to develop students' scientific thinking skills. The curriculum developers, suggest that students should be given a chance to discuss everyday life issues in science classrooms. Students' social engagement (degree of participation in a community or society) in real life issues allows them to integrate science and other science related issues. Virtually every individual has to make decisions about science related issue that has a direct effect on the quality of their lives as well as on society. Earlier studies argued that SSI can be tapped to engage students in exploring the moral implications of science within the broader contexts of society (Zeidler & Lewis, 2003). Thus, practical and theoretical approaches to how to utilize SSI as a teaching context to increase students' science understanding and relatedness needed to be addressed. In this study, I used SSI as a teaching context and tried to enhance participants' reflective judgment which is an important skill for scientifically literate individuals.

It can be explicitly seen that SSI comprise a core base of scientific literacy. Furthermore, significant amount of research links SSI with other important aspects of science education including argumentation (Jimenez Aleixandre & Pereiro Munoz, 2002), NOS (Sadler, Chambers, & Zeidler, 2004), epistemology (Liu, Linn & Tsai, 2011) and reflective judgment (Zeidler, Sadler, Applebaum, & Callahan, 2009). Science educators developed numerous new curricula and instructional approaches that increase the SL over the last decade in order to give students a more authentic science experience in the classroom (Walker & Sampson, 2013). Constructivist approach has been identified as one of the contributors to SL and argumentation. Kaufman (2004) pointed out that constructivism has an important role in developing scientific literacy in real experience and real experiences let students understand natural events. Developing scientific literacy, engaging PTs in real life issues, exploring their reflective judgment and argumentation skills through SSI in an inquiry based laboratory can be stressed as explicit goals of the present study.

1.1 Theoretical Framework

Over the past half century, there has been a shift from the positivist view to post positivist among philosophers and sociologists of science. This shift enables the proposal that knowledge is not a discovered issue but is a human constructed issue that is subjective (Nussbaum, 1989). Post-positivist views of science do not take science as a pure empirical process but rather as a social process where students can actively engage with knowledge construction. According to this view, knowledge is not transmitted from teacher to student but constructed by the student, and students are not passive receivers of knowledge from their teacher. It has been proposed that learning is a construction process (e.g., Moll, 1992; Piaget, 1973; Vygotsky, 1978). "Constructivism is a dynamic and interactive model of how humans learn (Bybee, 1997, p. 176)." Constructivist researchers gave their attention to investigating how people understand the nature of knowledge and knowing and how these understandings change across different notions of psychological developments.

The constructivist framework guided the present study. Constructivist perspective on learning assumes that knowledge is actively built or "constructed" by the learner (Driver, Asoko, Leach, Mortimer, & Scott, 1994). This construction can occur individually (personal constructivism) or as a social process (social constructivism). The study provides social constructivist learning environment to the PTs and supports the active learning experiences recommended by the National Science Education Standarts (NRC, 1996) in the laboratory. Constructivist approach, in which students learn about a subject through the experience of problem solving, requires students' active participation in the construction of knowledge. It is a style of active learning. Students' active engagement in scientific activities is called ''doing science''. With regard to engaging in laboratory activities associated with doing science: "Laboratory activities appeal as a way to learn with understanding and, at the same time, engage in a process of constructing knowledge by doing science" (Tobin, 1990, p. 405). Hodson (1993) indicates that "doing science" is a major aspect of science education and suggests that laboratories should not only be used to teach specific scientific methods or particular laboratory techniques but also be used to engage students in inquiry.

According to social constructivist views of learning, inquiry-based learning environments are a fruitful setting to facilitate students' knowledge construction and evaluation. In their critical review regarding school science laboratories, Hofstein and Lunetta (2004) emphasize that inquiry should be a major goal of laboratory instruction and suggested that inquiry based laboratory applications may help students to develop ideas about the nature of scientific community. A vast majority of scientists also have recommended that inquiry be placed at the core of science instruction (Bybee, 2000; Bell, Smetana, & Bills, 2005; Walker & Sampson, 2013). Germann, Aram, & Burke (1996) asserted that inquiry oriented laboratories enhance students' reasoning skills, higher-order thinking skills, and science process skills. All these skills contribute to SL and, as previously mentioned, SL is a longstanding goal of science education.

Claugh and Clark (1994) asserted that inquiry laboratory activities are appropriate places to experience the goals of constructivist learning approaches (e.g.

active engagement, direct observation, interaction with peers, personal involvement, etc.). Constructivist learning approaches develop students' competence in scientific inquiry by acknowledging their prior knowledge, curiosity, and real-life experiences and providing a range of activities such as classroom discussions, laboratory experiences. It is clear that scientific inquiry is given importance in science education literature and enables students to ask questions, develop concepts and frameworks, improve communication skills, and construct scientific claims (Walker & Sampson, 2013). Scientific inquiry is defined as:

> …the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. (The National Academy of Sciences, NSES, 1996, p.23)

Science educators aimed to increase scientific literacy and have developed authentic learning tools and instructional approaches over the past few decades. Scientific inquiry was common across these approaches. For example, Walker and Sampson, (2013) tested the effectiveness of inquiry based laboratory course on students' ability to develop scientific argumentation over the course of a semester. Researchers asserted inquiry and argumentation are complementary goals that make laboratory experiences more scientifically authentic and educative for students' knowledge construction (Jimenez-Aleixandre, 2007).

Teachers are key elements of the teaching process that helps students to construct their own knowledge. Researchers gave utmost importance to teacher education being aware of the importance of them on students' active and social engagements in real life issues and knowledge construction. PTs are one of the important sequences of links in education process starting from as a learner at the beginning of their undergraduate education and ends with a candidate teacher at the end of senior years. Teacher educators aim to explore effective policies and procedure to equip PTs with the knowledge, behaviors and skills they require to perform their lessons effectively in the classroom. There is a significant amount of research that is conducted by teachers on their philosophical views of science (Monk & Osborne, 1997). It has still importance to explore teachers' philosophical views on science as its direct effects on their way of teaching. Constructivist views of science play important roles both in teachers' instruction process and students' learning process such as; reasoning strategies, higher order thinking, and comprehension.

While many researchers have conducted studies to test the effects of inquiry based laboratory applications by using well-structured physics experiments (Lunetta, 1974; Opkala & Onocha, 1988; Zacharia, 2003), chemistry experiments (Brown, LeMay & Bursten, 2000; Green, Elliot, & Cummins, 2004) or biology experiments (Howard & Miskowski, 2005; Yager, Engen, & Snider, 1969), less work is known about the effect of inquiry-based instruction with ill-structured problems such as those typically presented in this course. For example, while a student can test the fluidity of home-made mayonnaise and regular mayonnaise (sold in supermarkets) in the laboratory and record data regarding that the comparison obtaining scientifically repeatable data, if the researcher just focuses on scientific data in this mayonnaise experiment it is inadequate in putting students in touch with socioscientific aspects of science. On the other hand, if this issue is based on food additives and the researcher connects these issues to students' everyday lives it would be much better to engage them with socioscientific aspect of science. Engaging students with investigation into those additives in laboratories while allowing them to discuss the potential benefits or harmful effects of those additives makes such educative experiences more personally and socially relevant. While it may be important to test certain well-structured science problems, certainly an exploration of ill structured problems should also be tested in science laboratories to present a more accurate portrayal of science to students.

Students should be encouraged to explore possible solutions for such complicated problems such as climate change, genetically modified foods, alternative energy sources, why fast food hamburger has a longer shelf life than a homemade hamburger, and the like, in the laboratory. After developing a research question about these concepts, students can test their questions by designing experiments. SSI enriched science laboratory courses may compel students to link everyday life issues with appropriate experiment designs, data collection, analysis and interpretation protocols. Driver, Newton, and Osborne (2000) stressed that teachers need reorganizing laboratory activities while teaching a laboratory course from a constructivist perspective.

In summary, constructivist approaches framed the present study. In lights of this literature, argumentation and Reflective Judgment Model (RJM) suggested enriching the effectiveness of inquiry based learning environments. School science laboratories experiences should be enriched by embedding science content with socioscientific issues. Therefore, in this study I used Design Based Research (DBR) approach in an inquiry based laboratory course which is enhanced by inclusion of RJM and argumentation in the context of SSI. There were a series of socioscientific issues to embed science course and laboratory content within real world applications. They were used as a tool to explore PTs' RJM skills and argumentation patterns in the present study. The following sections will explain SSI and two major outcomes of this study: Reflective Judgment and argumentation in brief.

1.1.1 Socioscientific issues in the classroom

There is a significant amount of controversial issues and they are all convenient for SSI discourse, but the aim of this study is not only to discuss the controversial issues but also to conduct the experiments for each issue in the laboratory. In order to reach this goal, among those SSI I selected global environmental issues while framing the study context. Controversial issues related with the environmental problems are not only important in science education but also important for life beyond the classroom because of their impact on social, political and economic areas. These issues are often used in investigations by many science education researchers because of the importance they hold for the whole society. Typical issues include global climate change (Wilson, 2000), air pollution (Tuncer-Teksoz, 2011) nuclear power (Kilinc, Boyes, & Stanisstreet, 2012), hydroelectric power (HEP) station (Zhong & Power, 1996), renewable energy sources (Kılınç, Stanisstreet, & Boyes, 2009) biodiversity, genetically modified foods (Sonmez & Kılınç, 2012), and such. Society has anxiety about environmental danger. Benton and Redclift (1994) argued that the global issues of climate change, Ozon depletion, and food crisis across the world, air pollution due to the CO_2 emmission, and energy problems bring on environmental anxiety in the general public. Society is anxious about global environmental dangers since they obviously have no borders and no national boundaries. For example, while ice melts in the arctic region, the effects are not confined to that region since the sea level rise can cause global problems. While the Chernobyl disaster was initiated in Ukraine, its radioactive effects were felt in many other countries like Bulgaria, Turkey, Sweden, Holland, and England. Energy problems in one country can cause changes in consumption over the world. Global SSI are not only personally relevant; they are globally significant. “These emergent concerns, often reflecting SSI, give rise to the call for educating students as global citizens who are able to collaborate and communicate to resolve the issues in just and equitable ways while working toward providing a safe global community” (Lee et al., 2013).

For least ten years, science education researchers have been investigating research on ill-structured problems such as sun rays, mobile phones, genetically modified foods, gene therapy, nuclear power plant, and so on. Significant amounts of researchers have focused on SSI in science classroom practices (Liu et al., 2011; Kølsto, 2001; Topcu, Sadler, & Yılmaz-Tüzün, 2010; Zeidler, et al., 2009) to engage students with controversial real life issues. SSI were used as a tool to raise PTs curiosity, active engagement, and personal involvement as the issues are directly related with real life. SSI generally requires the use of scientific topics that have moral or ethical implication and compels students to engage in protracted dialogues and discussions. Role of SSI in science classroom is highlighted as:

> [SSI] are usually controversial in nature but have the added element of requiring a degree of moral reasoning or the evaluation of ethical concerns in the process of arriving at decisions regarding possible resolution of those issues. The intent is that such issues are personally meaningful and engaging to students, require the use of evidence-based reasoning, and provide a context for understanding scientific information. (Zeidler & Nichols, 2009, p.49).

Socioscientific issues attract students’ interest since the characteristics of its content are real, important, and generally controversial (Sadler, 2011). SSI-based instruction has been highlighted across a wide range of international research in such diverse countries as Australia, Israel, South Korea, Spain, Turkey, the United Kingdom, and the United States, for example (Zeidler, in press). The Science Technology Society (STS) and Science, Technology, Society and Environment (STS-E) movements, humanistic science teaching approaches, and teaching citizens science are the basic approaches that align or are subsumed within the aims of teaching science through SSI, although the SSI framework is anchored in a more comprehensive developmental, sociological and philosophical framework (Zeidler, Sadler, Simmons, & Howes, 2005). The main characteristics of SSI pedagogy can be listed as follows: (a) they are based on scientific knowledge; (b) students have to form their ideas and state their personal choices; (c) they are incomplete and involve conflicting issues; (d) they address personal, local and global controversial issues often with ethical and moral implications; and, (e) people engage with cost-benefit analysis in which potential risks interact with values (Zeidler, 2003). This compact list may not represent all the pedagogical features of SSI, but it summarizes the key nature of SSI in relation to scientific classroom implementation.

Quality in education relates to the quality of the work undertaken by a teacher, which has significant effects upon his students. Therefore, the initial step is having experienced teachers to educate students. If teachers have competence and experience about these issues then they can be able to discuss responsibly to global issues. Teachers, experienced in argumentation, reflective judgment and knowledge construction process, enable his students be able to discuss responsibly to socioscientific issues tempered by their own values, let them to actively engage in knowledge construction during classroom discussions.

In present study I used SSI as a context in inquiry laboratory course to explore PTs reflective judgment and argumentation skills; PTs were engaged in ill-structured problems, had to form a research question, state their personal choices about the ill-structured issues, use their scientific knowledge during the experiment process, understand the incomplete nature of ill- structured problems, engage cost-benefit analysis about the issues. These procedures may support PTs' active engagement in everyday life issues. They had a chance to test controversial issues in the laboratory that can foster understanding of science content and consequences involved in everyday scientific issues. These issues were used as a tool to understand PTs' argumentation skills and reflective judgment skills since the importance of these two outcomes in literature and the appropriateness of these controversial issues for argumentation.

In their comprehensive review of social theory and global environmental problems, Benton and Redclift (1994) asserted that environmental issues are interconnected to many disciplines such as physics, chemistry, geography, sociology etc. Unfortunately, the discussions about the environmental problems are dominated by physical science whereas the consequence of it is often painful for social science. Therefore, they suggested that social scientific assumptions should have to be questioned if environmental issues are to be fairly addressed. Current studies also recommend discussing global environmental problems in science education via socioscientific perspective. It is important to engage society with these global problems since the major delinquent for those problems is society itself. Lee, Chang, Choi, Kim, & Zeidler (2012) clearly point out the necessity of collaboration and communication to resolve the global issues for the safety of an international community.

Different societies and individuals within those societies hold diverse assumptions and conflicting views regarding these issues. For example, some people claim that the global climate change issue causes environmental disasters, but opponents of this idea have counterclaims that global climate change is a normal procedure for the earth, that there were some warming time periods in the past as well as cooling periods. In brief, no matter whatever the issue is, global environmental issues have many aspects and people have divergent opinions regarding those issues. These divergent opinions are welcome in argumentation classrooms and enrich the classroom discussions. Educational researchers examining these issues support the importance of critical thinking and critical stances on education about environmental issues (Keys, Hand, Prain, & Collins, 1999; Sahin, Ertepinar, Teksoz, 2012; Yılmaz-Tüzün, Teksoz-Tuncer, Aydemir, 2008; Rivard & Straw, 2000; Jimenez Aleixandre & Pereiro Munoz, 2002).This research also represents a shift in environmental education from traditional classroom practices to progressive approaches that emphasize responsible epistemological development through the exploration of SSI (Zeidler, Berkowitz and Bennett, 2014).

To sum up; the aim of environmental education and science education is to develop students' critical thinking skills and decision making skills. Engaging students with global environmental issues gives them a chance to actively participate in citizen science and to offer alternative solutions to current problems. "Students need to be educated as whole human beings in relation to the world they inhabit, who are not only intellectually competent but also sensitive to ongoing global SSI that affect others in different regions of the world" (Lee et al., 2012, p.927). Present study attempted to reach this goal by including reflective judgment in SSI context as there are examples of such studies suggesting RJM as fruitful method in SSI context (e.g Kolsto, 2001; Mezirov, 1990; Zeidler et al., 2009).

1.1.2 Reflective judgment

Presently, society is faced with so many SSI and along with the challenge to find reasonable explanations and solutions for these issues (e.g. climate change, water shortages, energy sources, gene therapy). The common characteristics for many of these issues are that they are ill-structured. Ill-structured problems are defined as problems that do not have a high degree of clear understanding or solutions. (Kuhn, 1991). King and Kitchener (2002), the contributors of reflective judgment research, explain ill-structured problems as ones that: "… cannot be solved by the mechanical application of an algorithm; they require making judgments based on the strength of available evidence and the adequacy of argument" (King & Kitchener, 2002, p.27). Each student defines the causes of problems in a different way. Hence, the solutions to the problems and the process of solving those problems can reasonably expected to be different depending on individuals' epistemological sophistication.

Reflective judgment describes the reasoning structures of individuals when they encountered with ill-defined problems. King and Kitchener (2002) have developed a model of epistemic cognition that describes how people structure their knowledge and justify their beliefs about ill-structured problems, which is also known as Reflective Judgment Model.

RJM describes seven distinct stages of epistemological development that focuses on how an individual views and acquires knowledge, and how s/he forms justifications of beliefs about that knowledge. Each stage has a logical coherence. Stages progressively represent more complex forms of beliefs and justification of knowledge. These seven stages are grouped into three major categories related to their level of epistemological sophistication: Pre-reflective (Stages 1-3); Quasi-reflective (Stages 4 and 5); and, Reflective (Stages 6 and 7).

The developmental stages are helpful to understand individuals' opinions to an issue, how they view reality, how they extent to which they may rely on authority or how they are confident with classic solutions to a complex issue, and such. Each stages represent different ways of thinking about an ill-structured issue. King and Kitchener (1994) developed the RJM by engaging participants with ill-structured problems, where students have to think about the alternative positions on an issue. There is logical coherence that can be stressed drawn SSI and RJM framework (Zeidler, et al., 2009). Both frameworks involve ill structured problems and issues that entail many differing opinions, require the ability to analyze positions, use evidence to support a position, and recognize the role of constructed knowledge (particularly in matters of moral sensitivity) in consensus building.

Thus, I linked SSI and RJM in an inquiry laboratory course to illustrate PTs developmental stages in contextually varied SSI (transportation issue, Climate Change, food additives, alternative energy, Industrial Revolution). As well as RJM, argumentation is also highlighted in the literature and asserted to develop conceptual understanding of science content (Sadler, 2004). Therefore, I also aimed to explore how their argumentation patterns emerged in SSI-based ILC by use of reflective judgment.

1.1.3 Argumentation

Recent science education literature has stressed the importance of argumentation in the classroom (e.g., Erduran & Jimenez-Aleixandre, 2012; Garcia-Mila, Gilabert, Erduran, & Felton, 2013; Organisation for Economic Co-operation and Development (OECD), 2012). Argumentation can be defined as " a verbal, social and rational activity aimed at convincing a reasonable critic of the acceptability of a standpoint by putting forward a constellation of propositions justifying or refuting the proposition expressed in the standpoint" (van Eemeren & Grootendorst, 2004, p. 1). As it can be seen from the definition of argumentation, it has not only verbal but also social and rational characteristic. While verbal and social processes of argumentation enhance students' communication skills, rational processes of argumentation enhance cognitive process skills (i.e., argument construction and discourse strategy) (Felton, 2004).

Argumentation has been an important part of human interactions throughout history. This can be seen not only in daily life activities (Voss & van Dyke, 2001) but also in school practice (Sampson & Clark, 2008). In recent years, a significant amount of research has highlighted the contributions of argumentation in science education (Aufschnaiter, Erduran, Osborne, & Simon, 2008; Duschl & Osborne, 2002; Jimenez-Aleixandrea, Rodrigez, & Duschl, 2000; Rivard & Straw, 2000). Students' scientific decision making steps (Driver, Newton, & Osborne, 2000), responses to environmental issues (Kortland, 1996) and socioscientific issues (Zeidler & Lewis, 2003) are investigated in that research. These studies have shown consensus on the claim that argumentation increases students' understanding of science processes (e.g., Kelly, Chen, & Prothero, 2000; Kuhn & Udell, 2003; Newton, Driver, & Osborne, 1999), and argumentation-based learning environments promote students' conceptualization of science (Bell & Linn, 2000). Therefore, enhancing learning environments that tap argumentation strategies should be supported in science classrooms in that they enable students to more fully engage in socioscientific activities.

Numerous researchers (e.g., Jimenez-Aleixandre et al., 2000; Kuhn & Udell 2003; Sadler & Fowler, 2006; Topcu, et al., 2010; Walker & Zeidler, 2007) have investigated students' generation of arguments in SSI. The results of these studies illustrated that (a) some students make claims but cannot support their claims with warrants or evidence (Jimenez-Aleixandre et al., 2000), that (b) engaging students in SSI and debating with peers enhances argumentation skills (Kuhn & Udell 2003), that (c) knowledge about SSI increase levels of argumentation (Sadler & Fowler, 2006) that (d) informal reasoning about SSI depends on the issue context; and, (e) scaffold inquiry can aid in SSI argumentation while explicit instruction on argument structure and fallacious reasoning prior to engaging in debate activities or during the activities themselves can help students enter into more productive discourse. It is obvious in the results of these studies that students' argumentation levels are different depending on the issue and students' knowledge about the issue. The literature highlights that SSI focused activities can enhance student reasoning and argumentation practices (Albe, 2008; Zohar & Nemet, 2002).

In this study, SSI implementation investigated in two steps. In first step, PTs are engaged in argumentation discourse. They discussed each issue in the classroom. Science educators suggest that, through evidence-based argumentation discourse, students learn to formulate their own decisions and understand people who have opposite views (Walker & Zeidler, 2007). Implementation of SSI is an essential aspect in argumentation discourse because the researcher's role is to promote evidence-based critical thinking and argumentation; s/he is not promoting any particular belief. PTs engaged in argumentation in order to improve their understanding of SSI. In second step, PTs tested their positions in the laboratory. The selected context for this study is Global Environmental Problems. I selected these issues because of their ubiquity in modern society and amenability to classroom discourse and argumentation.

1.2 Statement of Problem and Research Questions

The socioscientific movement focuses mainly on allowing students to handle the science-based issues that shape their current world and those which will determine their future world (Sadler, 2004). SSI is included in major science teaching investigations such as NOS (Bell & Lederman, 2003), argumentation (Mason & Scirica, 2006) and reflective judgment (Zeidler et. al, 2009). These investigations aimed to determine how students' reflective judgment skills, and argumentation patterns revealed in SSI context. Short term SSI treatments in literature provide a snapshot for students' instant points of view regarding an issue; however, it is not possible to capture the development of reflective judgment over the period of couple of weeks (Zeidler et al., 2009). Thus in this study I arranged a semester long SSI focused course to capture participants' reflective judgment patterns.

Most science laboratory applications are appear to be dominated by "cut and dry" science experiments. Students typically test an electrical circuit, a thermodynamic law or the appearance of plant cells in hypertonic/ hypotonic solutions etc. in order to illustrate the corresponding scientific concepts to students. Students became familiar with scientific issues in those laboratories, but they are not well prepared to deal with scientific and technological controversy. However, more recent supported in the literature is found for the necessity of students exploring integrated knowledge that connects science to social and ethical issues in which it resides (Hughes, 2000; Mueller & Zeidler, 2010; Mueller, Zeidler, & Jenkins, 2011; Zeidler, et al., 2005). Therefore, I aimed to engage PTs with socioscientific issues in the laboratory. Thus may give them a chance to connect science related issues to social and ethical issues in the laboratory. The overarching purpose of this study was to investigate to what extend PTs' reflective judgment skills improved over a semester course focused on different SSI, to understand the argumentation skills of them revealed in SSI based-ILC by use of reflective judgment, and to explore if there is an association between reflective judgment and argumentation.

1.2.1 Research question-1

RQ1. What effect does an SSI based-ILC have on pre-service teachers' reflective judgment?

1.2.1.1. Rationale for RQ1

Scientific literacy vision highlights students' use of science in real-life contexts and encourages comparisons to progressive change in science education. In the past few decades, science educators with reformist goals have focused on SSI as learning contexts (Sadler & Zeidler, 2009). The ability to make informed judgments about real-life issues is stated as a need for being a scientifically literate person (Zeidler, 2003). Science educators conducted numerous studies regarding SSI and suggested that an SSI based curriculum can advance reflective judgment (Zeidler, et al., 2009). There are some applications of SSI based curricula and reflective judgment in literature. However, previous research do not let students to actively engaged with ill-structured issues but utilized interview protocol: Prototypic Reflective Judgment Interview (PRJI) or computer based surveys: Reasoning about Complex Issues (RCI) to assess students' reflective judgment skills and. Students are generally engaged in ill structured scenarios in both PRJI and RCI investigations (King & Kitchener, 1994; Parry, 2010). They were given RCI questionnaire or they listened ill-structured scenarios from the interviewer and were asked about their positions to each issue.

Researcher asserts that, the students just hear or read about the problematic issue in those scenarios and did not engage in an investigation to solve that problem. As previously discussed, present study highlights active participation of PTs. Thus, PTs' active participation could contribute to raise their understandings of those issues. The researcher assert these problems can be resolved through conducting experiments and controversies obtained through investigations can be discussed by students. In other words, I suggest that students should be given some constructivist learning environments such as in inquiry based laboratory courses and conduct experiments. I designed the SSI-based ILC in order to engage students in constructivist learning environments and give them a chance to test their ideas about SSI. The course made students to develop their research question, to state a hypothesis about the issue, conduct experiments, to observe the process, to collect data, to evaluate data, to discuss the issue, and to make conclusions. Therefore, it is emergent to explore what effect an SSI based-ILC has on pre-service teachers' reflective judgment.

1.2.2 Research question-2

RQ2. What are the argumentation skills of PTs revealed in SSI based-ILC by use of reflective judgment?

1.2.2.1 Rationale for RQ2

The contributions of argumentation and reflective judgment on knowledge construction have been highlighted in previous part. Knowledge construction is asserted as the base of critical thinking when individuals are engaged in ill-structured problem solving (King & Kitchener, 1994). During the SSI based inquiry laboratory instruction the preservice teachers were expected to construct their knowledge about SSI as a social process in collaborative classroom discussions and to test their ideas in the laboratory. The contributions of argumentation to classroom discussions are undeniable as it supports peer interactions which have impact on reasoning (Zeidler, Sadler, Simmons, & Howes, 2005) and promotes scientific literacy (Aikenhead, 2000).

King and Kitchener (2002), developers of the RJM model, describe some activities as contributing to the development of Reflective Judgment such as designing research to engage participants with ill-structured task (McBurney, 1995), presenting an ideal environment for students to collect relevant data, evaluate credibility of data and make an evidence based argument. Cicala (1997) stressed the role of frequent guidance, challenging questions, continuous feedbacks, educational experiences, such as; active engagement and classroom discussions, in PTs reflective thinking progression. It is clear in the literature that engaging argumentation contributes reflective judgment skills (Moody & Estep, 2010). However; there is lack of research that assesses the association between the two. Current study may shed some light on RJM and argumentation literature by highlighting if there is an association between these two scores. Thus, the second question focused on PTs' argumentation levels revealed in SSI based ILC by use of reflective judgment.

1.2.3 Research question-3

RQ3. Is there an association between RJM and argumentation scores of PTs revealed in SSI based-ILC?

1.2.3.1. Rationale for RQ3

The previous question attempted to explore PTs' RJM and argumentation skills and aimed to investigate if there is an association between these two outcome variables. A number of science education researchers have highlighted the place of argumentation in discussions about SSI (Duschl, Ellenbogen, & Erduran, 1999; Kelly & Takao, 2002; Mason & Scirica, 2006; Zeidler & Keefer, 2003). Argumentation is asserted to have a significant role in science education since it contributes to learning scientific skills (McNeill & Krajcik, 2009) gaining critical thinking skills (Sadler, Barab, & Scabb, 2007), and contributing to being an active democratic citizen (Lee, et al. 2012; Lee et al., 2013; Zeidler, 2003). The fruitfulness of argumentation as a tool for analyzing students' ways of thinking and understanding their reasoning mechanism proved fruitful in other studies as well (Kelly & Takao, 2002; Osborne, Erduran, & Simon, 2004). The link between PTs reflective judgment and argumentation skills can contribute to science education research as their importance in evidence-based reasoning and knowledge construction. Therefore, it is better to check if there is a statistical association between these two scores. Besides it is better to check whether this association (if any) is practical or not.

1.3 Significance of the Study

The practical significance of this study is manifested through its participants (preservice teachers). Human beings play a central role in all environmental problems such as water pollution, air pollution due to the transportation issue, food shortages, and exaggerated energy consumption, etc. Therefore, we need first and foremost to educate people. There is a general acceptance of teachers' importance in the education process. Every single teacher, whatever their major area (science, math or arts) is responsible for contributing to students' responsible citizenship. Practicing responsible citizenship requires having the opportunity to explore a wide range decisions, and developing a caring attitude towards critical aspects of social and eco-justice (Zeidler et al., 2014). School science can play an important part for raising students' environmental awareness and attitudes only if teachers see the exploration of these issues as a part of their central science teaching mission. Exploring how teachers come to know about environmental issues and how they construct their critical stances on these kinds of issue is worth analyzing since their personal experiences on these issues may directly transfer how they may approach such issues with their future students.

The theoretical significance of the study is its contribution of empirical evidence in science education research regarding SSI. Socioscientific issue based curriculum is supported in previous research (Callahan, Zeidler, Cone, & Burek, 2005; Zeidler et al., 2009) argumentation (Walker & Zeidler, 2007) and epistemological development (Zeidler et al., 2009). However, there is little study that aims to document semester-long effects of SSI treatments specifically in the context of laboratory settings. The current study aims to engage preservice teachers in SSI regarding global environmental problems. A semester long application provides evidence regarding pre-service teachers' reasoning progress on RJM and argumentation skills.

1.4 Summary

Scientific literacy is defined as a longstanding goal of science education and claims to be the heart of recent national reform documents (e.g., Program For International Student Assessment (PISA, 2013); United Nations Environment Program (UNEP, 2012). Scientific literacy leads one to be able to read and understand articles about science in the popular press and to engage in controversial issues about the validity of the conclusions. Within the present study, an SSI based ILC was designed in order to assess the development of two key factors that contribute to scientific literacy: reflective judgment and argumentation. As this SSI research is aimed at engaging learners with scientific problems that are directly relevant to their lives, it seems reasonably to infer that an SSI based inquiry-oriented science laboratory experience can promote pre-service teachers' scientific literacy.

CHAPTER 2

2. LITERATURE REVIEW

The main purpose of this study was to investigate PTs' reflective judgment skills and to investigate the development of argumentation skills in the context of SSI in an inquiry-based science laboratory. In addition to the main focus, the effects of context on PTs reflective reasoning, argumentation skills were explored in this study. Connections among reflective judgment and argumentation with ill-structured problems will justify the incorporation of SSI as a means for examining these outcomes.

In this section, first, the theoretical framework of this study is introduced. Second, scientific literacy and inquiry-oriented science laboratory are discussed to show the connection between scientific literacy, socioscientific issues, RJM, and argumentation. Third, the importance of reflective judgment stages of reasoning is discussed. Fourth, in light of the literature, argumentation and its relation to socioscientific issues is examined. Last, the need for the incorporation of selected SSI in the laboratory is presented.

Figure 1 (below) represents the theoretical framework of this study. In this framework, two outcome variables (RJM and Argumentation) are explored and their contributions to the implementation of socioscientific issues are discussed. The study was implemented in an inquiry-oriented science laboratory. An essential variable related to reasoning in socioscientific contexts is reflective judgment, whereby students develop the ability to gather and analyze data, and use multiple sources to make reasoned arguments (Zeidler et al., 2009). Other variable is argumentation, addressed as a core element of scientific enterprise (Evagorou & Osborne, 2013), can potentially support the practice of SSI in helping science educators to design more effective learning environments. It is also important to note that many researchers have integrated argumentation in a socioscientific context to explore students' or teachers' quality of evidence-based reasoning among different ill-structured issues (Aufschnaiter, Erduran, Osborne & Simon, 2008; Crippen, 2012; Khisfe, 2012; Rivard & Straw, 2000). This study was conducted in an inquiry oriented laboratory; which gave the PTs a chance to investigate aspects of real-life SSI in a laboratory setting.

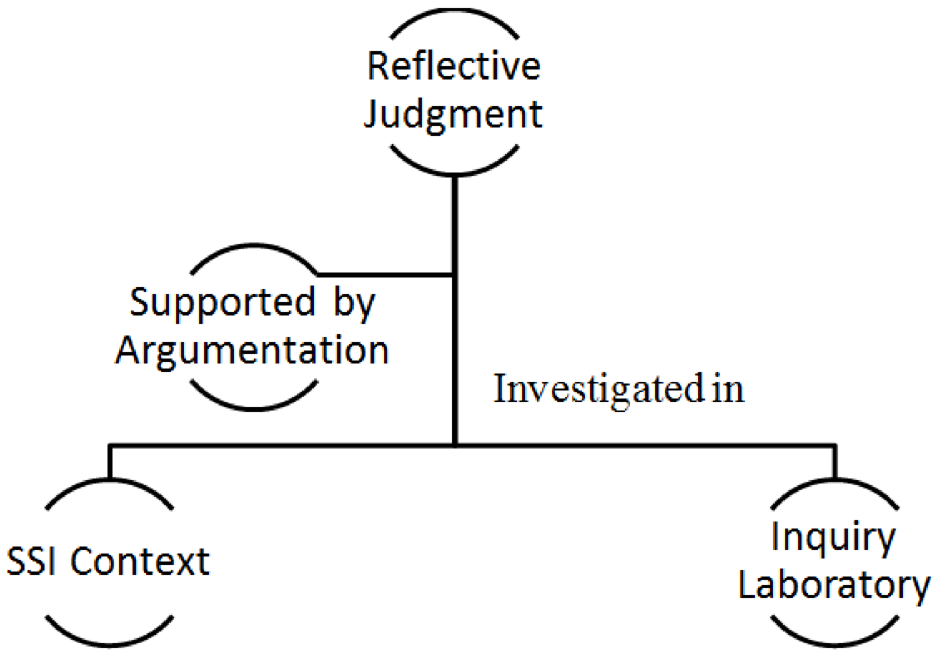

Figure 1 Theoretical Framework of the Study

The term "SL" has been used in science education literature for more than fifty years. The term is mostly interrelated with the aims of science education (Sadler & Zeidler, 2009). Although it is discussed as widely accepted goal of science education, there is no consensus on the definition of the term (Baybee, 1997). An experimental project, *21st Century Science* aimed to identify the knowledge and skills of a scientifically literate person in order to clarify the term. According to the project, a scientifically literate person is expected to be able to:

- appreciate and understand the impact of science and technology on everyday life;
- take informed personal decisions about things that involve science, such as health, diet, use of energy resources;
- read and understand the essential points of media reports about matters that involve science;
- reflect critically on the information included in, and (often more important) omitted from, such reports; and
- take part confidently in discussions with others about issues involving science.

(Retrieved December 24, 2013, from: http://www.nuffieldfoundation.org/twenty-first-century-science/scientific-literacy)

Sadler and Zeidler (2009) proposed three premises which build upon one another to articulate SL as defined by the SSI framework. These premises are: (a) scientific literacy ought to be a goal for all students, (b) science education ought to provide opportunities for learners to experience science in contexts similar to the contexts that they may confront in their daily-life, and (c) if educators want to use real world issues related to science (to engage students in meaningful learning), then they ought not dismiss other elements of issues that may be seen as beyond the boundaries of traditional science.

Citizens in a society are commonly faced with situations where they are required to express their opinions and make decisions about public science-based issues. They try to use scientific information, identify claims, evaluate evidence and draw their own conclusions on these issues. Professional associations in science education emphasize the importance of conceptualizing scientific literacy to improve learners' ability to analyze, synthesize, and evaluate data and evidence (NRC, 2012). Scientific literacy implies the capacity to pose and evaluate arguments based on evidence and to apply conclusions from such arguments appropriately (NSES, 2012). Ryder (2001) highlights the account for understanding evidence, and recognizing the source of evidence in order to participate in decision-making. It is asserted that SL is central to individuals' decision making, the ability to deal with moral and ethical issues, and the ability to understand connections inherent in SSI (Zeidler, 2001).

The MoNE (2013) addressed the connections among evidence-based reasoning, social and personal decisions with scientific literacy. The council highlighted the need for the development of inquiry, problem solving and decision making abilities in order to become lifelong learners, and to have a sense of wonder about the world. Students are expected to appreciate and understand how the interrelation of science, technology, society and environment will affect their daily lives and their futures. Socioscientific issues have become important in science education because they have a central role in the promotion of functional scientific literacy. Figure 2 presents the socioscientific elements of promoting functional scientific literacy.

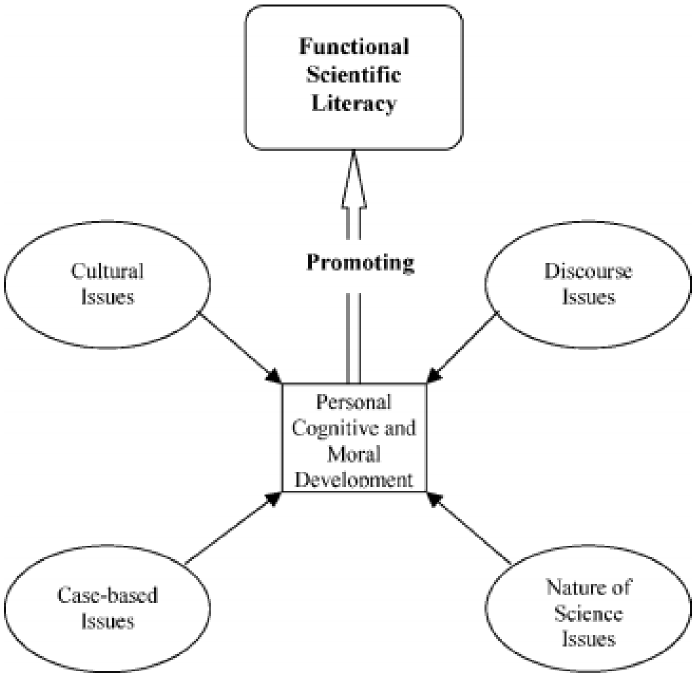

Figure 2 Components of Functional Scientific Literacy

Note Adapted from "The role of moral reasoning on socioscientific issues and discourse in science education" by D. L. Zeidler, 2003, p. 12, copyright 2003 by the The Netherlands: Kluwer Academic Press.

Zeidler and Keefer (2003) stated four major components of functional scientific literacy which are; cultural issues, case-based issues, NOS issues and discourse issues. The contributions of these components to learners' personal, cognitive, and moral development have been addressed in numerous research (e.g., Jimenez Aleixandre & Pereiro Munoz, 2002; Liu et al., 2011; Sadler et al., 2004). It is seen from the figure that each component (cultural issues, discourse issues, nature of science issues, case-based issues) has contribution to personal, moral, and cognitive development, and all these promotes functional scientific literacy. Most science educators agree that all students need to be functionally scientifically literate and make informed judgments about decisions that impact the biological, physical and social environment (Deboer, 2000; Dillon, 2009; Holbrook, & Rannikmae, 2009; Ryder, 2001).

NOS plays an important role in the development of SL, stated as one of four components by Zeidler and Kefer (2003) and is asserted as the basis of scientific literacy by Holbrook, and Rannikmae (2009). It is proper to address the link between NOS and SL at this point which is reflected in the following quote:

> …relates to the nature of science in a social setting and encompasses socio-scientific decision making. Here the nature of science is to interact with other areas such as economics, environmental, social, politics and certain moral and ethical aspects. The decision-making process sees the nature of science as one of interacting with all these areas leading to a decision in which the reasoning can be related to arguments on the importance of the science and the other aspects at the time the decision is being made. This puts forward an image of science as tentative, not able to provide a definite answer, but bringing to bear reasoned argumentation on the science theories and methods related to the issue (Holbrook & Rennikmae, 2009, p.282).

This explanation aligns with the definition of scientific literacy used in the present study. SL requires engaging with economic, environmental, social and political issues. Furthermore, it is clear in the literature that cultural and case-based issues are addressed as two additional components of functional scientific literacy in Figure 2. These factors can increase the relevance of the problem to the students and researchers have equated relevance with students' interest (Matthews, 2004). Thus, tapping these factors may lead to active participation in attending to scientific and social problems.

In summary, scientific literacy has been a desired goal of science education for several decades. Social scientists and science educators have investigated SSI with the aim to increase learners' interest in daily life issues and ill-structured problems. These studies were designed to engage students with everyday life issues, to understand how science affects their lives, and to be able to link science with society. Thus, it is commonplace in science education to study socioscientific issues in order to foster scientific literacy and to familiarize learners with science in action. This study used reflective judgment and argumentation in order to enhance PTs awareness of the effects of science related issue into their everyday life experiences and advance their scientific literacy in the context of SSI. The study investigated an inquiry-oriented science laboratory that included hands-on inquiry activities to engage PTs with everyday life problems.

2.1 Reflective Judgment

Reflective judgment is to bring closure to uncertain situations when applying a formula and deriving a correct solution is not possible (Dewey, 1933). The domain of reflective judgment involves a set of assumptions made about the status of knowledge and evidence as people reason through a set of ill-structured problems (King & Kitchener, 1994). Elements related to reflective judgment are emphasized as a goal of education. For example, a reason for institutions to teach students reflective thinking is stated in *The Challenge of Connecting Learning,* a report by the Association of American Colleges (AAC) as:

> In the final analysis, the challenge of college, for students and faculty members alike, is empowering individuals to know that the world is far more complex than it first appears and that they must make interpretive arguments and decisions-judgments that entail real consequences for which they must take responsibility and from which they may not flee by disclaiming expertise (AAC, 1991, pp. 16-17)

King and Kitchener (2004) described the theoretical assumptions that have guided the development of the RJM in the last 25 years. Reflective judgment is considered a construct that represents individuals' views on knowledge and justification of knowledge. The construct is drawn from the theoretical work of many researchers (i.e., Dewey, 1938; Piaget 1974; Flavell, 1977; Perry, 1981; Fischer, 1980; and Kegan, 1982) by King and Kitchener in 1994. The model rejects two well-known assumptions espoused by previous theorists from this tradition. First, unlike Piaget, RJM does not assume that cognitive development is best measured by deductive reasoning. The second contradiction was that there is no cross-cultural universality. King and Kitchener (1994) admit that there is a complex stage development rather than a simple stage model of development. They criticized that characterizing individuals being only "in" or "at" one stage of development is misleading. Development in reflective thinking is described as:

> … waves across a mixture of stages, where the peak of a wave is the most commonly used set of assumptions. While there is still an observable pattern to the movement between stages, this developmental movement is better described as the changing shape of the wave rather than as a pattern of uniform steps interspersed with plateaus (King, Kitchener, & Wood, 1994 p. 140).

Reflective Judgment, as used by King and Kitchener (1994), overlapped substantially with the rich history of critical thinking, and concurred with Dewey regarding the importance of making decisions (Moody & Estep, 2010). Judgment process related to other concepts such as critical thinking and information literacy. Kitchener, King, Wood, and Davison, (1989) conducted a six year longitudinal study to evaluate the stage properties of the Reflective Judgment model on three groups of young adults (high school juniors, college juniors, and doctoral level graduate students). They used the reflective judgment interview to measure adults' scores. The literature review support that development in reflective judgment occurs in an upward direction as participant grows older. In addition to age, researchers claimed that, at minimum, there must be a moderate amount of consistency in subjects' performance across tasks. In addition to consistency, researcher also aimed to test the effects of education on participants' reflective judgment. They found that there is greater growth in epistemic cognition for those who attend and complete college than for those who do not. Kitchener et al. (1989) suggested both the sequence and consistency can be useful in describing learner characteristics in order to enhance educational environments.

Ill-structured problems are used in order to explore learners reflective judgment such as determining the causes of overpopulation, hunger, climate change, most efficient energy sources, genetically modified foods, and transportation issue (people in need to travel acros the world since the globalization that causes excess amount of CO_2 emission), because they are complex problems of society that "cannot be described with a high degree of completeness or solved with a high degree of certainty" (King & Kitchener, 1994, p. 10) and challenge the individual to justify their claims and the evidence used to back those claims. The most valid and reliable measure for RJM, used across these studies, is an interview protocol (the Prototypic Reflective Judgment Interview; King & Kitchener, 1994).

2.1.1 Prototypic reflective judgment interview

Prototypic reflective judgment interview is a semi-structured interview developed by King and Kitchener (1994). It includes seven prototypic questions and two to five prompting questions. These questions were designed to elicit ratable data about individuals' epistemological assumptions (i.e., fundamental beliefs about knowledge and how it is acquired). Researchers used five standard ill-structured problems during the interviews which are: Egyptian pyramids, creation vs. evolution, food additives, and nuclear energy. In addition to these five standard problems, discipline-based reflective judgment problems were developed for psychology, business, and chemistry. Due to the flexible nature of reflective judgment problems, I aimed to expand the range of these problems in the present research. For instance, in addition to the nuclear energy, the current study discussed solar energy, wind energy, hydroelectric energy, etc. Ill-structured problems were placed at the center of research with the aim to measure PTs stage developments across different contexts.

The RJI standard probe questions are (King & Kitchener, 1994, p.102):

1. What do you think about these statements?
2. How did you come to hold that point of view?
3. On what do you base that point of view?
4. Can you ever know for sure that your position on this issue is correct? How or why not?
5. When two people differ about matters such as this, is it the case that one opinion is right, and one is wrong? If yes, what do you mean by "right"? If no, can you say that one opinion is in some way better than the other? What do you mean by "better"?
6. How is it possible that people have such different views about this subject?
7. How is it possible that experts in the field disagree about this subject?

The current study evoked both the PRJI, as well as the use of laboratory manuals as a source of data to examine PTs' stage developments

2.1.2 Assessing reflective judgment model

The RJM is described as seven distinct assumptions about knowledge (view of knowledge) and how it is acquired (justification of beliefs). Each assumption, which is called a stage, has a logical coherence. These stages represent more complex forms of justification. Each stage utilizes different ill-structured problem-solving strategies. These seven stages are grouped into three major categories of reasoning: pre-reflective (Stages 1-3), the quasi-reflective (Stages 4 and 5) and the reflective (Stages 6 and 7). These stages will be explained briefly in the following paragraphs.

As previously stated, there are seven stages in reflective judgment model. These stages can be seen as a hierarchical model since they are listed in order. King and Kitchener (2002) present two arguments for this. First, lower stages are simpler than higher stages. The higher the stage, the more complex it is. Higher stages are asserted to be more abstract and composed of interrelated arguments. Second, the stages are conceptualized to possess a natural logic to their progression. One must understand a single concrete view of knowledge in order to develop multiple abstract views of knowledge. RJM focuses on the person's concept of knowledge and how s/he justifies those concepts.

Pre-reflective Thinking (Stage 1, 2, and 3)

Stage-1

Individuals, who have a single, concrete and absolute knowledge, are categorized under this stage. These people believe that "what I have seen is true." Knowledge is thought to be obtained by direct observation; therefore, it is absolute and predetermined. The thinking characteristic of stage-1 is naïve because individuals do not need to justify their claims. There is a failure to understand that two people can disagree about an issue. People don't have any doubt about their beliefs, and they are not open to criticism. They assume that what exist in newspapers is true. These people cannot connect two different viewpoints at the same issue, which is a precondition for handling ill-structured problems.

Stage-2

Individuals, who believe that there is a true reality and this reality can be known with certainty are categorized under this stage. Knowledge is thought to be certain and to be obtained by the senses (as in the previous stage-direct observation) or via authority figures such as teachers, scientists, parents, or religious leaders. These people believe that “if it is on the news, it has to be true.” People who disagree with the authorities are assumed to be totally wrong. They also assume that there is an absolutely right and wrong answer for all problems. Individuals recognize for some issues there are different opinions and understand that two people can disagree about an issue. This is a prerequisite for understanding that some problems are ill-structured. However, individuals at this stage hold the view that truth can be known with absolute certainty, they cannot recognize that the problems posed in the reflective judgment interviews are ill-structured.

Stage 3

Individuals that believe in certain situations even authorities may not know the truth is categorized under this stage. Knowledge is assumed to be certain, or permanently uncertain. Permanently uncertain situations explained by personal beliefs, they try to justify their beliefs as personal opinion when the link between evidence and beliefs is unclear. These individuals may refer to factual information that supports their opinion. In the area of certainty, knowledge is obtained from authorities. Individuals believe that authorities have the right answers for current issues and beliefs are justified by using authority claims. The major difference from stage-2 is that the person who holds stage-3 admits that in some cases knowledge is temporarily uncertain.

Quasi-Reflective Thinking (Stages 4 and 5)

Stage 4

Individuals who realize that some problems are ill-structured and know that there is some uncertainty about the answers to these problems are categorized under this stage. Knowledge is seen as an ambiguous element and understood as an abstraction. These people do not limit themselves to concrete explanations. They have an initial understanding of the phenomenon and try to use evidence to support their position. However, they ignore some evidence that is contrary to their core ideas while selecting evidence that supports pre-established ideas. They cannot use multiple reasoning mechanisms to solve a problem. Rather, they link a single line of evidence to a single issue.

Stage 5

Individuals who realize that people may not know with certainty, knowledge is contextual and subjective, and filtered through a person's perceptions are categorized under this stage. At stage-5, individuals coordinate theory evidence, and recognize there are alternative theories for a particular theory. Different views and conclusions are considered in this stage. Unfortunately, they lack the ability to coordinate evidence and alternative theories in a well-reasoned argumentation.

Reflective Thinking (Stages 6 and 7)

Stage 6

Individuals who are aware of the ill-structured nature of problems and who construct knowledge by using various sources are categorized under this stage. The major criteria of this stage are that individuals realize in order to understand a complex issue; one should look at multiple perspectives and coordinate those viewpoints before suggesting resolution. They know that knowledge is uncertain, and try to compare and relate different points of view regarding an issue. Individuals using stage 6 assumptions are able to evaluate differential quality of evidence supporting varied viewpoints. Individuals at stage-6 can coordinate knowledge and justification. They can compare the evidence for and against the safety of food additives or the safety of nuclear energy (ill-structured problems in general). Therefore, these individuals reject the terms right and wrong, they evaluate the expertise, opinions, and conclusions of experts.

Stage 7

Individuals reaching this point of development realize that ill-structured problems can be considered by synthesizing evidence and opinions from multiple relevant sources, and suggest the most reasonable solutions based on available evidence. They are aware of that there is not an a priori given reality and solution so they recognize the need to socially construct their own knowledge. The major difference of this stage from the previous stage is that individuals making judgments about given issue are open minded, work to improve the efficacy of their beliefs, and understand their suggested solutions are tentative, open to criticism and reevaluation.

2.2 Argumentation

Current science education reforms indicated that the goal of science education is not only to teach scientific concepts but also to help students understand societal problems (Erduran & Jimenez-Aleixandre, 2007). Socioscientific issues address these societal problems. Effective argumentation requires teaching higher order thinking skills and teaching content regarding socioscientific issues (Duschl, 2007). The characteristics of argumentation with its social, verbal, and intellectual features are helpful to engage students with ill-structured problems. Hence, argumentation frameworks are commonly used in science education literature for analyzing reasoning in the context of students engaging in socioscientific discourse. Students written argumentation essays or informal classroom discussions are used as data source by many researchers (Kelly & Takao, 2002; Osborne, Erduran, & Simon, 2004; Duschl et al., 2002; Newton et al., 1999).

Argumentation plays an important role in socioscientific issues. It entails the ability for students to engage in active dialogue as they evaluate evidence, use critical thinking skills, and formulate hypotheses on various topics. Researchers use argumentation as a tool to explore students', teachers' or preservice teachers' understandings of SSI. Classroom argumentation discourse is a social process where students have a chance to engage in active discussion, challenge their peers, justify their claims with evidence, and to persuade their opponents (Evagorou & Osborne, 2013). Classroom discussions or collaborative argumentation requires students to discuss the issue in multiple ways; students can learn other's positions during these discussion (Schwarz, 2009). Questions prompted by the teacher or asked by the student to challenge their peers or to understand the issue in detail is considered a thinking process skill related to critical thinking (Cuccio-Schirripa & Steiner, 2000), and central to argumentation (Evagorou & Osborne, 2013).

Classroom discussions are supported by many researchers because of its significant contributions to learning. For example, Gage and Berliner (1998) asserted that the reflection in group contexts contributes to meaningful and effective social learning. Reflective group discussions contribute to students' learning from each other (Yacoubian & BouJaoude, 2010). Resnick (2010) suggested that when students explicitly challenge each other's ideas, their reasoning gains become higher. The fruitfulness of argumentation encourages researcher to focus on students' argumentation skills.

Sampson and Blanchard (2012) highlighted the contributions of argumentation on students understanding of the concepts and process of science. They stressed that there is limited numbers of study to engage students in classroom discussions. One of the reasons for the rare implementation of argumentation, the authors assert, is teachers' lack of pedagogical knowledge to design lessons that engage students in argumentation. Therefore, they aimed to understand teachers' argumentation strategies used to engage their students in argumentation activities. Teachers relied on their past experiences and their content knowledge to explain a phenomena rather than actual scientific data. Few of the teachers used data and evidence to support their claims. The lack of teachers' use of evidence, and their reliance on personal knowledge rather than scientific data is related with teachers being inexperienced to conduct effective argumentation with their students. Sampson and Blanchard (2012) suggested that science education researchers should help inservice and pre-service teachers learn more about the scientific argumentation. A review of argumentation literature revealed important uses of argumentation in socioscientific issues context. This next section summarizes the major findings of selected argumentation research investigated in SSI contexts.

2.2.1 Argumentation in the context of SSI

A number of science educators have explored the students' argumentation skills by engaging them in scientific issues (Kelly Druker, & Chen, 1998; Sampson & Clark, 2008; Sandoval & Millwood, 2005) as well as socioscientific issues (Evagorou & Osborne, 2013; Zohar & Nemet, 2002; Zeidler et al., 2009). Using SSI as the context of instruction gives the students opportunity to understand how moral, ethical and personal values permeate scientific issues (Zeidler et al., 2009). It is clearly stated that, for socioscientific issues, there are no clear-cut solutions, and the alternative solutions cannot be fully determined by empirical or theoretical evidence (Sadler, 2011). Researchers have conducted a significant amount of research in order to explore the effectiveness of argumentation in SSI context.

One of the recent studies on argumentation in SSI contexts was conducted by Khisfe (2013). The researcher aimed to explore the influence of explicit argumentation instruction in the context of a socioscientific issue. Seventh grade students were engaged with water usage and safety issues. Students' understanding of the topic and the quality of their argumentations were explored by multiple data sources (questionnaire, interviews). The researcher focused on absence/presence of students' justifications of claims and evaluated the validity of justifications. The results of the study showed that SSI treatment enhanced the quality of argumentation (students support their arguments with more than one justification). The importance of SSI context was highlighted as being an optimal condition for classroom argumentation. The researcher also suggested that SSI helped the learners in their application of scientific ideas and reasoning on the issue, as well as the integration of moral, ethical, and social concerns relevant to the problem.

SSI has also been advocated because it enhances students' interests of the issue and motivates the students to engage with debated issues. Students are familiar with SSI within their daily life. Patronis, Potari, and Spiliotopoulou (1999) examined students' quality of arguments by exploring the ways in which students arrive at a decision when they work on a real-life problem. In their study, the government was planning to construct a road in a local area. The planning of a major road was a real problem for the area where the school was situated. The students discussed the design of the road in their area. Some of the students suggested the acceptance of governments planning by taking care of some safety matters (traffic lights, zebra crossings for the pedestrians, etc.) some of them suggested to construct a bridge over the school road. The students discussed disadvantages of road, or bridge as an alternative solution, and cost of the road etc. The classroom discussions gave the students an opportunity to explain their points of view while evaluating other points of view for the issue. The nature of the debated issue (building a road in school area) did not require an exact method of solution, therefore students' justifications of their ideas were not judged on the basis of their being scientifically right or wrong. Students had to convince their peers that their own proposal was the optimal solution. The analysis was based on students decision-making strategies expressed in classroom discussions. Results addressed that students are able to develop arguments and reach conclusions when they face a situation in which they are familiar within daily life.

Table 1 below summarizes selected argumentation studies investigated in a SSI context. The researchers (Aufschnaiter et al. (2008); Jimenez- Aleixandre, Rodriguez, & Duschl, (2000); Kuhn and Udell (2003); Osborne et al. (2004); Sadler (2006); Topcu, Sadler, & Yılmaz-Tüzün (2010)) aimed to explore argumentation skills of various groups (i.e., high school students, college level students, preservice teachers etc.) in the context of multiple SSI (genetic, cloning, funding a zoo, phases of the moon, blood pressure, capital punishment, global warming, etc.). One of the common findings of these researches is engaging in argumentative issues and debating with peers enhanced students' argumentation skills. Students' prior experiences, SSI context familiarity, and prior knowledge affect their argumentation skills.

Table 1 Argumentation in the Context of SSI

Researchers	**Sample**	**Socioscientific Issues**	**Main findings**
Aufschnaiter et al. (2008)	Junior high school students	Funding a zoo Phases of the moon Blood pressure	Prior experiences and knowledge affected argumentation structure; students' familiarity and understanding of the content of the task affected the quality of argumentation.
Jimenez- Aleixandre and Duschl (2000)	9th grade high school students	Mendelian genetics	Students made claims but could not support their claims with warrants or evidence.
Kuhn and Udell (2003)	Middle school students - Age 12 to 14	Capital punishment	Engaging in argumentative issues and debating with peers enhanced argumentation skills
Osborne et al. (2004)	Grade 8 (age 12-14)	Funding of a new zoo	The use of argumentation is teacher dependent – in other word, that there are no universals. Developing argument quality is a long term process.
Sadler (2006)	High school students	Genetics – gene therapy and cloning	Science major students constructed better arguments than non-science major class.
Topcu, Sadler, & Yılmaz-Tüzün (2010)	Preservice Teachers	Gene Therapy Human cloning Global warming	individual issue context may not significantly influence informal reasoning. The informal reasoning practices of individuals are consistent across SSI contexts.

2.2.2 Argumentation & environmental issues

Decision-making strategies are also given importance in SSI literature. A significant amount of research has been conducted to explore participants' decision-making on given SSI, particularly in the realm of environmental issues. Bell and Lederman (2003) aimed to explore factors that affect adults' decision-making procedures. They conducted a study with 21 science education professors. They used four different technology-embedded scenarios consisting of fetal tissue implementation, global warming, the relationship between diet and cancer, and the relationship between smoking and cancer. Surprising, results of the study indicated that participants did not substantially use scientific evidence to make decisions on these issues. Social/ political issues, ethical considerations and personal values were the most dominant factors related to their decision making.

Similar to Bell and Lederman, Jimenez-Aleixandre and Pereiro-Munoz (2002) also conducted a study on an environmental management issue in order to explore 11th grade students' decision making-procedures. The study was conducted in biology and geology courses. The aim of the study was twofold. First, to study the components of knowledge and skills needed to reach a decision in socio-scientific c contexts. Second aim was to identify them in classroom discourse. Researchers used environmental conflicts for constructing the context of the study. Audio and video recordings of small group discussions were used as data sources. Researcher explored two dimensions of decision making: students use relevant knowledge in order to understand and make decisions about the problem; the students also aimed at processing source of knowledge and critical evaluation of authority for evaluating possible solutions to the problem. Results of the study indicated that students' decisions were dependent on their conceptual understanding of the issues as well as value judgments. Students' ecological considerations dominated their economic considerations.

Some of the example environmental issues were summarized in Table 2. These issues were global warming, water pollution, environmental management, and the effects of climate change on the world. The researchers included some socioscientific issues like cigarette and cancer, diet and cancer. The quality of the students’ argumentation and their decision makings skills were explored in these studies.

Table 2 Environmental Issues in Argumentation Context

Researchers	Sample	Environmental issue	Main findings
Bell & Lederman (2003)	University Professors & Research scientists	Fetal tissue implantation, global warming, the relationship between diet and cancer; cigarette smoking and cancer	Social, political, ethical issues affects participants' decision- making.
Karisan and Topcu (2011)	Preservice Science Teachers	Global Climate Change Issue	Preservice Science Teachers (PST) have difficulty with developing multiple lines of reasoning.
Keys et al (1999)	8th grade	Water pollution	Science writing heuristic is better than classical lab reports regarding data collection, evidence formation, supporting claims, etc.
Jimenez Aleixandre and Pereiro Munoz (2002)	11th grade students (16-17 years old)	Environmental management	Involving students in authentic activities facilitates conceptual knowledge understanding and values.

Keys et al. (1999) conducted a study with 8th grade students. Participants of the study were two classes of 8th grade students along with their earth science teacher. The context of the study was water pollution. Students actively engaged with the water pollution issue, sampled the water, observed, and conducted a series of chemical and physical tests to decide the level of water pollution. This issue was purposefully selected since students were familiar with this curriculum. Using actual raw data enabled them to interpret, collect, analyze and synthesize information about the water shortage issue. Students also wrote a scientific paper about the water pollution issue. The teacher used writing prompts in order to support students' critical thinking skills. Students' written reports, video-tapes of target team discussions, audiotapes of target team interviews, and pre-study questionnaires were used as data sources. Results of the study indicate the quality and quantity of students' written reports improved throughout the course of their experiences.

Karisan and Topcu (2011) aimed to explore preservice science teachers' written argumentation skills and analyze the development of their argumentation writing ability over the course of class discussions. PSTs collected their data interactively through a web site that was created by the researchers in order to argue possible climate change effects on the Earth. The effects of the global climate change issue were presented through four different cases; polar ice melting, drought, environmental disasters, and living organisms. Data sources for this study consisted of students' reflection papers. All participants succeeded in posing solvable and supportable thesis statements; however, they had difficulty developing multiple lines of reasoning or describing the underlying mechanisms. The results of this study indicated that PSTs' written argumentation tended to improve with argumentation experience. This result is consistent with Keys et al. (1999) findings; both studies highlighted the importance of argumentation experience in the increase of students' reasoning skills.

In summary, there is a good degree of consensus supporting the engagement of students in socioscientific issues and environmental problems help them to familiarize how each impact their daily lives, and to give them a chance to reflect on those issues. Therefore, the present study aimed to incorporate similar aspects of SSI experiences in a science laboratory setting.

2.3 Inquiry Oriented Science Laboratory

Inquiry-based laboratories aim to engage students in the activity of science. Students have a chance to comprehend scientific practices and appreciate the nature of scientific knowledge by directly experiencing inquiry learning. Common terms in science literature related to science laboratory environments include “doing science,” “hands-on science,” and “real-world science,” and are frequent descriptors of inquiry-based learning approaches (Crawford, 2000). Hodson (1993) views ‘‘doing science’’ as a major part of science education, and he suggests that the focus of laboratory instruction should be placed on inquiry rather than learning specific laboratory techniques. It is important to define what inquiry is and what the role of inquiry in science teaching is. Herron (1971) defined four types of inquiry which are; verification, structured, guided, and open inquiry. The difference between these inquiry methods have been summarized in Table 3

Table 3 Levels of Inquiry

	Source of the question	**Data collection methods**	**Interpretation of results**
Level 0 Verification	Given by teacher	Given by teacher	Given by teacher
Level 1 Structured	Given by teacher	Given by teacher	Open to student
Level 2 Guided	Given by teacher	Open to student	Open to student
Level 3 Open	Open to student	Open to student	Open to student

Note Adapted from “The nature of scientific inquiry” by M. D. Herron, 1971, *School Review*, 79, 171-212.

Present study used open inquiry to engage PTs SSI in the laboratory. Inquiry based activities demands students to construct their own understanding by solving real-world problems (NRC, 2012) instead of following rote procedures from a chapter in a textbook (Crawford, 2000). Inquiry-based activities minimize the dependency of science experiments to a single set of procedures, such as identifying variables, classifying, identifying sources of error, or predicting a particular set of outcomes. Rather, inquiry activities provide an opportunity for students to engage in exploring fundamental questions about the world. Green, Elliot, and Cummins (2004) highlighted the importance of real-world problems promoting students science learning and point to their students surprise and delight that they could use scientific theories to address real-world problems. In fact, sometimes students obtained new information that could not be located in any scholarly journal or regional report. Inquiry learning, therefore, can serve as a locus for invention, craft and creativity.

Next Generation Science Standards (2012) attempted to clarify the ambiguity by the term "inquiry." The committee maintained that inquiry, in previous standards documents, had been interpreted over time in many different ways. However, they indicated that as in all inquiry-based approaches to science teaching, students are expected to be able to engage in the practices by themselves not merely learn about them secondhand. They note that unless students directly experience scientific practices for themselves, they will not be able to appreciate the nature of scientific knowledge itself. Engaging scientific inquiry helps the students to understand how scientists work and how scientific knowledge is developed.

The committee (NRC, 2012, p.49) proposed eight steps for scientific inquiry, which are presented as practices for K-12 science classrooms:

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

This study aimed to engage PTs with these eight practices during the investigation. Throughout the inquiry laboratory activities, students not only needed to "know" science concepts, but also needed to develop a research question and use their creativity to find alternative solutions to their research questions. Tobin (1990) asserted that meaningful learning can be realized by engaging students in seeking solutions to problems. Hence, the participants here were expected to design their own experiments, generate research questions, and analyze data providing evidence to support their solutions.

The fruitfulness of inquiry based learning has been investigated by numerous researchers (i.e., Crawford, 2000; Ebenezer, Kaya, & Ebenezer, 2011; Green, Elliot, & Cummins (2004); Seethaler & Linn, 2004). Key aspects of their research have been summarized in Table 4 (below). The researchers conducted these investigations with various age groups from12 to 22. Although the participants of these studies differed in grade levels, and the context of the research was varied (i.e., ecology, chemistry, genetically modified food), researchers have reached similar conclusions about the effects of inquiry-based activities such as inquiry oriented science laboratories provide more cognitive involvement and improve students' interest in science. Educational reformers are attempting to bring more of the practices of scientific inquiry into student learning activities (NRC, 1996). Students' active involvement and engagement in inquiry activities requires establishing a learning setting (Linn, diSessa, Pea, & Songer, 1994).

Design based research collective (2003) argued that DBR approach can help create and extend knowledge about developing, enacting, and sustaining innovative learning environments. Over the past two decades design based research has been accepted as an appropriate method for investigating educational innovations in classrooms. Many researchers adapted DBR approach in classroom settings (e.g Bell, 2004; Bell & Linn, 2002; Brown, 1992; Reiser, Tabak, & Sandoval, 2001; White, 1993). Practitioners and researchers work together to produce meaningful change in contexts of practice in these research.

Reiser et al. (2001) designed Biology Guided Inquiry Learning Environments, a program of research to support inquiry learning in biology. Reiser et al. (2001) criticized traditional laboratory teaching, such as transforming scientific facts rather than argumentation construction and reflective inquiry. They suggest creating a classroom culture of inquiry that consists of knowledge construction. On the other hand, Bell and Linn (2002) designed a Web-based Inquiry Science Environment (WISE) which is a technology enhanced research base, flexible and adaptive learning environment. The WISE project used a customized inquiry map that is altered depending on students' prior experience with inquiry. Researchers conclude that DBR let students to form arguments about scientific phenomena, to compare their ideas with peers, to evaluate opposing views, to construct their own knowledge.

To sum, present study used DBR approach to investigate SSI in science laboratory, which is not common for science laboratories, try to explore PTs' reflective judgment skills revealed in their laboratory manuals in written form,as well as their oral explanations. Table 4 is an example of some inquiry oriented science laboratory studies which shed some light onthepresent study during design phase.

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Table 4 Some Laboratory Studies in the Context of Inquiry

Researchers	**Sample**	**Inquiry based Laboratory Context**	**Main findings**
Crawford (2000)	300 students (grade 9-12)	Ecology Course: United States Fish and Wild life Service, A local citizens' group concerned about river quality logging company in town, a local grower of gourmet lettuces, and the nearby university	*Teachers need to embrace inquiry as a content and pedagogy, collaboration between teacher and students * teacher and student roles are complex and changing *Greater levels of involvement are required by teachers than in traditional teaching.
Ebenezer, Kaya, & Ebenezer (2011)	125 students (Grade 9-12)	Lake Erie Ecosystem Is there a difference in pH between water in the Lake Erie channel and the 2 ponds?	* students went through the experience of researching real-life issues and benefited from the mentoring process and/or from their previous science learning experience * scientific inquiry enhance learning
Green, Elliot, & Cummins (2004)	20 students (honors college)	Introductory Chemistry Course: Students examined * the concentrations of copper and bicarbonate in a local golf course pond * the composition of seawater with that of inland ponds and lakes with a view toward locating Florida waters on Gibbs's diagram of worldwide water chemistry.	* Students surprise, indeed, delight that they could use chemical theory to address real-world prob. * ILC tended to involve genuine discovery, in the sense that students were often obtaining new information that could not be located in any scholarly journal or regional report. * inquiry-based learning can awaken an interest in science
Seethaler & Linn (2004)	173 students (8^{th} gr.)	Genetically modified food (Students were free to choose the agricultural method that seemed most ideal to them)	*students developed a more sophisticated understanding of GMF and agricultural methods*students were able to make appropriate use of evidence to argue for their positions on agriculture

2.3.1 The Incorporation of socioscientific issues in science laboratory

Contemporary science education research highlights the importance of students' active participation during knowledge construction. Science education researchers recommended that inquiry be placed at the core of science instruction (Bybee, 2000). Inquiry oriented laboratories are claimed to enhance students' reasoning skills, higher-order thinking skills, and science process skills which contributes to scientific literacy. The premise of the present study is that students should not only engage with scientific issues but also socioscientific issues in the laboratory. The need for incorporation of SSI in a science laboratory course can be explained in many aspects. The Next Generation Science Standards (NGSES, 2012) specifically addresses particular characteristics of science instruction which are necessary for providing a key tool for understanding and investigating more complex ideas and solving problems, as well as relating instruction to the interests and life experiences of students with societal or personal concerns. These two requirements for effective science instruction provide a rationale for the inclusion of everyday life issues in science laboratories.

Furthermore, the goal of science education stated in both international (NRC, 2012) and national (MONE, 2013) councils is to graduate students who can engage in public discourse on science-related issues, be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives. The key component here is to transform scientific knowledge into daily life experiences. When students participate in real-world environmental projects, their awareness of the problem or problem-solving techniques are enhanced, and they gain an understanding of personal relevance contributed to existing science-related issues (Ebenezer et al., 2011).

There are undeniable major challenges embedded in science that confront society such as preventing and treating disease, generating sufficient energy, maintaining food and fresh water supplies, or addressing the climate change (NRC, 2012). The NGSES (2012) indicate that any education that focuses solely on the products of science, ignores the application of science in real-world issues, and ignores how scientific ideas are developed (processes) misrepresents the activity of science. It is important for students, as citizens in this technology-rich and scientifically complex world, to see how science and engineering are instrumental in addressing major challenges that confront society today. In order to avoid misrepresentation of science and provide a deeper understanding about real-world issues, the inclusion of SSI contextualized in science laboratory experiences may aid in addressing this issue.

2.3.2 Selected SSI issues for inquiry laboratory instruction

Transportation Issue

IPCC (2007) reported that human activities are responsible for the increase in green house gases in the atmosphere over the 200 years. Environmental Protection Agency (EPA, 2012) highlighted that 28 % of 2012 greenhouse gase emmissions from transportation come from burning fossil fuels for cars, ships, trains, planes. The higher the transportation facilities, the higher the greenhouse gas emmissions which is the largest source of air pollution. Air pollution is one of many potentially serious environmental problems. Air pollution, defined as the addition of harmful chemicals to the atmosphere, is a threat to people, animals and plants. There are two types of air pollution; natural sources (e.g., volcanic activity, smoke and carbon monoxide from wildfires, methane emitted by digestion of food) and man-made sources (e.g., power plants, motor vehicles, chemicals, hair spray, and aerosol).

Polluted air can cause severe health problems such as breathing, cancer, heart disease, and headaches, sore eyes, dry or scratchy throat, nose, and mouth. The World Health Organization states that 2.4 million people die each year from causes directly attributable to air pollution (World Health Organization [WHO], 2002). The most serious pollutants are results from the burning of fossil fuels, increase of population, industrialization, and consumption patterns of human beings. Tuncer-Humanbeing are addicted to transport sector due to the economic, social, or political reasons. Unfortunately, there is positive relationship between transportation and air pollution issue. Teksöz (2011) highlighted the importance of having knowledge, positive attitudes, responsibility, and skills on such environmental issues related to sustainable choices. The present study included transportation issue in the course content since the researcher asserts that it is an ill-structured issue; humanbeing neither give up their cars nor want to pollute the air. Transportation enables trade between people, travel around the world which is an essential for the development of civilizations. On the other hand, as I previously mentioned the transportation is the largest source of air pollution. Therefore, it would be appropriate to discuss the source of air pollution, its effects, and probable precautions that can be taken for sustainable transportation.

Food Additives

The world's population is expected to increase from the one billion it was in 1850 to ten billion by 2050. This rapid increase in the population makes people more dependent on industry. This dramatic increase in population growth has led to exponential requirements for energy, natural resources, as well as food-related technology. People living in modern industrial countries anticipate a wide range of food additives to be available throughout the whole year (Saltmarsh & Insall, 2013). Food additives are commonly used across the world. Fast foods, as well as many other foods, include food additives such as colorings, emulsifiers, flavorings, and gelling agents. While society as a whole is against using food additives in general, many of materials those called as additives are not new and have been used in foods for hundreds of years (Saltmarsh & Insall, 2013). This issue was selected because PTs are somewhat familiar with the issue and they will be able to test or experience the effects of food additives in laboratory.

Alternative Energy Sources

Energy is an irrefutable necessity for any country, and shortages are a common problem across the world. Nonrenewable energy sources, such as coal, fossil fuels, natural gas, and hydroelectric power are commonly used energy sources. People have relied on these kinds of energy since 1870 with the industrial revolution While Countries depend on this energy, nonrenewable energy sources are, of course, limited. Governments hope to use renewable energy sources such as sun, wind, hydro energy, geothermal in order to find a cure to their demand for energy.

The energy issue and the search for viable alternative energy sources are on the Turkish Government's agenda too. For example, The Turkish Government is planning to build three nuclear power plants in different cities of Turkey; two of these cities Mersin (2011) and Sinop (2013) were announced by Turkish Atomic Energy Authority (TAEA, 2013), but one of them has yet to be made public. PSTs are familiar with this issue since it has broad media coverage. Academicians, politicians, Greenpeace members, and sometimes other local people who are living in Sinop or Mersin discuss the issue on Radio and TV programs, blogs, and social media without reaching a clear consensus about the issue.

Another debated issue is hydroelectric power plants. Turkey has approximately 150 hydroelectric power plants (Ministry of Energy and Natural Resources [MENR], 2013). Turkey's water resources are commonly used by these plants. These plants are the biggest energy source for the country, and it seems to be relatively risk-free when compared to nuclear power plants, but many are against hydroelectric power plants since it causes water shortages. Farmers and ecological organizations following the issue have tried to derail new hydroelectric power plant construction efforts. However, there are proponents of this issue who prefer these plants to nuclear power plants. This issue is chosen as another discussion topic for this study since it contains polarizing positions.

Thermal power plants are also a common energy source in Turkey (Serpen, Aksoy, Ongur, Korkmaz, 2008). Other countries who commonly use Thermal power across the world wide are China, Japanese, USA, Iceland (MENR, 2013). Turkey holds a substantially high geothermal potential since it is located on the Alpine-Himalayan belt. Geothermal potential of Turkey is 31.500 MW (MENR, 2013). Experts in Turkey expect those four more power plants to be operating by the end of 2013, installing 150 more MW of geothermal power and bringing the installed capacity to over 300 MW (Matek, 2013). People generally have a positive attitude towards thermal power plants when compared the nuclear and hydroelectric power plant. Although there is general acceptance across the society towards it being used as an energy source, the plants also pose a potential risk for the environment. In brief, energy sources have several advantages and disadvantages. For example; nuclear energy has security risk as Chernobyl disaster or Fukushima explosion contrarily it has the highest energy potential ; wind power are risk for migratory birds and needs a lot of space to construct, but it is renewable and do not have any waste product. Growing consumer awareness of energy problems and sustainable energy sources is thought to be urgent issues in environmental education literature. Therefore, I selected the energy issue to discuss in this study.

Climate Change Issue

Climate change is a global environmental issue. People have an array of views on this issue, there used to be two main opposing views about CC that is it's a natural phenomena versus it is the result of developments since the industrial revolution producing an increase in the amount of greenhouse gases having a direct effect on CC. The opponents of the latter view assert that CC it is just a hypothesis, and believe that people who claim that greenhouse gases cause climate change are against economic development, or that the data has no scientific validation etc. There is a great controversy among society about the causes of climate change. Still, there was uncertainty about the precise causes of the issue and the rate of its effects on nature such as, glacier melting, sea level rise, drought, disease and so on. What is not clear is how society and world communities should respond to this issue. Hence, CC was selected as a discussion topic in order to have PTs look at the issue from multiple perspectives, and provide an opportunity to test their hypotheses in the laboratory by designing their own experiments. It is important to warn the reader here that climate change was a controversial issue when this study was conducted (2013 spring semester) therefore it was integrated into the course content. Lately, IPCC (2014) provided a clear and up to date view of the current state of scientific knowledge relevant to climate change. The IPCC committee reported that human are responsible for climate change and there is no way to claim that it is a natural process. Hence, one should keep in mind CC is not a controversial issue.

The Industrial Revolution Issue

The Industrial Revolution is thought to be a historic milestone for economic, historical, political and sociological growth (Goldstone, 2002). The economic improvements caused a parallel dramatic increase in life expectancy. Developments in the Industrial Revolution, cotton spinning, iron products, railways, rail equipment, electrical equipment, autos, trucks, diesel engines, aircraft, indoor plumbing, textiles, and so on, have all contributed to the well-being of society.

These were positive changes in the quality of life thanks to the Industrial Revolution, but there were negative effects as well. There are many environmental problems (excess amount of CO_2 emission, water pollution, solid pollution, energy depletion) and social problems (world wars due to the demand of oil and raw material etc.). A corresponding increase in carbon emissions, decrease in natural resources, increase in human health problems due to pollution are also direct effects of IR on our environment and society. Unfortunately, people did not realize the full impact of the Industrial Revolution until about 100 years later in the 1800s. The new industries led to severe ecological problems such as increased chemical consumption which led to poisoning of rivers and soils, increased fossil fuel consumption leading to air pollution, and an excess amount of carbon emission contributing to the greenhouse effect (Mitchell, 2010). These effects are also potentially linked to climate change. The selection of the Industrial Revolution as a discussion topic is thought to be an appropriate issue because of its direct impact on other SSI units (energy problem, climate change, food shortages) that frame this study.

2.4 Summary

The overarching goal of science education is to highlight the importance of “doing science.” It is to be able to state the goal of an investigation, predict outcomes, and plan a course of action that will provide the best evidence to support a claim or position. In order to reach this broader goal, science educators should engage students in inquiry activities that require higher order thinking. The present study shifts the conversation from investigations limited to scientific contexts to an investigations that consider socioscientific contexts in the laboratory. In the present study, the importance of scientific investigations in the laboratory is fully recognized, but so is the emphasis for the need to explore socioscientific contexts in the laboratory because of their direct effect on everyday life.

To sum up, this study maintains reflective discussions are crucial in advancing preservice teachers’ argumentation skills in an inquiry-based laboratory, as it is the case in the regular science classrooms. There is a general consensus about the importance of science laboratory, however, none of these research studies focused on SSI within the context of the laboratory. The present study aims to fill this void.

CHAPTER 3

3. METHOD

The aim of the study was to investigate to what extend PTs' reflective judgment skills improved over a semester course focused on different SSI, to understand the argumentation skills of them revealed in SSI based-ILC by use of reflective judgment, and to explore if there is an association between reflective judgment and argumentation. The laboratory course was an elective course for elementary education program and was named "Laboratory Applications in Science Education II." The course was redesigned to investigate conceptual aspects of the current study, with the main focus on global environmental problems.

The following sections cover research questions, research method, data collection and analysis procedures. Information on trustworthiness, the role of the researcher, ethics, delimitations, and assumptions of the study are also explained.

3.1 Research Questions

RQ1. What effect does an SSI based-ILC have on pre-service teachers' reflective judgment?

RQ2. What are the argumentation skills of PTs revealed in SSI based-ILC by use of reflective judgment?

RQ3. Is there an association between RJM and argumentation scores of PTs revealed in SSI based-ILC?

3.2 Participants

The researcher used the convenient sampling method because this sampling strategy relies on available subjects who are easily accessible. College and university professors commonly use their students as subjects in their research projects (Berg, 2001) and it is the most common sampling strategy (Patton, 2002). Another issue in participant selection was PTs willingness to participate in the study. It was important to have volunteer participants since the course aims to engage PTs in intellectually demanding activities such as argumentation, socioscientific issues, and reflective judgment. The course was an elective laboratory course therefore; all of the participants were interested with the laboratory and selected the course on purpose. One of the participants was sophomore student; although their program (ESE program) suggests taking elective courses on third or fourth year she took the course in advance. One of them was senior student and was planning to graduate at the end of the semester, remaining of the participants, eighteen PTs, were junior students. The PTs' willingness to participate in this study was another issue that I took into consideration.

At the beginning of the course, 20 out of 23 PTs agreed to join the study on voluntarily. Of the 20 PTs, 19 were female, and 1 was male with a mean age of 21 years (ranging from 18-25). The participants were 20 pre-service teachers enrolled in two different programs; Early Childhood Education (ECE), and Elementary Science Education (ESE) therefore, participants have different academic background.

The ECE program requires students to complete 48 mandatory courses and 4 elective courses. These courses have a wide range of coverage and broad educational goals. For example; students begin the program with a general psychology course, anatomy and physiology courses, and continue with health education, sociology, music, computer, teaching methods, classroom managements, and the like. Participants in this study had already taken anatomy, basic science, teaching science in early childhood education and physiology courses to enhance their science background. They also took education and awareness for sustainability and climate change education for sustainability courses as elective courses aimed at enhancing their environmental awareness. Students graduating from the ECE program typically obtain jobs teaching early childhood in public and private primary schools. (The courses offered in the ECE program at Middle East Technical University (METU) are provided in the Appendix A.)

The ESE program aims to develop teachers with a sound understanding of how children learn science so that their students are confident in using technology, capable of problem-solving, and attentive to human rights, democracy, and ethics. The students, enrolling the ESE program, take general science courses in their first and second years and then start to take pedagogy courses in their third and fourth year. Participants in this study have completed science education courses in addition to other courses such as; physics, chemistry, biology, technology, history, and English at the time this study was conducted. Education and awareness for sustainability and climate change education for sustainability courses were also available as elective courses in elementary education department. 17 of the 20 students completed these courses before participating in this study. The participants also completed several pedagogy courses that prepared them for teaching. The pre-service teachers graduating from this program teach science in public and private schools from fourth to eighth grades in primary and middle schools. The courses offered in the ESE program at METU are provided in Appendix B.

Participants, as being a teacher candidate, attended some career programs including seminars, presentations, and activities with primary and elementary school students in order to enhance their professional development. One of the PTs volunteered for disabled students, she organized audiobook database at the assistive technology lab for students with visual impairments. Seven of PTs (ECE) taught elementary school children from low-income districts music and art, one of them worked as babysitter (ECE students). One of them was working at toy library, an association in Ankara, as toy librarian. Three of the PTs (ESE) taught physics, chemistry, biology and math to children from low-income districts. There were two PTs, who were volunteers to work in a special education community to help disabled elementary students. The participants were aware of the importance of practicing these programs before graduation for their professional development. Out of 20, 15 PTs reported that they attended at least one of above programs.

3.3 Study Context

The study was conducted in SSI-based Inquiry laboratory course which was bounded by both time and place. Particularly, it was bounded by one semester of data collection in an SSI based inquiry science laboratory course. The course was an elective course and there were one instructor and six course assistants for the course. The assistants were determined before the semester begins. The instructor made initial inquiries to potential assistant who might be willing to assist the SSI based-ILC and who are familiar with NOS aspects, scientific methods, experiment process. Each assistant has a bachelor degree in science education and have taken graduate level courses. The assistants have at least master degree in science education. Five of them have taken graduate level courses towards a doctoral degree in science education. One of them was in his second semester of the master program in science education. Course assistants have different interest area such as NOS, Pedagogic Content Knowledge (PCK), sustainable development, and such but all have similar science background. They all graduated from the department of elementary science education and completed the same curriculum during their undergraduate education. Table 5 is a summary of assistants' background, their interest areas and degree in the program.

Table 5 Academic Background of the Assistants

Assistant	Department	Degree	Interest area
Assistant 1	ESE	Master	PCK
Assistant 2	ESE	PhD candidate	Sustainable development
Assistant 3	ESE	PhD candidate	NOS,PCK, Environment
Assistant 4	ESE	PhD candidate	Sustainable dev., PCK
Assistant 5	ESE	PhD candidate	Sustainable development
Assistant 6	ESE	PhD candidate	Argumentation, SSI, RJM

The researcher and the assistants conducted pre-discussions for each issue (transportation issue, food additives, energy, climate change and industrial revolution) before the semester begin. During and following the pre-discussions, it was determined that each of the assistant have had both background knowledge and pedagogical strategies to assist the SSI based-ILC. All of the course assistants were trained on these issues, for example; the power point presentations, discussion weeks and experiment weeks were structured in order to design similar learning environments for each issue.

The course aimed to link theoretical knowledge to practical knowledge. Therefore, each issue was covered in two weeks. The first week, will be called as discussion weeks, PTs are exposed to classroom discussion and the following week, will be called as experiment week, PTs performed experiments regarding discussion issue. The course assistants have the responsibility to help their groups to prepare the presentation, to organize laboratory manual.

There were five different but closely interrelated socioscientific issues (transportation issue, food additives, energy sources, climate change issue, and the industrial revolution). These issues were assigned to the groups and aimed to be covered in ten weeks. PTs prepared a power point presentation (PPT) for each issue. The presentations give information about the issue from multiple perspectives. The aim of the presentations was to initiate the classroom discussions. Discussion weeks were video recorded, and these video recordings were later used as a data source.

Discussion week

PTs formed group of four at the beginning of the semester. Each group was responsible to make a presentation in the classroom. For example first group was responsible to prepare PPT about transportation issue, second group was responsible for food additive issue, third group presented alternative energy issue, and next group addressed climate change issue. They have had to make a PPT and present it in the classroom. PTs came together on the weekend make internet or library search for that issue, sent their documents to the assistants. Their assistant was responsible to check their search and give feedback to them on Tuesdays. General guidelines for classroom presentations were listed as; they should use magazines headlines, articles, YouTube video presentation of controversy, and photographs in their presentation. During classroom discussions, four PTs were responsible to guide the discussion but neither the presenters nor the assistants dominate the discussions. Hess (2012) outlined the contributions of discussing controversial issues in classroom. Present study aimed to integrate controversial issues into the laboratory by engaging PTs with classroom discussions.

The selected controversial issues were discussed during discussion weeks. Classroom discussions were framed by using Hess's (2012) review and the aim of the discussions can be summarized as following.

Table 6 The Aim of Discussing Controversial Issues in Classroom

- To address controversial issue in the classroom in order to increase content familiarity
- To practice the discussion of the public's problems.
- To cover intriguing issues during the discussions.
- To engage PTs with complex and ill structured issues
- To construct and exchange moral views
- To provide PTs diverse points of view
- To offer students to test their ideas against the ideas of their peers
- Let PTs engage in collaborative learning
- To positively influence content understanding, and critical thinking ability

Classroom discussions were found appropriate and effective to develop students' decision making skills on complex and social problems. Wilen (2004) attempted to refute misconceptions about classroom discussions and listed some concepts to improve instructional applications of classroom discussions those were used in the present study. Dillon (1994) listed four statements (declarative, reflective, statement of interest, speaker referral) for teachers to encourage students' participation in classroom discussions. In order to standardize each discussion across five issues the researcher outlined general guidelines for the presenters (see Table 7) and for the researcher (see table 8) to integrate SSI in the classroom by using Wilen's (2004) critics and Dillon's (2004) four statements.

Table 7 General Guidelines for Presenters to Present an SSI in the Classroom

- Consider the physical set up of the classroom
- To pay attention the visual organization of presentations
- Present concrete common reference such as articles, newspaper, video
- To summarize and analyze readings
- To ask brief and focused questions
- To encourage peers to involve discussions
- To address both positive and negative aspects of the issue.
- To address the causes of the issue, effects of the issue, alternative solutions.
- To address controversial opinions about the issue
- To use time effectively
- Prevent participants interrupt each other
- End the presentations with a general question; what should we do?

Table 8 General Guidelines for the Researcher to Integrate SSI in the Classroom

- Help groups to prepare PPT
- Give feedbacks for the visual and conceptual inadequacy of PPT
- To initiate the discussion with higher cognitive-level question to get multiple perspective on the issue being discussed
- To encourage students to make connections between past and present knowledge.
- To ask probing questions to clarify students response
- Declarative statement: stating a thought that comes to mind as a reaction to what a PT has just said
- Reflective restatement: repeating or paraphrasing what a PT has said to emphasize it
- Statement of interest: stating that she would like to hear more about what a PT has just said
- Speaker referral: Explain a link between the comments of two people
- To encourage the PTs to challenge their peers, to make a claim, to provide evidence for their claims
- Avoid only few students dominate the discussion, pay attention to engage less vocal students in discussions
- Avoid discussion to move off-topic.
- Help students to feel comfortable engaging in discussions
- Supports variety of opinions
- Foster non-threatening environment, different opinions are welcomed
- Use questions to help students connect important concepts
- Emphasize that assistants were neither the source of correct answers nor the source of authority to judge the PTs responses to the issues

General guidelines helped the researcher to have standard classroom discussions across five controversial topic. Following the discussion week PTs formed a research question about the issue and were asked to design an experiment to find an answer to their research question.

Conducting experiment

Constructivist theory guided the present study. The experiments were designed by using open inquiry method which is an appropriate way to let PTs to construct their knowledge on controversial issues. There is no step by step scientific procedure but a cyclic model (see Figure 3) to engage open inquiry. Even so, it is still important to make sure all the groups followed the same instructional procedure during the investigation. Researcher aims to clarify what has been expected from PTs before the experiments, during the experiments and to what degree the course assistants will guide the experiments. Therefore, the experimentation process was described in detail. Due to the dynamic nature of open inquiry, it is important to stress that these description is not the only-or the ideal-model. The intention of the researcher is to present some of the important aspects of open inquiry that was applied during the investigation process.

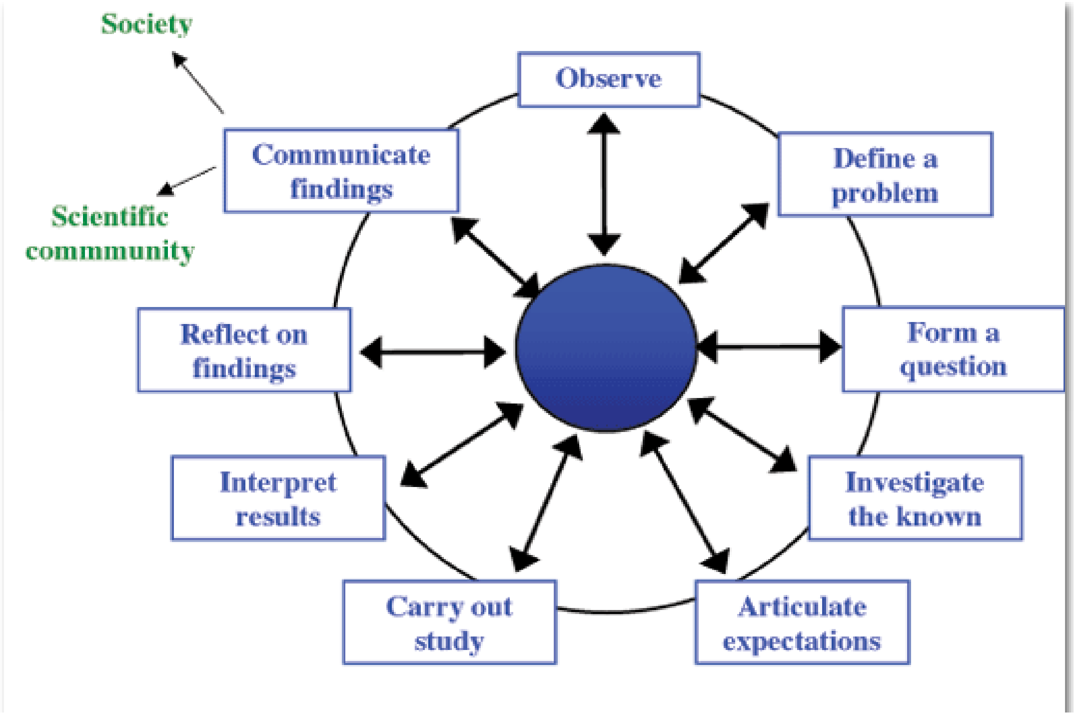

Figure 3 Conception of Scientific Inquiry

Note Adapted from “A scientific method based upon research scientists’ conceptions of scientific inquiry." by R. Reiff, W. S. Harwood, T. Phillipson, 2002, Proceedings of the 2002 Annual International Conference of the Association for the Education of Teachers in Science, eds. Peter A. Rubba, James A. Rye, Warren J. Di Biase, Barbara A. Crawford. ERIC.

PTs had to engage in ill-structured problems, and they had to discuss alternative solutions for those problems, by developing a research question, and investigating experiments. Each group prepared their manual and sent it to the researcher on Wednesday. The laboratory manuals were semi-structured. PTs were partially free to design their manuals, they were free to choose the experiment. All the groups had to include seven PRJI questions into their manuals but free to decide where to include these questions (i.e., at the end of the manual or together with the experiment questions). PTs were first introduced an example manual (Appendix C) and engaged with the experiment in order to experience PRJI questions in the laboratory. Each question discussed in the laboratory in order to make PTs familiar with those questions. The science laboratory became the learning environment where PTs worked together in ill-structured problem solving situations. Shiland (1999) made specific implications for modifying laboratory activities to increase students’ participation. Present study applied those implications to increase PTs' engagement in SSI based inquiry activities. Table 9 summarizes the Shiland's (1999) implications and the characteristics of the present study.

Table 9 Modification of Laboratory Activities to Increase PTs Participation

Shiland's (1999) implications	**Present research**
Have the student identify the relevant variable	PTs come together and decide what to investigate in the laboratory, Create research question (RQ) of their own
Have the students design the procedure or reduce the procedure to the essential parts	PTs wrote their plan for how they are going to investigate the RQ Engaged in small discussion, share their point of view Did internet search to obtain supporting evidence Did brainstorming on the evidence collected Drew a conclusion on which experiment will be performed in class
Have the student design the data table	PTs extended the procedural questions (directions about the experiment) with reflective judgment questions (redirect the PTs think about ill-structured issues).
Use a standard lab design worksheet	Each laboratory manual included standard parts which are; research question, experiment procedure, and reflective judgment questions
Rewrite the laboratory as a single problem whose solution is not obvious	PTs were engaged with controversial issues which do not have clear cut solutions
Give the students an opportunity to discuss their predictions, explanations	PTs shared their individual opinions about the issue being discussed

Conducting experiments required using basic science process skills, which are observation, inference, measurement, communicating and predicting. For example, PTs observed the effects of acids on plants by using hydrochloric acid and sulphuric acid. They observed what happened to the plants when they drop the acidic solutions, they recorded their observation. They changed the amount of acidic solution and made second observation, they record what they observed, they made inference about the effects of acid rains, linked the issue with climate change. They made some predictions about the reasons for climate change and possible link between climate change and acid rains. At the end, PTs communicate their predictions with their peers. After conducting experiment the individuals answered open-ended RJM questions (see Appendix I) about the issue investigated and they engaged in reflective discussion with their peers but they filled the lab manuals individually. The researcher guided the discussions by asking probing questions with an attempt to make the ill-structured issue clear and understandable for PTs. Thus may help PTs to support their claims with appropriate evidence.

Selected SSI were covered throughout the classroom discussions and were examined in the laboratory. PTs were free to choose which experiment will be investigated, the researcher was responsible to give feedbacks to the groups. In present study, the researcher aimed to have student centered learning environments and oriented the discussions and experiments by taking the PTs at the center of the research. Thus, the assistants' role was to facilitate the experiments rather than to dominate. The facilitator role of the teacher identified in numerous research (e.g Harden & Crosby, 2000; Motschnig-Pitrik &Holzinger, 2002; Sahin, 2013). The major characteristics of the teacher as a facilitator were reviewed in those research. I framed the roles of the assistants by using the implications of the previous research (Motschnig-Pitrik &Holzinger, 2002) to support constructivist learning environment.

Table 10 The Facilitator Role of The Assistants

- Ask the importance of the research question
- Had materials (necessary to conduct the experiment) available
- Minimal guidance to set up an experiment design
- Let PTs to explain their point of view about the SSI (one by one in a group)
- Let PTs to test their ideas
- Observe PTs during data recording, analyzing, assist them as needed.
- Encourage divergent thinking (by asking probing questions)
- Emphasize the ill structured nature of the issue (there is no correct answer)
- Allow students the freedom to discuss opposing ideas
- Avoid to answer direct questions of PTs but respond with guiding questions

3.4 Research Design

Qualitative research method was used to investigate the effects of multiple SSI on PTs' reflective judgment skills, and to explore what are the argumentation skills of PTs revealed in SSI based ILC by use of reflective judgment. In addition to qualitative method, the quantitative data analysis method was used to interpret is there a correlation between reflective judgment and argumentation scores. PTs' laboratory manuals, interviews and classroom discussions were analyzed qualitatively. Qualitative research enables researchers to conduct in-depth studies about a wide range of topics (Yin, 2011), intends to explore human behaviors within the contexts of their natural occurrence (Bogdan & Biklen, 1992), and seeks to understand the world from participants' perspectives (Lincoln & Guba, 1985). Stake (1995) asserts that the qualitative researcher seeks to understand complex interrelationships that lie within systems and utilize inquiry to promote understanding rather than to explain it.

In addition to qualitative descriptions, quantitative descriptions in terms of chi square, fisher exact test correlations were presented for the hypothesized relationships between reflective judgment stages and argumentation levels within socioscientific issues. Quantitative research enables whether the experimentally observed results (RJM and argumentation scores) are consistent with our hypothesis.

In this respect, mixed data analysis method which includes both qualitative and quantitative data analysis method was used in this study.

The present study is an emerging design aimed to investigate SSI in science laboratory, to explore PTs' reflective judgment skills revealed in laboratory manuals those were prepared by practitioners and researcher collaboratively. Mixed methods were used for analyzing data to maximize the validity as well as increase the objectivity, and reliability of research (Bell, 2004). Figure 4 is graphic summary of research design and method covers the participants, settings, research tools, data collection and analysis tools those were used in this study. Following section explains DBR approach, guided the present study.

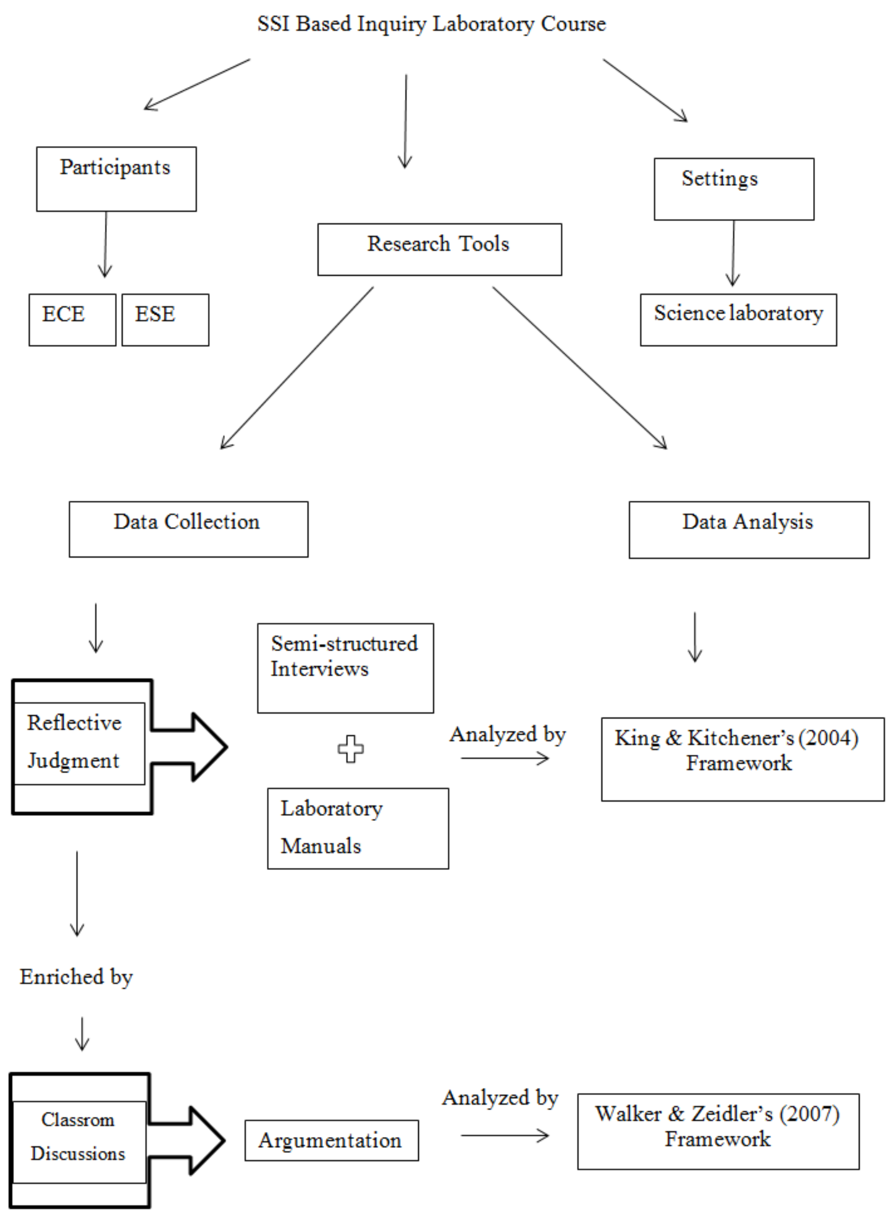

Figure 4 Graphic Summary of Research Design

The education literature emphasizes a strong and complicated relationship between theory and practice. Recently, Sari and Lim (2012) asserted that educational research and daily practices of educational issues do not overlap which causes a gap between theory and practice. DBR is an emergent reaction to the inadequancy of some traditional research approaches to link theory and practice within educational research. Lai, Calandra, and Ma (2009) defined DBR as “supporting design and development of prototypical products to solve complex authentic context specific problem (p. 120)”.

A design-based research approach was selected for the present study. The research was conducted in the SSI based inquiry laboratory course. SSI-based ILC has been redesigned by the researcher and revised throughout the semester with the active participation of the preservice teachers. The researcher was the coordinator of the course, participated as facilitator of the classroom discussions and laboratory sessions. There were five more assistants, who helped the PTs to prepare power point presentations and to design and implement their experiments. The core focus of the present design-based research was to investigate SSI in a laboratory and to explore PTs reflective judgment skills. Reflective judgment skills were commonly assessed by interviewing participants (King and Kitchener, 1994; Mezirov, 1981). However; I aimed to include prototypic RJM questions into laboratory manuals to asses PTs reflective judgment skills in written form (see Appedix C).

Writing activities have been commonly used in science lessons by many practitioners (Kelly, Druker, & Chen, 1998; Kelly & Takao, 2001; Keys, Hand, Prain, & Collins, 1999). The uses of scientific writing have focused on analysis of students’ products and views about science, showed a range of applications of writing to learn and learning to write (Kelly & Chen, 1999; Kelly et al., 2000; Prain & Hand, 1999). Written assignments help students to construct an understanding of science (Kelly et al., 1999), and to structure and organize knowledge in a consistent manner (Rivard et al., 2000). As previously indicated, science laboratories were dominated by well-structured experiments however the present study included SSI (ill-structured problems) into the science laboratory course. In addition to this, the study attempted to assess reflective judgment skills in written form by laboratory manuals. Inclusion of SSI and assessing reflective judgment skills in written form (besides interviews) delineates the present study from other forms of research (e.g. well-structured science experiments or just interviewing participants).

DBR has a cyclic approach, theoretical design and practical design applied interactively and that empirical research findings helped researcher to make continuous modifications of both theory and practice. Neither design based approach nor the present study look for universal solutions but look for deep understanding of the factors that affect improvement in local contexts (i.e., including SSI into inquiry laboratory).

Joseph (2004) point out that DBR lacks an established process for its conduct and stressed that it is still an emerging methodology. Thus, the present study was conducted within a cyclic approach without an established research process. Although there is no single way to conduct a design based research, I used Plomp's (2007) phases as a guide to conduct the present study which are;

1. Preliminary research: needs and context analysis, review of literature, development of a conceptual or theoretical framework for the study;
2. Prototyping phase: iterative design phase consisting of iterations, each being micro-cycle of research with formative evaluation as the most important research activity aimed at improving and refining the intervention;
3. Assessment phase: (semi-) summative evaluation to conclude whether the solution or intervention meets the pre-determined specifications. As also this phase often results in recommendations for improvement of the intervention, we call this phase semi-summative. (p.15)

In this course, PTs engaged in concrete experiences in order to understand the highly complex and abstract concepts such as, food additives, CC, Industrial revolution and alternative energy problem. Herron (1971) described four levels of inquiry, which are confirmatory, structured, guided, and open. In this study, I used

DBR approach and open inquiry method to explore PTs development of reflective judgment skills in SSI based laboratory course. PTs formulated their own question, designed and selected their own procedure in order to examine their topic-related questions. The PTs were given opportunity to derive questions, design and carry out experiments, communicate their results to their peers

Figure 5 presents the research procedure. According to Figure 5, the first phase was covered in three steps; designing the course content, obtaining ethical permission, and training the course assistants and the preservice teachers. The second phase, prototyping phase was the first micro cycle of this study. The first issue was covered in two weeks. Refinement of problems, solutions and methods were instantly conducted during this phase. The last phase, the assessment phase ended in eight weeks, included four microcycles (food additives, alternative energy, the climate change, the industrial revolution) and summarized in last step.

	Stage	**Criteria**	**Short description**	**Current research**
1	Preliminary research	Emphasis mainly on content validity, not much on consistency and practicality	Review of the literature and of (passed and/or present) projects addressing questions similar to the ones in this study. This results in (guidelines for) a framework and first blueprint for the intervention	Designing the course content (choosing 5 ill-structured issues) Ethical permission Assistant training
2	Prototyping stage	Initially: consistency (construct validity) and practicality. Later on mainly practicalityand gradually attention for efficiency.	Development of a sequence of prototypes that will be tried out and revised on the basis of formative evaluations. Early prototypes can be just paper-based for which the formative evaluation takes place via expert judgments	Investigating micro cycle-1: transportation issue Reflective Judgment, Interview, Discussion hours, Experimentation (Revisions took place at this phase)
3	Assesment Phase	Practicality and efficiency	Evaluate whether target users can work with intervention (practicality) and are willing to apply it in their teaching (relevance & sustainability). Also whether the intervention is effective	Investigating four micro-cycles to test the effectiveness of the new design.

Figure 5 Flowchart of Research the Procedure

3.4.1 Phase 1: Preliminary research

Preliminary research phase described by Plomps (2007) as the needs and context analysis, review of the related literature, development of conceptual or theoretical framework for the study. The researcher conducted a semester-long literature review before selecting the course content and deciding the theoretical framework of the present study. The researcher and the course instructor redesigned the science laboratory course in order to reach the goal of this study. There was a significant amount of controversial issues and while they were all acceptable for SSI discourse some of them critically picked for the goal of the study. Throughout the course our goal was not only to make PTs to discuss the controversial issues, but also to test each issue in the laboratory. Therefore, while selecting SSI to include in the course consideration was given to the controversial issues in terms of whether they were amenable to laboratory testing. Thus, the course content was framed by selected global environmental problems that could be investigated in the laboratory setting. Furthermore, the issues have significance for not only Turkey, but also other countries in the world.

For this study, the researcher selected SSI accociated with the global problems. Significance of these SSI are highlighted in the literature; transportation issue (Colvile, Hutchinson, Mindell, & Warren, 2001), food crisis (United Nations [UN], 2008), climate change (Wilson, 2000), energy problems (Jin & Anderson, 2012), and the Indurstrial Revolution (Kasa, 2009) during the preliminary phase.

In the first week, PTs were informed about these issues briefly. They formed five different groups and there were five course assistants for the groups. The researcher was also the course assistant (sixth one) but she did not have a student group in order to be able to observe all groups during the experiments. She attended all weeks during the implementation, asked some questions to the assistants or to the PTs during the experiments, observed all presentations and experiments.

Each of the assistants involved in the study has had some exposure to NOS in the past. They were also familiar with STS but only one of them, course coordinator, has a special interest in SSI and argumentation in science education. Because of lack of background knowledge about SSI and RJM, the assistants were trained about theoretical framework and goals of SSI based-ILC. The course coordinator addressed three main issues during training. First one was the goal of the course, second one was the theoretical framework behind the SSI based-ILC, and the third one was RJM model and its characteristics.

3.4.2 Phase 2: Prototyping phase

Plomp (2007) described the second phase of DBR as iterative design phase consisting of iterations, each being micro-cycle of research with formative evaluation as the most important research activity aimed at improving and refining the intervention. Present study conducted five micro-cycle of research to explore PTs' reflective judgment skills in SSI-based inquiry laboratory course. One of the advantages of design based research is researcher develops the instrument with participants in collaboratively and to check and test the adequacy of research instruments throughout the research process. In the first micro cycle, the researcher aimed to check whether the lab manuals and prototypic RJM questions are clear for PTs or not. This was worth checking, because it is the first time that PRJI questions were used in laboratory manuals. The seven PTs from the department of elementary science education engaged with ill-structured issues in previous courses (i.e., Science-Technology- Society) but this was the first time for rest of the PTs (13 of the PTs from the department of ECE) to engage in ill-structured problems. Therefore, cycle 1 shed some light on the applicability of the current study.

Transportation issue was selected as the first content. The researcher attempted to investigate the developments in transportation issue (alternative ways to travel around the world) and its effects on environment (air pollution) in the first micro-cycle. This issue was selected for the first issue since the PTs have prior knowledge about the transportation issue and its effects on the environment. Ader (1995) asserts the air pollution due to the excess amount of CO_2 emission was addressed in media and society was exposured to the pollution in real worl conditions. Thus, as compared to other issues (i.e., climate change, alternative energy or industrial revolution) covered in this course, the transportation issue was simple to understand for PTs. The second, transportation issue was interrelated to rest of the issues (e.g. climte change due to excess amount of CO_2, industrial revolution, need to find alternative energy sources due to oil-crisis etc.), transportation issue can be assumed as basement to construct other ill-structured issues in the laboratory. Selecting a familiar topic was thought to be appropriate since the aim of the first micro-cycle is to introduce the new design to the PTs, to practice what will be addressed during the discussion, how RJM questions will be included into the mannuals, what are the role of the presenters during the discussion and etc. The researcher, as an observer of the process, was active throughout the process. There were some potential risks during the implementation these risks were evaluated and some revisions were done at the end of the first micro-cycle.

Micro cycle-1: Accomplishment, decisions, and revisions*:*

The PTs formed five groups and were assigned to make research about transportation issue before they come to the class meeting. Each group was responsible to prepare a PPT for their presentation in class. In order to prepare an effective presentation the PTs came together and conducted research about the issue. Conducting research was the first step to prepare an effective PPT. PTs studied in group of four, each PTs were given a specific part to do research and they individually presented their part to the assistant. The students used three articles for reviewing the issue, collected the magazine headlines, watched five video and selected one of them to present in the classroom, and so many photographs to present the issue in a controversial way. Assignments were given on Thursdays. PTs were expected to work together, make a deep analysis about the issue over the weekend, and they were expected to submit their presentation drafts to their assistants on Monday. Assistants were responsible for giving feedback to the students on Tuesday. Assigned group presented the final version of the presentation to their assistant on Wednesday.

The second step was presenting the transportation issue into the classroom. They aimed to address both positive and negative aspects of the transportation issue. Presenters started to presentation by showing a YouTube video about the issue and continued with photographs and some formal information about the history of the issue. Presenters used presentation cards during the classroom discussions. They used PPT when they wanted to show a video, photograph, or graphics. PTs were given a standard rubric about effective power point presentation techniques and specific points that should be addressed during presentations. There are many researchers (e.g. Dufrene & Lehman, 2004; Leigh, 2003; Mahin, 2004; Vik, 2004) who advocates use of PPT in classrooms and suggest some strategies to make an effective presentation. The rubric was adapted from work of Dufrene and Lehman (2004). Their suggestions about preparing an effective presentation were included into the rubric. These are planning transitional flow, planning the visual organization of presentations, using simple and precise word; asking leading questions during the discussion to reinforce ideas, addressing controversial opinions for the issue, encouraging peers to involve discussions, and to using time effectively in equal time periods.

This implementation plan worked properly, as a course coordinator the researcher was able to control all groups power point presentations' research processes and provided feedback if necessary besides groups' assistants' feedback before the classroom presentation. At the end of the first presentation week the researcher realized that there might be one potential threat in group studies which was that only one or a few students might prepare the whole class activities and some students might do nothing before the meeting. In order to eliminate this threat, she changed the assignment plan and gave a particular task to each PT in the group and asked them to make individual presentation about their particular task. For example, if there were four students, she assigned four tasks, such as analyzing positive effects of the issue, negative effects of the issue, related article review, and video & newspaper review. Each PT was responsible to send their research findings to the researcher. The individual presentations let the assistants be sure that all the members of a group actively engaged the research process and to be sure all issues that will be addressed in PPT be equally shared by group members. During classroom discussions, four PTs were responsible to make presentation and to guide the discussion but neither the presenters nor the assistants dominate the discussions.

Every single participant was expected to actively participate in discussions. Informal classroom discussions are interspersed throughout five socioscientific issues in order to provide opportunities for reflection and for sharing and critiquing opposing ideas. The presentation group's role was to guide the discussions. The four PTs (presenters) were responsible to highlight leading questions and to encourage the rest of the classroom to challenge their peers, to make a claim, to provide evidence for their claims. The assistants were neither the source of correct answers nor the source of authority to judge the PTs responses to the issues. Four issues were discussed in the same format; presenters guide the discussions and asked leading questions to initiate the discussion. The number of the questions that were addressed during the discussions were quite similar. Presenters asked ten to fifteen questions per discussion and assistants added eight to ten questions. All the discussions lasted four hours and conducted in same format; starting from a controversial issue ending with a research question about that issue. Each group developed a research question (see Table 12) at the end of discussion hours.

In the fifth week, the PTs were introduced to an example laboratory manual that was developed by the researcher (see Appendix C). Before conducting the experiment, the PTs were given a chance to examine the example lab manual and discuss the RJM prototypic questions with their assistants. The manual started with a research question, continued with short information about the investigated issue, some measurement process for the experiment and seven standard reflective judgment probing questions.

The researcher wanted to present an example manual in the fifth week rather than asking them to prepare a manual, because it was the first time for students to engage in SSI based experiments. Students were not familiar with conducting experiments for ill-structured problems. Asking them to prepare an SSI based laboratory manual might be challenging for them; therefore I presented an example one and gave them a chance to analyze it in the second phase (prototyping phase). There were five graduate assistants, each with four students in their group. The fifth week has utmost importance because it was also a demonstration for students. Students were expected to prepare their own manual in the following weeks.

First micro-cylce helped the researcher in order to see accomplishment of planned study (i.e., PPT, discussion hours, engage in ill structured issues in the laboratory), necessary decisions that should be given (introducing an example manual and expecting PTs prepare their own material, and required revisions (assignment plan for PPT) in order to eliminate possible problems that undermines the outcomes of the design.

3.4.3 Phase 3: Assessment phase

Micro cycle 2:

Each group generated a research question about the current issue at the end of the discussion week by using key concepts of that issue (causes of the issue, effects of the issue, alternative solutions for that issue) that were examined during the discussion weeks. Generating research questions guided them to design their experiments and prepare their lab manual for the following week. The PTs conducted their experiments in the second week. Each student answered the questions on their lab reports, and these reports were collected by the researcher and used as data source. The researcher conducted interviews with PTs in order to ask more follow up questions (RJM) by taking a random sub-sample (see section 3.5 for further information about data collection procedure).

This study gave a chance to PTs learning from each other by involving in reflective discussions. Discussion weeks included PPT prepared by PTs. The Table 11 was adapted from Zeidler et al. (2011) study, and used as an outline which provided a general guideline for the PTs. The outline was distributed to the PTs and they were expected to address these issues in their presentations. The form was used to assess PTs presentation performance as a standard rubric by the researcher.

Table 11 Outline: Developing an SSI Unit

1. Topic/Subject Matter Introduction	Performed by Presenters	Performed by Assistants
a. Magazine headlines, articles, and advertisements	✓	✓
b. YouTube video presentation of controversy associated with subject matter	✓	✓
c. Photographs	✓	✓
d. Models	X	X
e. Other media formats	✓	✓
2. Challenging Core Beliefs	✓	✓
a. Contentious questions that "attacks" common beliefs	✓	✓
b. Challenging "Common knowledge" of subject matter	✓	✓
c. Misconceptions	X	✓
3. Formal Instruction	X	X
a. Related science information	✓	✓
4. Group Activity		
a. Development of related topic/subject matter questions	X	✓
b. Individual investigation of data and evidence	✓	✓
c. Small group negotiation of evidence	✓	✓
d. Group presentation of consensus understanding	✓	✓
5. Develop Contextual Questions	✓	✓
a. Fundamental science concepts of subject matter	✓	✓
b. Defeating misconceptions	✓	✓
c. Contemporary claims regarding subject matter	✓	✓
6. Class Discussion	✓	✓
a. Evidence reliability of contemporary issues	✓	✓
b. Importance of specific knowledge for informal decision-making	X	✓
7. Teacher Reiteration of Content/Subject Matter	X	✓
a. Essential learning of subject matter content	X	✓
b. Purpose and relevance of specific knowledge	✓	✓
c. Application of content knowledge	✓	✓
8. Knowledge and Reasoning Assessments	X	✓
a. Group presentations	✓	X
b. Posters	X	X
c. Argumentation/debate activities	✓	✓

Classroom discussions were their chance to share opposite ideas about controversial topics. All the discussions were outlined as shown in Table 11. The researcher aimed to standardize classroom discussions in order to make a summative assessment at the end of the investigation.

Sixth week, Group-2 made a presentation about food additive issues. Although the issue seems like a modern century's problem, presenters aimed to give a broad perspective to their peers about the issue by highlighting its history. Advantages and possible harms of these additives were discussed in the classroom. They discussed food additives, types of those additives and side effects of them, they also argued what does e-numbers mean, and how does Acceptable Daily Intake calculated. Seventh week, PTs developed their research questions, designed their own experiments and tested their ideas regarding food additives in the laboratory.

Eight week, Group-3 prepared a detailed presentation regarding the energy, renewable and nonrenewable energy sources. Although there were lots of energy types and they all have advantages and disadvantages, five of them were covered during the classroom presentations because of time limitation (4 hours for each discussion). These five energy sources were common sources across the world and PTs were familiar with those sources because of Turkish government's energy politics. Five issues, those were addressed in this week, nuclear energy, hydroelectric energy, geothermal energy, wind energy, and solar energy. Presenters aimed to discuss some major issues about the energy problem. For example, they addressed which source supply the biggest amount of energy, which source has potential environmental risk, which one is safe but supply inadequate energy and such. They used videos, graphics, indicated advantages and disadvantages, and highlighted safety problems for each sources. Ninth week, the PTs engaged in the science laboratory and conducted experiments regarding the energy issue. Each group developed their own research questions for energy issue, designed an experiment to test their questions and performed the experiments in the laboratory.

Tenth week, Group-4 presented the climate change issue in discussion hours. The climate change issue has been argued in many journals, on TVs, newspapers. PTs have lots of chance to hear on TVs or to read it from a magazines etc. The issue is very popular across the world but there are lots of different opinions about the issue. Group-4 aimed to find divergent views about the issue and presented those views in the classroom to challenge their peers' core beliefs. They started with some formal information about ozone layer. They clarified whether there is a relationship between ozone layer and CC or not. They addressed the effects of the issue on living beings, glaciers, sea levels. They discussed the current and future consequences of CC. Eleventh week; all groups developed their own research question and tested their ideas about CC issue in the laboratory.

Twelfth week, Group-5 presented the Industrial Revolution issue. Since the issue has many aspects and the impacts of the revolution on the environment have been discussed in not only on TV but also many scientific articles, students had no difficulty to find relevant documents. The appropriateness of the sources was controlled by the group's assistant. The presentation started with the history of the IR, continued with benefits of industry to our life, effects of Industrial revolution on Turkey. They tried to present the issue from multiple perspectives. They addressed both negative and positive effects of the revolution to our country. Course assistants asked to challenging questions during the presentation in order to initiate the discussion. Discussion hours lasted in 4 hours all of the conversations were video recorded and transcribed verbatim. Thirteenth week; each group developed their own research questions for the effects of industrial revolution, designed an experiment to test their questions and performed the experiments in the laboratory.

The aim of the discussion weeks was to attract PTs attention to SSI and to cover intriguing issues during the discussions. Neither presenters nor course assistants aimed to display a solution for the issues or to direct the PTs towards a general conclusion about the issue. The presentations ended with a general question; what should we do? The PTs had to think about the issue and had to develop a research questions for the experiment week. They developed their own question and tested it in the laboratory. On Thursdays, at the end of the presentation, each group was assigned to design an experiment for the next week. The experiments were not "cut and dry" experiments. The issues were ill-structured and students had to test ill-structured issues in the laboratory. Therefore, they were free to choose what to test. For example, in energy week, each group had different solutions for the energy problem. Some of them claimed that wind power is the best suitable energy source, the other wanted to test hydroelectric powers, and some of them claimed that solar energy was the best energy sources. Each group designed their own experiments. Therefore, there were five different experiments for each issue.

PTs engaged with an example lab manual (Appendix C) in the first micro cycle on the fifth week. This manual was prepared by the researcher. It was provided as an example to the PTs. The experiment was conducted by the course coordinator. The PTs used this manual as a guide for preparing their own manuals. At the following weeks food additives, alternative energy sources, the climate change and the Industrial Revolution and its impacts on the environment were tested in the laboratory. The groups developed their own research questions and designed their manuals (see Appendix D, E, F, G). There were five different groups and each group developed their own research questions for each issue. The PTs' research questions can be seen in Table 12. Throughout the course the PTs developed twenty different research questions and tested their questions while conducting experiments. Table 12 presents PTs' research questions for each socioscientific issues.

Table 12 PTs' Research Questions for Each Socioscientific Issue

The SSI	Group No	Research Question
Food Additives	1	How do food colorings change the properties of milk?
	2	Will there be a difference between taste/smell of drink those are prepared by using natural colorings and artificial colorings?
	3	What does happen to the products, when these food additives are used?
	4	How does an emulsifier effect food industry?
	5	Which one do you prefer: a sugar or a sweetener?
Alternative Energy	1	How can we use sunlight to produce energy more efficiently?
	2	How solar energy can be used to heat water?
	3	How do hydroelectric power plants produce electricity by transforming P.E to K.E?
	4	How can we use wind as an energy source?
	5	How can thermal power plants be used as an energy source?
Climate Change	1	Does acidic rain have a negative effect on our life and how acid rain can affect our world?
	2	Do amount of CO_2 have effect on temperature?
	3	How do CO_2 effects temperature?
	4	Is there any relationship between global warming and sea level rise?
	5	Whether the amount of carbon dioxide affect the temperature or not?
Industrial Revolution	1	How water pollution that caused by industrial revolution, can be controlled, or reduced?
	2	How industrial wastes can be cleaned from water?
	3	How do industrial wastes affect plants?
	4	How the air pollution, caused by industrial wastes, can be tested?
	5	How the soil pollution, caused by industrial wastes, can be resolved?

3.5 Data Collection

Current study attempted to use qualitative data to examine PTs' developments of reflective judgment in an inquiry laboratory course and to explore to what extent did their argumentation skills develop by use of reflective judgment. Data triangulated by using interviews, written laboratory documents and video transcriptions. Following sections are brief explanations for each data collection tool. Data was collected on 2012-2013 spring semester. Data collection procedure ended in 13 weeks. Table 13 presents the instruments those are used in this study.

Table 13 Research Instruments

Construct	Instruments
Reflective Judgment	Laboratory manuals
PRJI	Prototypic Reflective Judgment Interview
Argumentation	Oral Argumentation

3.5.1 Reflective judgment instruments

Reflective judgment is generally assessed through the online survey, the RCI test, as well as an interview protocol, the PRJI. Current study used PRJI (See Appendix H) which is a semi-structured interview developed by King and Kitchener (1994) assesses respondents‟ level of reflective judgment on various scenarios". Researcher conducted the interviews. Each of the interviews was completed in an office workspace, and each of the interviews lasted between ten to fifteen minutes. The interviews were audio recorded using a digital audio recorder. The student provided his or her name for the interviewer at the beginning of the interview. The audio recordings were then transcribed by the researcher.

In addition to PRJI, I used an alternative assessment tool for assessing PTs reflective judgments. PTs adopted PRJI questions in their laboratory reports (see Appendix D to G). The laboratory manuals provided data for exploring RJM.

3.5.2 Argumentation instruments

The argumentation patterns of PTs, developed in group discussions on each controversial issue, were used as data source. All discussions were audio recorded and were transcribed in verbatim. These video transcriptions were used during analysis procedure. The aim of this analysis was to explore; how do PTs elaborate arguments while confronted to SSI in classroom discussions.

Each of the interviews was completed in an office workspace, and each of the interviews lasted between fifteen to twenty minutes. The interviews were audio recorded using a digital audio recorder. The PT provided his or her name for the interviewer at the beginning of the interview. The audio recordings were then transcribed by the researcher, the real name removed, and a random number was given to the PT for data analysis steps.

3.6 Data Analysis

3.6.1 Analysis of reflective judgments

The researcher, who was the course coordinator, conducted individual meetings with course assistants when they need and always had active communication via e-mail. Assistants helped their group while preparing the PPT, checking the validity of the content, coherence of the presentation, appropriateness the experiment, and they also guide them in the laboratory. At the end of the each experiment, she took two copies of all manuals one was for the instructor, and the other was for the group’s assistant. The original copies of the manuals were collected and analyzed by the researcher. PTs laboratory manuals and interview responses were scored by the groups’ assistants and by the course coordinator in accordance with the stages provided by King and Kitchener (1994) in Appendix I

Prior to scoring the manuals, the researcher and five assistant met to discuss the scoring of the laboratory manual. I used a previous article (Zeidler et al., 2009) that explicitly inform the reader about scoring RJM and give particular examples for RJM stages. This example article was sent to the assistants before the meeting and later we discussed the RJM stages together. The researcher also individually interviewed with the assistants about RJM scoring procedure.

King and Kitchener (1994, 2004) provided the framework for assessing reflective judgment. Each PT’s score was summarized into a three-digit code (e.g 4-4-5). Each digit represent a stage that can change from one to seven (the definition of each stage were explained in previous chapter, see Chapter-2, page-30 for further explanation). The primary digit represents the prevalent reflective stage. The secondary and tertiary digits provided the ability to examine the range of answers provided by the student. A sample score of 4-4-5 would represent a vast majority of responses at the stage four levels, with some responses at the stage five level. It should be noted that most PRJI responses reflect only one or two stages. However some students reflect less consistency in answers. An example of this is 4-5-3, which represents a predominant stage four thought, but some responses at stage five, and even less responses at stage three. The display of three stages (e.g., 4-5-3) occurs much less frequently. The three digit number was converted to a number between one and seven by using a weighted average with the primary score as 50% of the value, the secondary digit as 30%, and tertiary digit as 20% of the value. For example, a value of 4-5-3 would be converted to a decimal number by 4(.50) + 5(.30) + 3(.20) = 4.10.

Each assistant scored his/her groups of students laboratory manuals (4 PTs for each issue), the researcher scored all the manuals (20 PTs for each issue), but the instructor scored the problematic manuals that the scorers could not come up with an agreement (2-3 for each issue). The assistants and the researcher scored one of the manuals in a cooperative manner discussed each of the criteria as we progressed. Following this initial scoring procedure, the assistants scored PTs manuals independently to achieve an individual inter-rater reliability. Researcher's scores and group assistant's scores compared to calculate the initial inter-rater reliability. There were some cases that the inter-rater reliability was below 90% we came together with the assistant and discussed the scoring. If we could not come up with an agreement, we discussed the related issue with the course instructor. The instructor scored the manual independently, and we discussed the scores with her. The secondary inter-rater reliability was greater than 90%, which was determined to be an acceptable level.

To triangulate Reflective Judgment scores, the researcher used semi-structured reflective judgment interviews. Interviews were conducted with randomly selected PTs. Prototypic Reflective Judgment Interview questions (King & Kitchener, 1994) were asked to the PTs during the interview. Each interview was transcribed verbatim and scored independently by using three digit score analysis method as above mentioned. The inter rater reliability was checked by comparing two scorers' results. Inter rater reliability, which was greater than 90%, was as an acceptable level. The average interview scores were calculated and then compared with the average laboratory manual scores to triangulate the reflective judgment data.

3.6.2 Analysis of classroom argumentations

The PTs participated in classroom discussions about the debated issue. These classroom discussions lasted in four hours. Each discussion was audio recorded and transcribed verbatim. Analyzing the content of PTs' reasoning on the food additives, CC, energy, and IR debate, the quality of their arguments were assessed utilizing Toulmin's (1958) model of argument. The researcher used an adapted version of Toulmin Argumentation Pattern (TAP), used by Zohar & Nemet (2002) as well as Sadler & Donnelley (2006) and Walker & Zeidler (2007) in order to analyze the PTs' use of claims, grounds, warrants, backings, and rebuttals to support their debate position. Every single PT's contribution to the dialogue was analyzed for their Subject Matter Knowledge (SMK), use of claims, grounds to support their opinions. The evaluation rubric includes four levels (zero to three) to rate the grounds of each PTs conversational turn from the transcriptions of the classroom discussions. If there were no evidence claims in PTs arguments researcher rated `0` for that argument. If there was evidence but the PTs have incorrect consideration of evidence claims, it was rated as `one` level argument. The `two` level arguments have consideration of non-specific evidence claims. Finally, the `three` level arguments include correct consideration of specific evidence claims.

PTs' quality of argumentation and use of evidence were analyzed by using Walker and Zeidler's (2007) framework. PTs contributed the discussion by multiple turns and most of these conversational turns were rated (informal line of dialogues were excluded) the flexible nature of the classroom discussions let PTs to support their ideas. However, it was common that PTs argumentation levels varied during and across the discussions. For example a PT proposed Level-0 arguments two times, Level-1 arguments four times, Level-2 arguments two times and no Level-3 arguments in climate change discussion, I will express her score as (2-4-2-0). Final argumentation position of this PT decided as Level-1 since a vast majority of responses were at this level (four times). Not only highest frequency but also highest level was taken into consideration as deciding final argumentation position of a PT. For example PT-7 presented (3-2-4-4) arguments in alternative energy discussion although the frequency of Level-2 and Level-3 arguments were the same, final position of her was stated as Level-3 since this level already includes the Level-2 in it.

The course instructor and a science education professor helped the researcher during the argumentation analysis. The professors are experienced in SSI research and had investigated numerous SSI, and argumentation research in their previous studies. The excerpts were used to provide a more concise and cohesive presentation of the transcripts.

In addition to RJM analysis by using King and Kitchener's (1994) framework and argumentation analysis by using Walker and Zeidler's (2007) framework, the relationship between argumentation and reflective judgment levels of PTs were described by statistical analysis such as chi square and Fischer's exact test. IBM SPSS Statistics 20 program was used for all of the statistical analysis. Non-parametric statistics were preferred as the small sample size in groups and having difficulties in meeting the level of measurement, normal distribution, and homogeneity of variance assumptions of parametric tests.

3.7 Trustworthiness

Lincoln and Guba (1985) presented a framework to enhance the trustworthiness of the qualitative studies. Trustworthiness of the current study was established based on the framework presented by Lincoln and Guba (1985). Three techniques was used in order to have valid and reliable findings which are triangulation, member checking, providing thick description.

To enhance the reliability of the data, I triangulated PTs' interview analysis and their laboratory practice with the reports they actually produced. I also used researcher triangulation to establish inter-rater reliability of the data analysis. The different researchers scored each paper line-by-line, and graded papers by using the related rubric (RJM, Argumentation). Each researcher reviewed the papers and assessed them independently. The rate of agreement on the assignment results between two researchers was calculated. Two researchers argued the differences between their grading and reached an agreement about the discrepant point of views. Triangulation improved the quality of data analysis and the accuracy of the findings.

External validity can be defined as transferring a study results into another study (Merriam, 1998). Lincoln and Guba (1985) explained external validity by the term applicability which refers to transferability. The question of external validity for this study is tried to be solve by thick descriptions of participants, data collection procedure, data collection tools and finally data analysis procedure.

If research findings can be replicated this means the research has reliability (Merriam, 2009). In social sciences replication is considered as a problematic issue since human behaviors are never static (Merriam, 2009). Lincoln and Guba (1985) conceptualize this issue as dependability or consistency that moves the focus from results replication to results consistency with the data collected.

3.8 Ethical Issues

Researcher took permission from the Ethical Committee at METU for the ethical consideration in this (Appendix J) and asked all preservice teachers to sign the consent form (Appendix K). On registration week, 23 PTs registered for the course. First week, researcher talked to every single PT, who registered the course, about course content. Students were informed about the data collection procedure, video-recording part, experimentation procedure, weekly interviews, and such. All of them were informed that there would be no harm or deception. Second week, aims and rules of laboratory were introduced to the students. They were explicitly informed about it was a doctoral dissertation implementation. The data was collected in an elective science laboratory course; preservice teachers had a chance to drop the course. Third week was the add-drop week in METU. Some of the students (3 of the 23 students) who feel uncomfortable to participate in video-recording dropped the course on add-drop week and remaining twenty students willingly participated in this study. Researcher ensured that the confidentiality of data -video recordings, voice recordings and laboratory reports- would be protected, and students' names would not be revealed anywhere. They were asked to write pseudonyms on their laboratory reports as well as their real names. I used randomly assigned numbers instead of students' real names.

As a requirement of the course, preservice teachers were asked to make presentations (once every two weeks), to address the issue from multiple perspectives in classroom discussions, to design experiments on the following week and to conduct their experiments in the laboratory. All of these requirements contributed their final grades. Since the study constructed on ill-structured problems there were no clear cut solutions for these problems and no true answer for an issue, the assistants informed all the participants that there were no right answers to the problems. The researcher tried to encourage them share their ideas freely by clearly indicating that I did not aim to assess their answers as true or false response, but aimed to evaluate their way of knowledge justification. Students' laboratory reports were weekly graded by course assistants in order to see their reflective judgment stage development however these grades did not announce until the end of the study considering the fact that grading might have affected their participation.

Although the researcher aimed to reduce ethical issues in the current study, there is still a potential risk named as reactivity (Lincon & Guba, 1985) in qualitative research. The presence of the camera when discussing social ethical and environmental issues might change the students' behavior. Our interpretations based on students' interactions while being recorded. The researcher tried to persuade the participants that the videos would be used only for research purpose in order to overcome this threat. She also spent time in the classroom to make the students got used to the camera.

3.9 Assumptions of the Study

This study aimed to investigate SSI in an inquiry based science laboratory course. The researcher made several assumptions during designing the course and investigating the study. The course has two different learning environments, one of them was classroom discussions, and the other one was laboratory applications. First of all, I assumed that PTs all have sufficient science and environment background to be able to complete the requirements of this course. In other words, the PTs in this study have already taken basic science course, sustainable development, and environmental course before selecting this course. It might be assumed that these courses enhance their background knowledge about SSI those were covered in this course.

The classroom discussions aimed to address the issue from multiple perspectives. The presenters tried to adequately address the benefits and harms of the issue. Another assumption in this study is that participating in those kinds of discussions engaged PTs to think about both negative and positive aspects of the issue that enhance their critical thinking skills. As before mentioned, all the discussion sessions were audio-recorded. The researcher also assumed that PTs participated in discussions as they always do in their other courses. Therefore, the classroom environments in the videos were also assumed to mirror real classroom environments. Furthermore, it was assumed that the PTs expressed and shared their ideas honestly during the study. In other words, they did not change their behaviors to please the facilitator. I also assumed that attending classroom discussions might be helpful for the PTs while developing a research question and designing their own experiments.

Each group had to develop a research question and had to test their ideas in the laboratory. I assumed that all the group members willingly participated to group meetings and actively engaged in experiment design procedure. The last and the most important assumption of this study is that engaging in an inquiry based science laboratory might give a chance to PTs to experience the ill-structured problems in real laboratory environments. It is assumed that this active involvement procedure enhanced PTs reflective judgment skills.

3.10 Delimitations of the Study

It should be proper to mention the delimitations of the study in this part. Delimitations are choices made by the researcher in order to describe the boundaries that the researcher has set for the study. This study was delimited to the classroom discussions and laboratory applications of ill-structured problems aimed at exploring students' argumentation skills and reflective judgment skills in SSI discourse.

The researcher focused on five global environmental problems in this study. After a semester long literature review, it was clear that there were a significant amount of controversial issues and they were all convenient for SSI discourse, but the aim of the study was not only discuss the controversial issues but also to conduct the experiments for each issue in the laboratory. Therefore, I checked the controversial issues whether they can be tested in the laboratory or not. I chose these five units because they were convenient to discuss the classroom and to perform issue related experiment in the laboratory.

The course was an elective science laboratory course and available for three different departments (ECE, EME, ESE) of a university. Due to the large number of potential participants in these departments, the course capacity restricted to 25 students. The researcher did not want to study with a huge sample but wanted to focus a group of volunteer students' SSI discourse skills in order to explore the issue in detail. I aimed to focus on volunteer students therefore explained the aim of the course to the students and gave explicit information about the thesis. Three students withdraw the course on add-drop weeks. Therefore, I was able to study with only volunteer students who were willingly participating in this study.

3.11 Summary

This study used qualitative research methods to explore the PTs SSI discourse skills in a semester long SSI-based inquiry science laboratory course. The course content based on ill-structured problems those address the global environmental issues. As the laboratory course is offered as an elective course, the students do not have to take the course; they attended the class because they were really interested in the course. Video recordings, laboratory manuals, and interviews were used as data source. Interviews conducted by the researcher and an additional graduate assistant and analyzed by two researchers. Laboratory manuals analyzed by six assistants, classroom discussions were analyzed by the researcher and two science professors in order to determine more sophisticated explanations regarding PTs argumentation patterns.

CHAPTER 4

4. RESULTS

Mixed data analysis method research guided the current study and the results were presented in two sections consisting of qualitative and quantitative results. Data analysis and discussion of particular findings are reported in this section. Major themes of the study are discussed in chapter 5, as is common in qualitative research. First and second research questions were qualitatively analyzed and reported. The reflective judgment skills of the participants were investigated using two instruments, PRJI and laboratory reports (including PRJI questions in written form). The second outcome variable of this study, argumentation, was examined by analyzing classroom discussions. Qualitative descriptions of the PTs argumentations and frequencies of their argumentation levels were given in terms of SSI and the levels of argumentation quality (Level 0 to 3). Third research question, seeks for the association between RJM and argumentation scores, was analyzed quantitatively by using SPSS statistical package.

4.1 Research Question 1

RQ1. What effect does an SSI based-ILC have on pre-service teachers' reflective judgment?

The Reflective Judgment Model, developed by King and Kitchener and refined over 20 years of research (King & Kitchener, 2002; Kitchener, 1983; King & Kitchener, 1994), is a framework for determining the level of reflection in participants thinking about knowledge and certainty and was one of the methods used to examine the students' way of knowing. This study attempted to answer whether PTs would attain higher levels of reflective judgment over the course of four months. The PTs' reflective judgment stages were revealed by analyzing their laboratory manuals and triangulating the manual scores with data from their semi-structured interviews. Participants' responses to each problem are transcribed as separate units.

4.1.1 Analysis of reflective judgment

Socioscientific issues were discussed in the classroom and were investigated in the laboratory through experiments. The PTs laboratory manuals were used as data source to analyze their reflective judgments. There were 20 PTs and five issues investigated in the laboratory, due to the absence of one the PTs for third experiment, ninety nine laboratory manuals were analyzed and reported in order to explore the PTs reflective judgment skills across different SSI**.** PTs' three digit score and average scores were calculated independently and represented in table format. (i.e., Table 14) The analysis steps were explained in detail in Chapter 3 (see Section 3.6). The PTs carried out and reflected on four experiments, as discussed below.

4.1.1.1 Food additives issue

Food additives were examined by five different groups with five different experiments. The PTs tested the effects of food colorings (Group-1, 2, and 3), emulsifiers and stabilizers (Group-4), sweeteners (Group-5) in the laboratory. Three groups tested the same issue (food colorings) by different experiments. This was the first time for PTs to develop a research question, design a laboratory manual, and test an ill-structured problem in this class. Table 14 summarizes the three digit scores and average scores of each PT for the food additives exercise.

Table 14 Average RJM Scores of Each PTs: Food Additives Issue

Student number	Three digit score			Average	Stage
1	5	5	6	5.2	Quasi Reflective
2	1	1	2	1.2	Pre Reflective
3	5	5	6	5.2	Quasi Reflective
4	5	5	4	4.8	Quasi Reflective
5	6	6	5	5.8	Reflective
6	5	5	4	4.8	Quasi Reflective
7	5	5	3	4.6	Quasi Reflective
8	6	6	7	6.2	Reflective
9	5	5	4	4.8	Quasi Reflective
10	3	3	2	2.8	Pre Reflective
11	5	5	4	4.8	Quasi Reflective
12	5	5	4	4.8	Quasi Reflective
13	4	4	5	4.2	Quasi Reflective
14	5	5	6	5.2	Quasi Reflective
15	1	1	4	1.6	Pre Reflective
16	1	1	2	1.2	Pre Reflective
17	6	6	7	6.2	Reflective
18	3	3	5	3.4	Pre reflective
19	3	6	5	4.3	Quasi Reflective
20	1	1	1	1	Pre reflective
Class average score				4.1	

Figure 8 shows the numbers of pre-reflective, quasi-reflective and reflective PTs in the food additives experiment. It is clear in the graphic that quasi-reflective stages were frequently observed across these experiments. Eleven of the 20 PTs fell into the quasi-reflective category; six of the PTs were pre-reflective, and three of them were in reflective category.

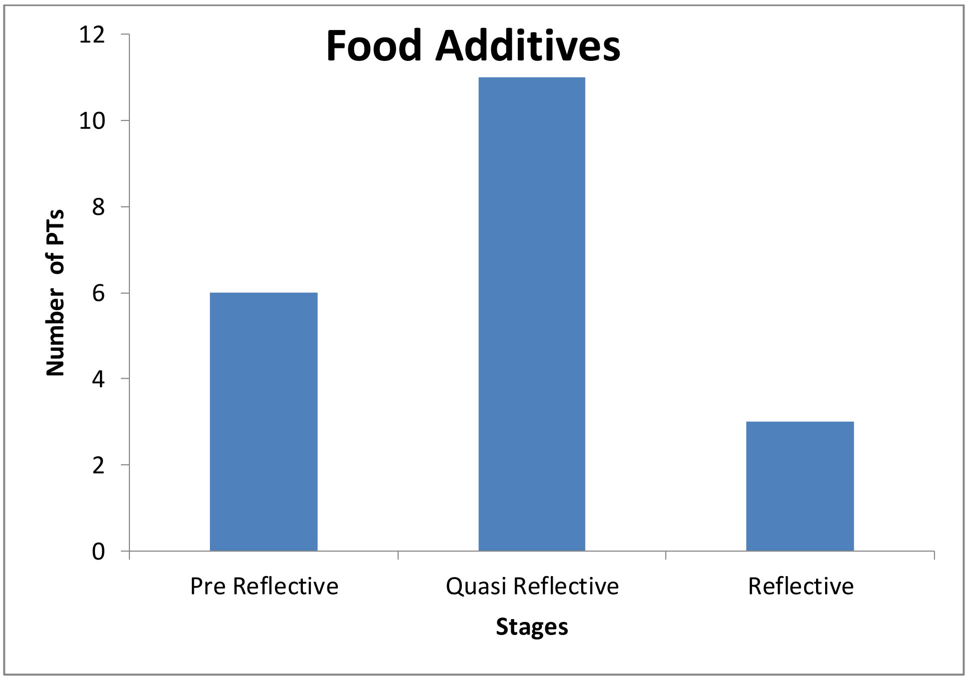

Figure 6 Numbers of Pre, Quasi, and Reflective Stages: Food Additives Issue

Figure 6 is general view of PTs RJM scores for food additive issues. As previously reported, five different groups developed five different experiments in order to analyze food additive issues in the laboratory. These groups have different RJM scores. Figure 7 shows the groups' RJM score differences for food additive issues.

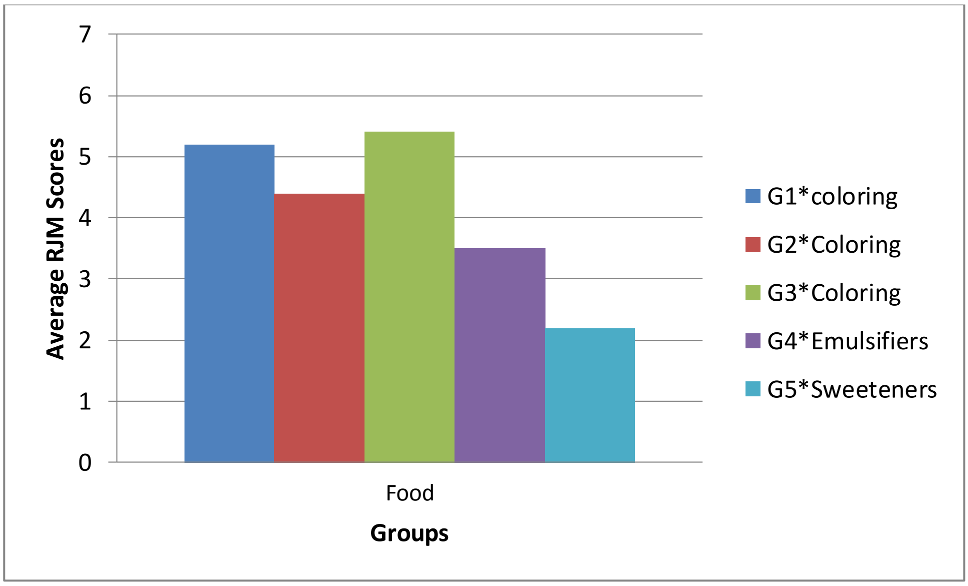

Figure 7 Average RJM Scores of Each Group: Food Additives Issue

Figure 7 shows the group differences across different food additive experiments. According to this figure the lowest RJM scores belonged to Group-5, (Average= 2.2), this group tested the effects of sweeteners in the laboratory. On the other hand, the highest RJM score belonged to Group 3 (Average=5.2), this group tested the food colorings in the laboratory. It is important to address that Group-1 and Group-2 also tested the food colorings in this laboratory by different experiments. Their average scores were 5.1 and 4.3, which were quite similar with Group-1's average score. The Group-4 average score was 3.5, they tested the effects of emulsifiers in this laboratory. To sum, PTs RJM scores showed differences across different experiment context (food colorings, emulsifiers, and sweeteners).

4.1.1.2 Alternative energy sources

Eight week of the implementation, alternative energy sources were examined. The first and the last group tested the efficiency of solar energy. The second group designed a wind turbine and examined how wind turbines work. The third group examined thermal energy, the most common energy source of Turkey. The fourth group conducted an experiment about functioning principles of hydroelectric power plants. This set of experiments on the energy issue provided the second opportunity for PTs to develop a research question, to design their own manual, and test an ill-structured problem in the laboratory. Table 15 summarizes the three digit scores and average scores of each PT for the alternative energy issue.

Table 15 Average RJM Scores of Each PTs: Alternative Energy Issue

Student number	Three digit score			Average	Stage
1	5	5	6	5.2	Quasi Reflective
2	Incomplete			0	Incomplete
3	6	6	5	5.8	Quasi Reflective
4	5	6	6	5.5	Quasi Reflective
5	5	5	5	5	Quasi Reflective
6	5	5	4	4.8	Quasi Reflective
7	5	5	6	5.2	Quasi Reflective
8	5	5	4	4.8	Quasi Reflective
9	5	5	4	4.8	Quasi Reflective
10	4	4	5	4.2	Quasi Reflective
11	2	2	1	1.8	Pre Reflective
12	5	5	4	4.8	Quasi Reflective
13	1	1	3	1.4	Pre Reflective
14	5	5	6	5.2	Quasi Reflective
15	6	6	5	5.8	Reflective
16	5	5	5	5	Quasi Reflective
17	5	5	6	5.2	Quasi Reflective
18	5	5	5	5	Quasi Reflective
19	6	6	7	6.2	Reflective
20	5	5	6	5.2	Quasi Reflective
Class Average score				4.5	

Figure 8 shows the number of pre-reflective, quasi-reflective, and reflective PTs in the alternative energy sources experiment. It is clear that quasi-reflective stages were frequently observed pattern for this week. Fifteen of the PTs fell into the quasi-reflective category, two of PTs were pre-reflective, and two of them were reflective. One of the PTs was absent this week, and her chart datum was coded as incomplete.

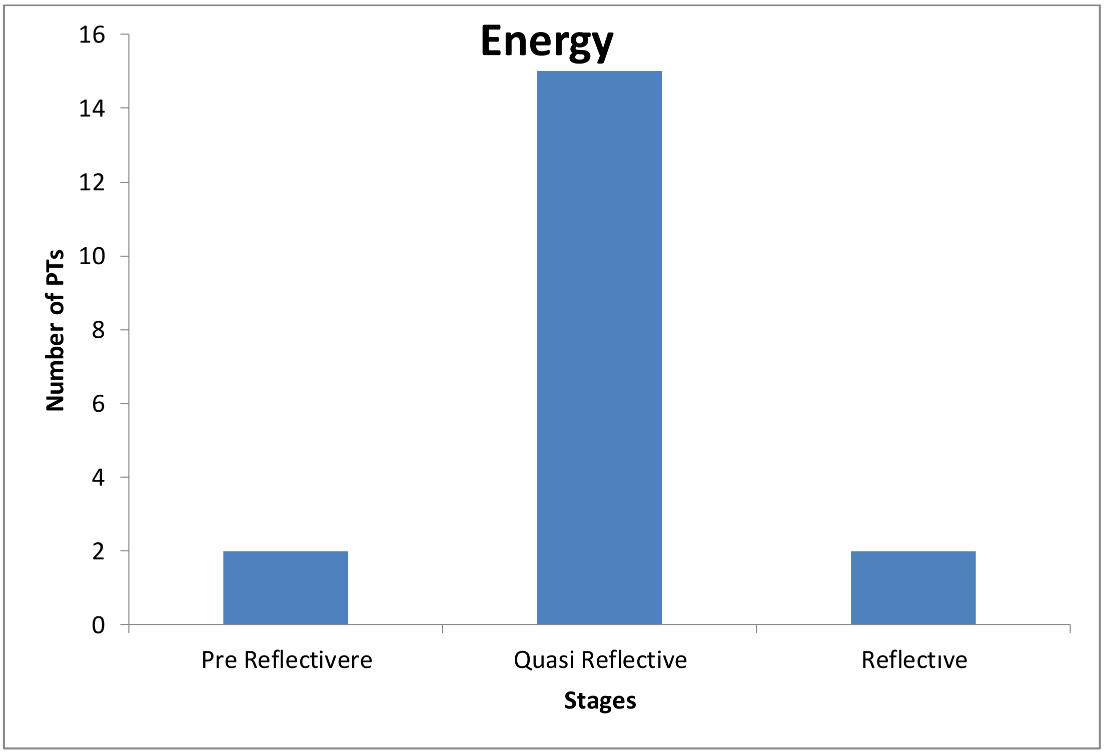

Figure 8 Numbers of Pre, Quasi, and Reflective Stages: for Energy Issue

Figure 8 is general view of PTs RJM scores for alternative energy sources. As previously reported, five different groups developed five different experiments in order to analyze alternative energy sources in the laboratory. These groups have different RJM scores. As it is clear from the Figure 8, quasi-reflective stages were dominant for this experiment. Pre-reflective and reflective stages were rare across the groups for energy issue. Figure 9 shows the groups' RJM score differences for alternative energy sources.

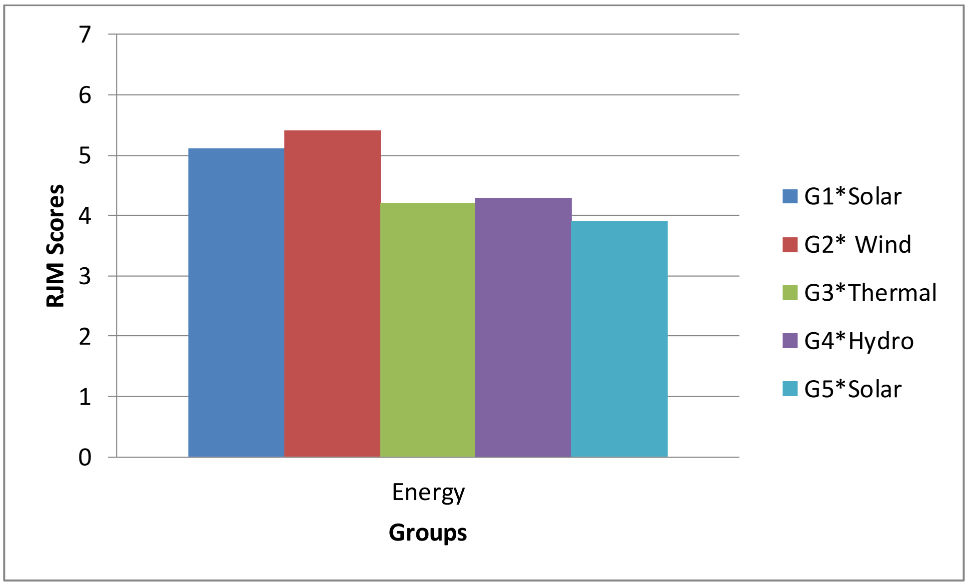

Figure 9 Average RJM Scores of Each Group: Alternative Energy Sources

Figure 9 shows the group differences across different energy sources experiments. According to this figure the lowest RJM scores belonged to Group-5, (Average= 3.9), this group tested the solar energy in the laboratory. On the other hand, the highest RJM score belonged to Group-2 (Average=5.4), this group designed a wind turbine in the laboratory and calculated the change in produced energy amount by increasing the amount of wind. Group-3 tested thermal energy (Average=4.2) while Group-4 tested the hydroelectric power plants (Average=4.3) both of the groups had similar scores for this experiment. To sum, all of the groups average scores fell into quasi-reflective stage with quite different averages ranged from 3.9 to 5.4. Comparing the groups' scores with previous experiment (food additives), only one group (group-5) showed a significant increase in average scores from 2.2 (pre-reflective) to 3.9 (quasi-reflective). Rest of the groups (group one to four) remained their stage across two experiments.

4.1.1.3 The Climate change issue

The effects of climate change were examined in this laboratory experiment. The first group designed an experiment about acid rain, the second group and the fourth group examined the effects of CO_2 in the atmosphere, the third group examined the greenhouse effect, and the last group designed an experiment to understand sea level rise and its effects to the environment. Climate change was a controversial issue for PTs. Some of them were confident that human beings have caused the recent changes in climate; however, some of them were not sure whether climate change is natural or not considering that it has happened in the past, and may now be repeating the natural warming and cooling periods. Table 16 summarizes the three digit scores and average scores of each PT for the climate change issue.

Table 16 Average RJM Scores of Each PTs: The Climate Change Issue

Student number	Three digit score			Average	Stage
1	3	4	5	3.7	Quasi Reflective
2	5	5	5	5	Quasi Reflective
3	6	6	5	5.8	Reflective
4	2	2	3	2.2	Pre reflective
5	5	5	6	5.2	Quasi Reflective
6	5	5	6	5.2	Quasi Reflective
7	5	5	5	5	Quasi Reflective
8	4	4	3	3.8	Quasi Reflective
9	5	5	6	5.2	Quasi Reflective
10	5	5	6	5.2	Quasi Reflective
11	5	5	4	4.8	Quasi Reflective
12	6	6	5	5.8	Reflective
13	5	5	5	5	Quasi Reflective
14	4	4	6	4.4	Quasi Reflective
15	5	5	4	4.8	Quasi Reflective
16	6	6	5	5.8	Reflective
17	5	5	6	5.2	Quasi Reflective
18	5	5	6	5.2	Quasi Reflective
19	6	6	5	5.8	Reflective
20	6	6	7	6.2	Reflective
Class average score				4,925	

Figure 10 shows the numbers of pre-reflective, quasi-reflective and reflective PTs for the climate change experiments. It is clear in the graphic that quasi-reflective stages were frequently observed across these experiments. Fourteen PTs fell into the quasi-reflective category, one of them was pre-reflective, and five of them were reflective.

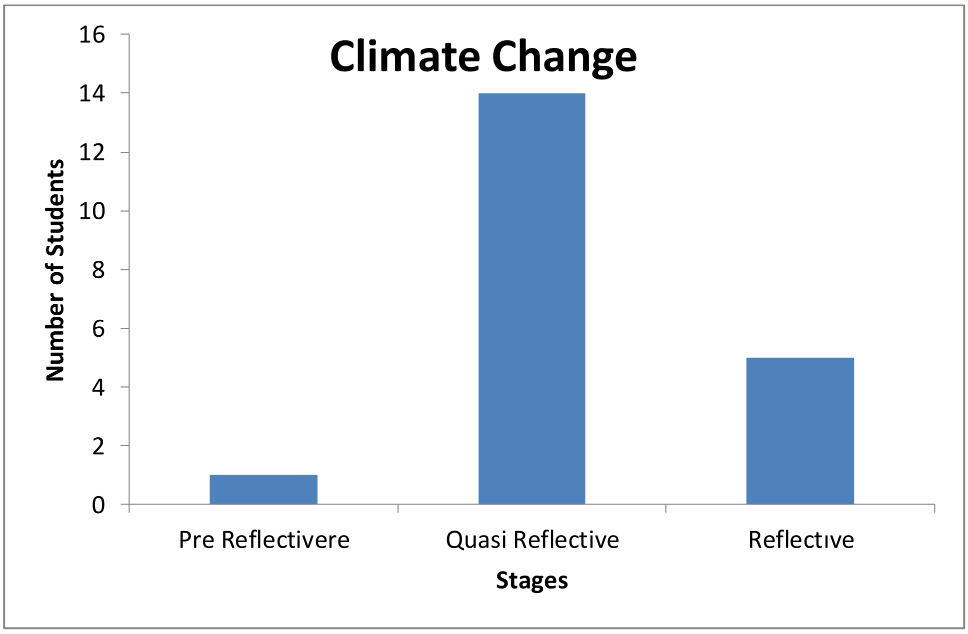

Figure 10 Numbers of Pre, Quasi and Reflective Stages: The Climate Change

Figure 10 is general view of PTs RJM scores for climate change issues. As previously reported, five different groups developed five different experiments in order to analyze CC issues in the laboratory. These groups have different RJM scores. Figure 11 shows the average RJM scores of each group for CC issues.

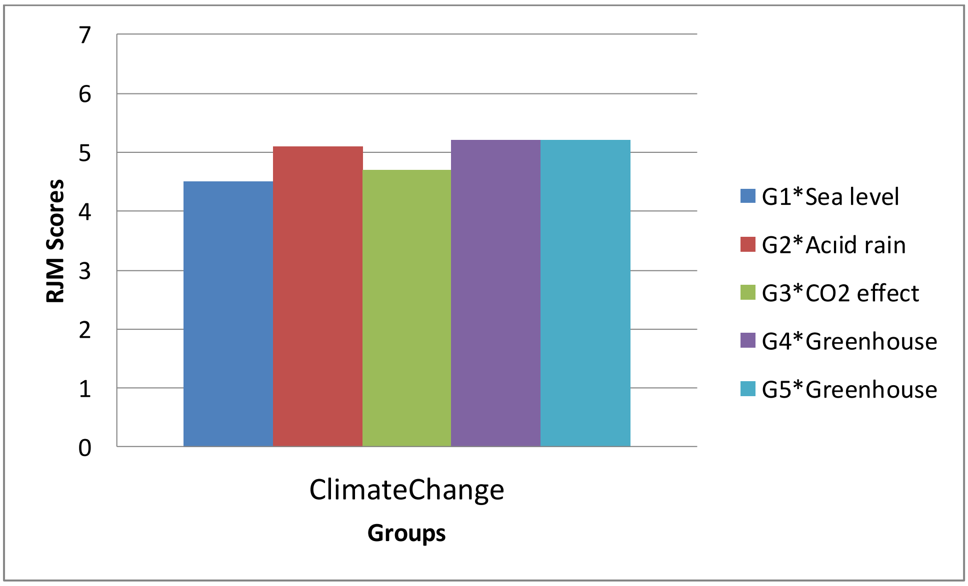

Figure 11 Average RJM Scores of Each Group: The Climate Change

Figure 11 shows the group differences across different climate change experiments. According to this figure the lowest RJM scores belonged to Group-1, (Average= 4.5), this group investigated the effects of sea level rise. On the other hand, the highest RJM score belonged to Group 4 and Group 5 (Average=5.2), these groups tested the greenhouse effect by designing different experiments in the laboratory. Group-2 tested acid rains (Average=5.1) and Group-3 tested CO_2 effect in this week. It is important to highlight that average scores across the groups are almost same for climate change issue. All groups' average scores fell into the quasi-reflective stages. To sum, PTs RJM scores were almost similar across different experiment context (acid rain, sea level rise, greenhouse gases).

4.1.1.4 The Industrial revolution

In the last experiment, the PTs examined the effects of the Industrial Revolution on people. The PTs tried to examine the effects of industrialization on society, on the daily living and working conditions of common people. The PTs designed experiments about the effects of industry on water resources and agriculture. Group-1 designed an experiment about the soil pollution occurred due to the industrialization, Group-2 worked on industrial air pollution, rest of the groups (Group-3,4,5) designed different experiments about water pollution occurred due to the industrialization. Table 17 summarizes the three digit scores and average scores of each PT for the Industrial Revolution issue.

Table 17 Average RJM Scores of Each PTs: The Industrial Revolution Issue

Student number	Three digit score			Average	Stage
1	4	4	5	4.2	Quasi Reflective
2	5	5	6	5.2	Quasi Reflective
3	5	5	6	5.2	Reflective
4	5	5	5	5	Quasi Reflective
5	5	5	5	5	Quasi Reflective
6	5	5	6	5.2	Quasi Reflective
7	6	6	5	5.8	Reflective
8	6	6	7	6.2	Reflective
9	6	6	5	5.8	Reflective
10	6	6	6	6	Reflective
11	4	4	4	4	Quasi Reflective
12	6	6	7	6.2	Reflective
13	5	5	5	5	Quasi Reflective
14	6	6	6	6	Reflective
15	5	5	6	5.2	Quasi Reflective
16	5	5	6	5.2	Quasi Reflective
17	6	6	6	6	Reflective
18	3	3	3	3	Pre Reflective
19	6	6	6	6	Reflective
20	5	5	6	5.2	Quasi Reflective
Class average score				5.27	

Figure 12 shows the numbers of pre-reflective, quasi-reflective and reflective PTs in the Industrial Revolution issue experiment. In this laboratory, the number of reflective judgment scores slightly increased. However, quasi reflective stages were still dominant. Ten PTs fell into quasi reflective category, one of them was pre-reflective, and nine of them were reflective.

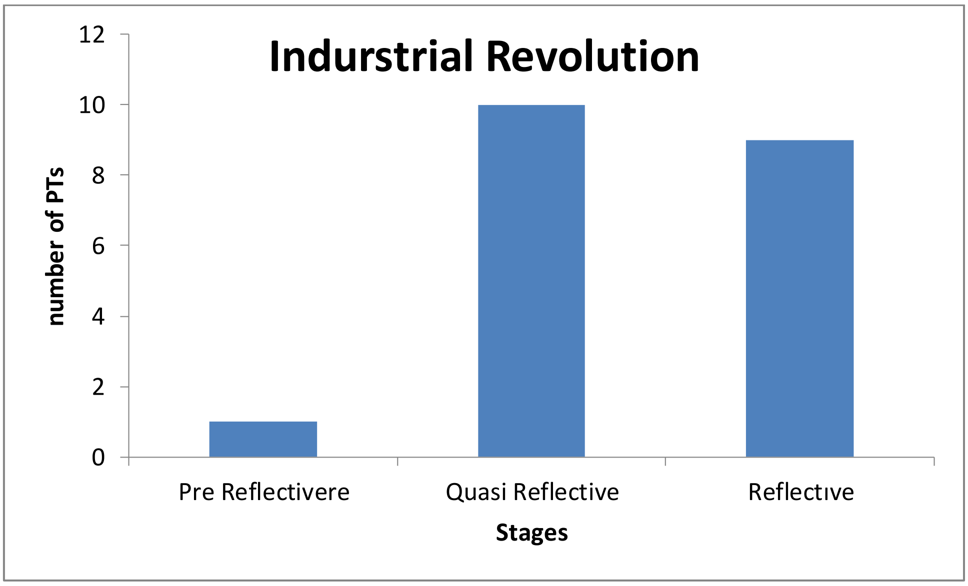

Figure 12 Numbers of Pre, Quasi and Reflective Stages: Industrial Revolution

Figure 12 is general view of PTs RJM scores for the IR issues. As previously reported, five different groups developed five different experiments (G1:soil pollution, G2:air pollution, G3-5:water pollution) in order to analyze the effects of IR issues on environment in the laboratory. These groups have different RJM scores. Figure 13 shows the groups' RJM score differences for this issue.

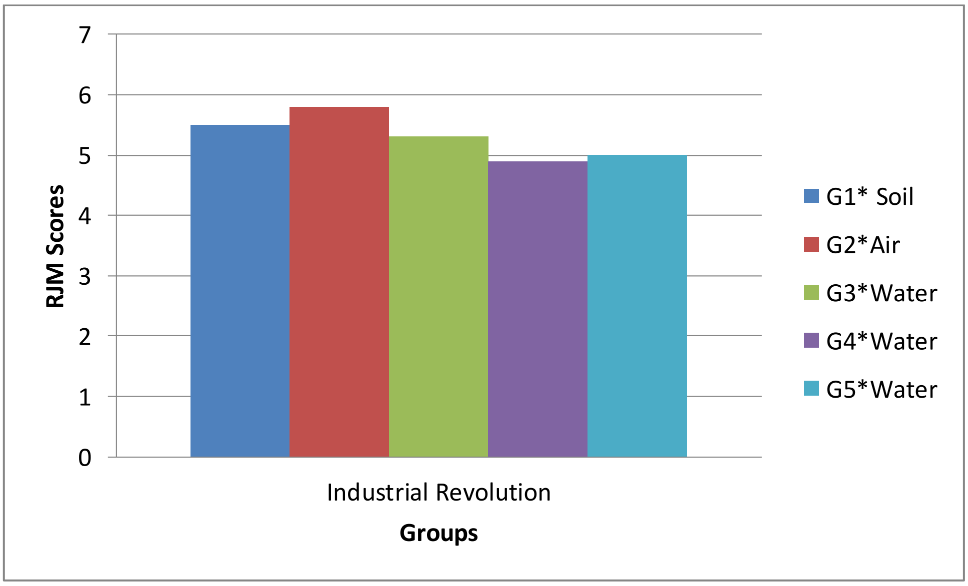

Figure 13 Average RJM Scores of Each Group: The Industrial Revolution

Figure 13 shows the group differences across different experiments regarding the effects of industrial revolution on environment. According to this figure the lowest RJM scores belonged to Group-4, (Average= 4.9), this group investigated the effects of IR on water sources. On the other hand, the highest RJM score belonged to Group-2 (Average=5.8), this group tested the effects of IR on air. Group-1 tested the effects of IR on soil (Average=5.5). Group-3 (Average=5.3) and Group-5 (Average=5.0) investigated their experiments about the effects of IR on water sources tested CO_2 effect in this week. This was the first time for some groups reached reflective stages as a group. It is important to highlight those two groups (Group-1 and Group-2) average scores fell into quasi-reflective stages for previous weeks however their average increased to reflective stages for this last experiment. Other groups' average scores remained as quasi-reflective.

To sum, the PTs developed their own experiments and reflected their judgments about ill-structured issues throughout this investigation. The PTs average scores and groups differences were summarized in previous table and figures. Numbers of pre-reflective, quasi reflective and reflective stages were summarized, it would be better to give direct quotation from PTs responses in order to exemplify how researchers decided PTs stage developments. Examples for each stage [pre-reflective (Table 18), quasi-reflective (Table 19), and reflective (Table 20)] were presented in different tables. Researchers' rationale for interpreting PTs stages were also explained in these tables.

Table 18 Examples of Reflective Judgment: Pre-reflective stage

RJM Question	Explanation	Stage	Rationale
What is your opinion about using sweetener?	I believe that sweeteners are very useful in food industry I know that it is good for the health of diabetic people	1	The student has concrete opinion for this issue. There is no alternative thought.
How did you come to hold that point of view?	My grandmother is diabetic. She uses sweetener. Her doctor recommended to her to use it. It must be healthy.	2	Source of knowledge is authority (in this case 'doctor').
On what do you base that point of view?	I read articles about aspartame and lump sugar content. Moreover, my friend made a presentation about this topic. On the other hand, I used it before, and I made observations. In the video, an expert said that 1 aspartame=25 lump sugar.	3	The student has single concrete answer. No doubt about the risks of using aspartame. based her views on personal experience of experts words.
Can you ever for sure that your position is correct?	I am sure that sweeteners good for health. Because if my grandmother uses it, her diabetes level is stabilized. If she forgets to use it her diabetes increases. So I am sure that sweeteners are beneficial. If it were not, doctors would not prescribe it.	2	In this explanation, it is clear that the student is sure about her opinions. She does not give any evidence about the issue but claims that they are useful. According to this student, authority (grandma's doctors) and observation (personal observation) are the source of knowledge.
When two people differ about matters such as this, is it the case that on opinion is right, and one is wrong?	Yes. There is right and wrong here. As I already told, my grandmother's diabetes level decrease. Using sweeteners is always healthy	1	Student has single and concrete views of knowledge. There is no alternative solution or opinions for her. Her personal experience (grandmother's case) is enough for her.

Table 19 Examples of Reflective Judgment: Quasi-reflective stage

RJM Question	Explanation	Stage	Rationale
What is your opinion about food colorings?	Foods seem enjoyable and attractive when we use food colorings. They provide fun foods. This attracts consumer. Although there are some regulations for using food colorings, different bodies may have different reactions to them. They can be dangerous,or they can cause allergic reactions.	5	She has subjective interpretation for using food colorings. She evaluates both side of the issue (attractive- allergic reactions) She is uncertain about using food colorings.
How did you come to hold that point of view?	I was working as practicing teacher in early childhood center I made this experiment. We used green and pink food coloring. …Children wanted to drink colorful milks instead of regular milk, according to this experiment; I think that food coloring is attractive. In addition to this, I do not have an exact idea if they are dangerous or not.	5	She understands that people can not know directly, but can within a context based on subjective interpretation of evidence. In here, PTs has context based subjective interpretation about using food colorings. She is uncertain about the issue. She has filtered the food coloring issue through her personal perspective. (not directly rely on authority)
On what do you base that point of view?	I suspect about this issue. Also, some researchers about food colorings don't have certain consequences. Food colorings have not only positive effects but also negative effects. But, I watched on the TV; some doctors support that food colorings are artificial, and they have a negative effect on human health over the long term. Sometimes doctors can have a bias. I do not know.	4	The PTs understand that knowledge is uncertain, and there is ambiguity. She realizes that authorities can have some bias.

Table 19 (Continued) Examples of Reflective Judgment: Quasi-reflective stage

RJM Question	Explanation	Stage	Rationale
Can you ever for sure that your position is correct?	I am not sure. I made a comment with my own experience; however, food engineer can claim that it may cause health problems, but this is also a claim that should be supported. We can not be sure whether the allergic reaction happened because of the additives or not.	5	She is aware of that she has subjective interpretation about the issue. She takes food engineers as authority, but she does not think that they are the source of right answers. She sees authorities as experts but knows that knowledge is limited by experts own perspectives.
How is it possible that people have different points of view for this issue?	This can be the result of their personal experiences. Their life conditions, priorities, profits, may affect their point of view. Some people earn money from food additives so they can support its usage.	5	She understands that this issue is contextual and that experts filter the knowledge through their personal perspective.
How is it possible that experts in the field disagree about this subject?	Some experts think about the commercial things, the others concern about health of people. According to their own benefits their ideas can differ.	4	She realizes that authority is often biased and fit the evidence to their beliefs.

Table 20 Examples of Reflective Judgment: Reflective Stage

RJM Question	Explanation	Stage	Rationale
What do you think about the climate change issue?	I think some scientist exaggerating the climate data. You know; Al Gore's Nobel prize has been cancelled because his work was ruled politically biased and containing scientific errors. But personally I experience some climate change problems, there are IPCC data. I think; the climate is changing but may be this change is a little bit exaggerating.	6	The student is aware of the problem. She evaluates the issue in both aspects. She tries to construct her knowledge by depending on variety source.
How did you come to hold that point of view?	Last week, we were responsible for presenting this issue in the classroom. Before the presentation, I was sure about the issue I mean, there is climate change and I had no suspect. But while researching the issue, I saw there are cons also.	7	Instead of relying on authority, she personally involved the issue and examined the both features, realized pro and cons of the issue.
On what do you base your point of view?	I read lots of articles; we watched national geographic documentary in class; there are lots of protocols such as Kyoto. You know the amount of CO_2 increase, sea level rise.. I mean; the nature is unbalanced know.	6	Knowledge is based on information from a variety of sources. (Articles, Documentaries, International Protocols, IPCC data, and her personal opinion)
Can you ever know for sure that your position on this issue is correct?	No, I cannot. because as we discussed in class even scientists (97 % proponents, 3 % deniers) Has diverse views.	7	She is not sure. Reflective thinkers justified their beliefs on the basis of probability, they can't know for sure, but wealth of evidence supports view

Table 20 *(Continued)* Examples of Reflective Judgment: Reflective Stage

RJM Question	Explanation	Stage	Rationale
When two people differ about matters such as this, is it the case that one opinion is right, and one is wrong?	No, I can not say. I would look at their justifications and have a conclusion.	7	She understands that there is no right and wrong answer for ill structured problems.
Can you say that one opinion is in some way better than the other?	Yes, I think proponents have better evidence than deniers. So, I can say that supporters of climate change issue have better arguments than deniers. We should take precautions but if deniers can find new evidence balances may change.	7	She is involved in constructing knowledge and is aware that knowledge changes in light of new evidence.
How is it possible that people have such different points of view about this subject?	Where, we stand affects what we see. Think about a person who lives in Tuvalu. He experience the sea level rise problem and may claim that there is climate change, but other people who live in a safe region, and read about deniers claims can conclude that there is no climate change.	7	She understands that people can not know directly, but can within a context based on subjective interpretation of evidence.
How is it possible that experts in the field disagree about this subject?	There are commercial or ideological reasons for this. Some experts earn money by denying the issue, some of them earn money by supporting the climate change issue. we see Nobel prize withdrawal because of misusing data, or we know if some experts deny the CC, industry advocates earn money.	7	She knows that the authority is often biased; they fit the evidence to their beliefs. She accept Authorities as experts in their field, but knows that their views are limited by their perspective.

4.1.2 An Overview to reflective judgment scores

To sum up, preservice teachers, enrolled in SSI based- ILC, have developed their research questions and designed their experiments to test the ill-structured issues in the laboratory. PTs' RJM scores assessments were triangulated by using two different instruments: laboratory reports and semi-structured interviews. The same PRJI questions were addressed in both tools, PTs responses to laboratory manuals were used as major data source in order to assess PTs' RJM. In addition to laboratory manuals, semi-structured interviews, conducted with a sub random sample, were used to triangulate data. Five groups' average RJM scores across four different experiments were presented in Figure 14.

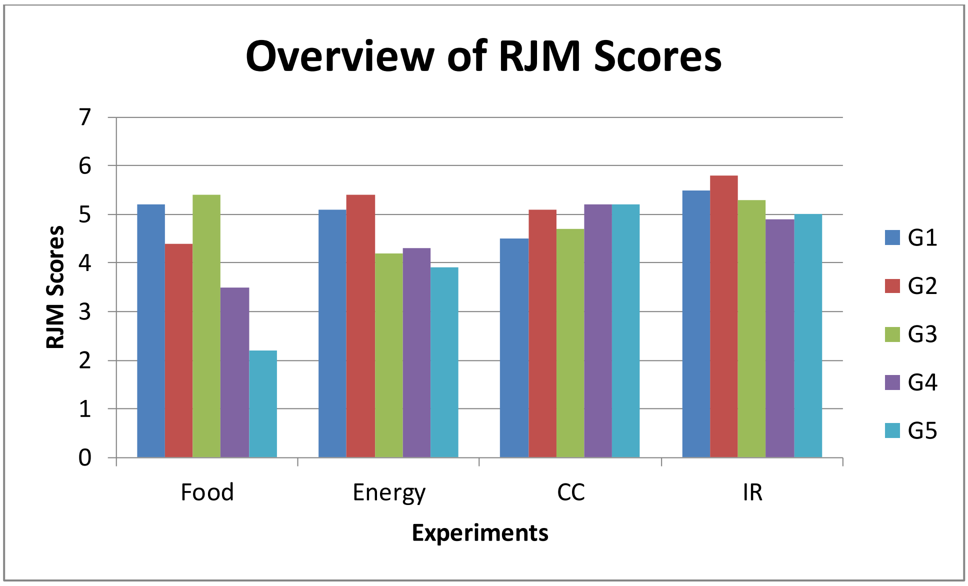

Figure 14 Average RJM Scores across the Four SSI

It is clear from the figure that quasi reflective stages were dominant across all issues. The second point emerged from the figure is groups' average RJM scores. PTs scores tended to increase from first experiment to last experiment. The most significant increase belonged to Group-5. Their average scores fell into pre-reflective stages in the first experiment, the group showed significant increase to the last experiment and fell into the quasi-reflective stage for the last two experiments. Gropu-2 has the third highest score for the first experiment. Their average score was 4.4 which was smaller than the Group-1 and Group-3's average score. However, they got the highest average (5.8) for the last experiment. By looking at the changes of the groups' average scores it is clear that they tended to increase, but in the figure it was seen that this is not true for all weeks. The decrease can be clearly seen from the average scores of Group-2 for the second and third weeks or average scores of Group-3 for the first and second week. Therefore, in addition to looking at general development from the first week to the last week experiments, it is better to be aware of the score differences across different context. These issues will be discussed in Chapter five in detail.

In addition to examining the transcripts for specific examples of reflective thought, descriptive statistics can be used to see mean differences, standard deviation and standard error of means across different experiments. Table 21 summarizes the descriptive information for PTs reflective judgment scores across different SSI.

Table 21 Descriptive Statistics for each SSI

	Mean	N	Std. Dev.	Std. Error Mean
Food additive	4.1	19	2.9	0.66
Energy	4.5	20	0	0
Climate Change	4.9	20	1.7	0.39
The Industrial Revolution	5.3	20	0.7	0.15

This descriptive information reveals the mean scores for each experiment. It is apparent that overall there is difference in the average scores from 4.1 to 5.3 from first experiment to last experiment. However, general trend were quasi-reflective across different SSI contexts for all groups. Although the class average scores are consistent and reported as quasi-reflective in these graphics, the entire group score presentations caused to lost individual differences. It was clear from the previous tables that the individual's scores for each issue varied from context to context. Fischer (1980) argued that "skills in a context" (i.e., the strength of the skill) can be variable and situational, changing as circumstances, time of day, or emotional stage changes. Therefore, it is better to be aware of the contextual differences and to check how PTs RJM scores vary across different ill-structured issues. In order to present a clear understanding for contextual differences of individuals' scores, I would like to present two PTs RJM scores, one of which has the highest average score (PT 17, average=5.7) of all experiments, the other has one of the lowest average score (PT 11, average=3.9) of all experiments. First, I presented (Figure 15) the PT-17's, who has the highest score average, RJM scores across four issue to show how RJM scores contextually varied. Second, I presented (Figure 16) the PT-11's, who has the lowest score average, RJM scores across four issue.

PT- 17 (see Figure 15) was categorized as reflective in all reports ($average_1$=6.2, $average_2$=5.2, $average_3$=5.2, $average_4$=6.0). PT-11 (see Figure 16) was categorized as pre-reflective ($average_2$=1.8) in her second report; however, her first, third and fourth reports were quasi-reflective ($average_1$=4.8, $average_3$=4.8 $average_4$=4.0). The contextual differences of PTs' RJM scores are visible in the figures below.

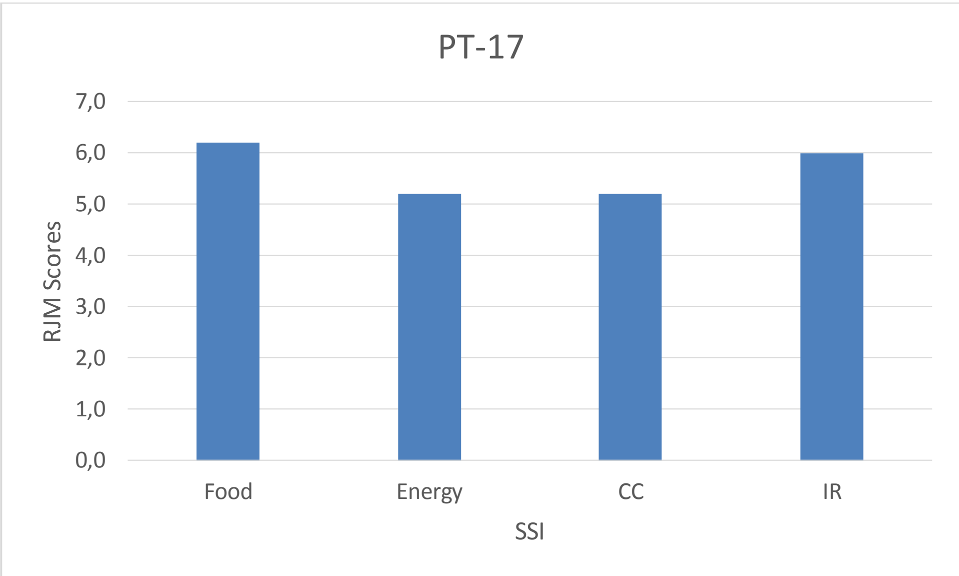

Figure 15 Contextual Differences of RJM scores (PT with the highest score)

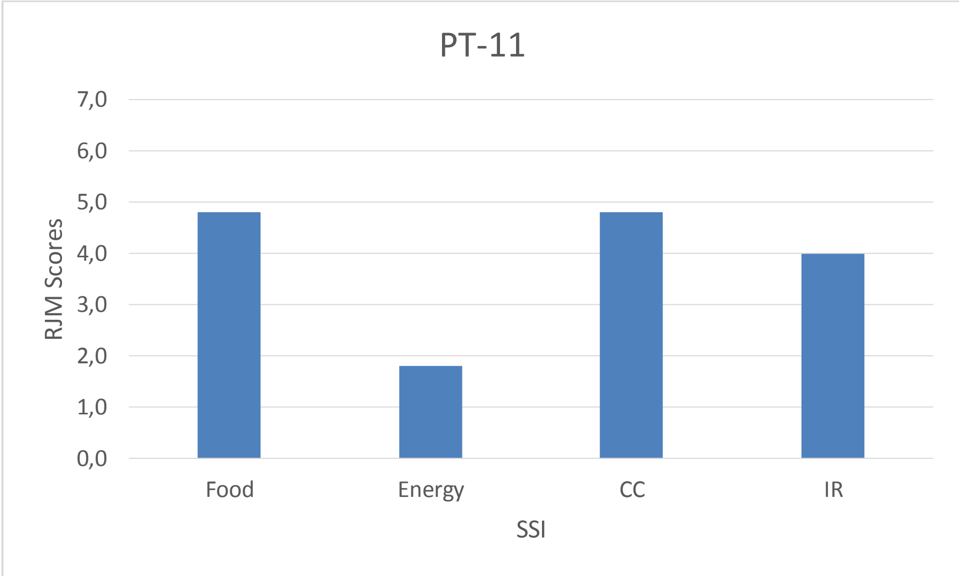

Figure 16 Contextual Differences of RJM scores (PT with the lowest score)

It is clear from the figure that PTs' reflective reasoning stages can differ from context to context. This is quite reasonable since the PTs' background knowledge about the issue or their personal interests can affect their reflective reasoning. This issue will also be addressed in chapter five in detail in the light of the related literature.

4.2 Research Question 2

RQ2. What are the argumentation skills of PTs revealed in SSI based-ILC by use of reflective judgment?

4.2.1 Analysis of Classroom Discussions

In order to assess the quality of preservice teachers' argumentation skills in the classroom discussion, Toulmin's (1958) model of argument was used. Each preservice teacher's turn (i.e., a single PT's contribution to the dialogue) was analyzed for his or her use of claims, grounds, warrants, backings, and rebuttals to support his or her claims. The researchers were interested to explore what domains of knowledge the PTs would utilize to justify and debate their position in SSI-based ILC. The grounds of the PTs for making their claims were rated for their use of evidence. The discussions lasted four hours.

There were five socioscientific issues namely, transportation issue, food additives, climate change, alternative energy, and industrial revolution issue discussed by the PTs. The levels of the PTs argumentations were described as four levels by argumentation analysis framework used in this study. The PTs' grounds for making their claims were rated for their reference to information. Some dialogue did not include a formal line of argument (i.e., claim, ground, warrant, backing, and rebuttal); the researcher did not rate these informal lines of dialogues. PTs subject matter knowledge, claims, and use of evidence to support their claims, was scored from zero to three, with three being the highest score. These levels were defined as;

Level 0: In this level, PTs did not use evidence or SMK to support their claims.

Level 1: In this level, PTs used incorrect evidence or SMK to support their claims.

Level 2: In this level, PTs used non-specific evidence or SMK to support their claims.

Level 3: For this level, PTs presented correct evidence or SMK to support their claims.

4.2.1.1 Food additives issue

The classroom presentation aimed to address both negative and positive aspects of food additives issue. Presentations summarized the history and types of food additives (i.e., food colorings, emulsifiers, sweeteners, flavorings, gelling agent, preservatives, anti-caking, antioxidants, and acidulants) advantages and disadvantages of food additives. The discussions were informal classroom discussions. Most of the PTs could construct a reason for their claims, but few PTs provided supporting evidence to back up their claims about food additives. The classroom discussions revealed that PTs have diverse opinions about using food additives. There were some PTs who were totally opponents or proponents of using food additives. However, it was difficult to assort some of the PTs as proponents or opponents of the issue. It was frequently seen throughout the discussions that individuals presented different point of views for these additives. For example, PT-

14 was a proponent of use of sweeteners whereas she was an opponent of using food colorings. Furthermore, PT-6 emphasized some advantages and disadvantages for using food colorings, and she was suspicious to have a certain decision for using food additives. She also criticized being totally for or against these additives. PT-3 was against the using food additives but supported using sweeteners because of personal experiences, her grandmother was diabetic and the doctor banned sugar to her and suggested using sweeteners. The debated issues were ill-structured issues as I discussed in previous sections. There were no clear cut solutions for these issues. Therefore, having conflicting statements about these issues and challenging views for different types of food additives were comprehensible for SSI-based discussions. These contradictions are parallel with the nature of SSI. Table 22 summarizes the number of proponents and opponents of food additives issue.

Table 22 Numbers of Proponents and Opponents: Food Additives

	Proponents	Opponents	No Response
Preservatives	10	6	4
Colorings	13	5	2
Emulsifiers	9	1	10
Sweeteners	13	4	3
(Anti-caking, antioxidants, acidulants etc.)	-	9	11

PTs constructed reasons for their claims. Proponents of using food additives presented multiple lines of reasoning during the discussion. They argued that the rapid increase in population growth forced people to find out new solutions for food dependence. Food additives are one of these alternative ways to produce cheap and durable consumer goods. Another argument of proponents was food additives enhance taste and appearance of the foods. Proponents also asserted that additives are used for several purposes including keeping food healthful until it is eaten, ensuring that the food is convenient to store. One of the participants claimed that food additives make the food healthier. She grounded her claim by saying that processed foods are higher in vitamins and lower in fat. Legislation was another basis for the arguments of proponents. They feel comfortable with the use of additives because countries are regulating their use. They addressed the use of E-numbers and the agencies like the International Division of Labor, an expert committee report on food additives. Table 23 presents PTs' pros, cons, and their frequencies for the food additives issue.

Table 23 PTs' Pros and Cons for Food Additives

Food Additives	Pros	Freq.	Cons	Freq.
	Enhance flavor	3	Allergic reactions	1
	Increase vitamin content	2	Obesity	3
	Extend shelf life	4	Hyper children	2
	Reduce nutrient loss	3	Heart attack risk.	4
	Visual appealing	5	Religion-forbidden	1
	Regulated by laws	2		

On the other hand, there are opponents of the issue, and they also stated their positions. One of the PTs rejected the use of food additives because of religious reasons; she asserted that people does not have right to change the nature of anything; she is against food additives, human cloning, gene therapy etc., believing that it is God's decision and people have no right to criticize it. There are some scientific reasons to reject the use of food additives which are; food additives cause allergic reactions, hyperactivity disorders, and cancer. Unfortunately, opponents failed to use evidence to support their claims. Most of the counter arguments were just claims and only a few of them supported their arguments by using justifications. They based their points of view on their personal experiences. For example, one of the opponents has sensitivity to aspartame; she used her personal experiences as grounds for her position. Some opponents also have some concern for the amount of additives. They claimed the numbers of laboratories and equipment for analyzing the ingredients of the foods were limited in Turkey, so regulations are not reliable.

As it is discussed in method chapter, I analyzed PTs classroom discussions about ill-structured issues by using a previous rubric developed by Walker and Zeidler (2007). The numbers of PTs' conversational turns, their use of evidence (correct or incorrect use of evidence effect their score), and use of subject matter knowledge (SMK) were analyzed and rated by the researchers. If PTs do not use evidence and do not refer to their SMK they are labeled as level zero arguments. There were 15 conversational turns rated as level zero arguments for food additive issues. If PTs use evidence which is incorrect they are labeled as level-1 arguments even the evidence is incorrect. For this experiment, 23 conversational turns were labeled as level-1. Furthermore, if they use non-specific evidence for their arguments and use non-specific SMK they are labeled as level-2, 38 turns in food additive discussions labeled as level-2 arguments. Finally, if PTs use correct evidence or SMK they are labeled as level-3 arguments. For food additive issues, 99 of 290 conversational turns were labeled as level-3 argument.

It is better to highlight that although the discussion hours lasted approximately four hours, the discussions did not always include formal line of arguments. The PTs act naturally during the discussions; therefore some of the conversations were not aligned with the debated issue or did not include a formal line of argument (data, claim, backing). These kinds of conversations were not rated by the researcher and reported as "not rated" conversations. Table 24 summarizes the number of level-0 to level-3 arguments of PTs revealed in classroom discussions.

Table 24 PTs' Levels of Argumentation: Food Additives

PTs	Level 0	Level 1	Level 2	Level 3	Final Position
PT-1	0	0	5	4	Level 2
PT-2	3	5	2	0	Level 1
PT-3	0	0	5	3	Level 2
PT-4	0	0	3	5	Level 3
PT-5	0	0	1	9	Level 3
PT-6	0	0	5	5	Level 3
PT-7	0	0	5	4	Level 2
PT-8	0	0	1	12	Level 3
PT-9	0	0	1	10	Level 3
PT-10	5	1	1	0	Level 1
PT-11	0	0	1	10	Level 3
PT-12	0	0	1	10	Level 3
PT-13	0	0	1	8	Level 3
PT-14	0	0	3	5	Level 3
PT-15	2	3	0	0	Level 1
PT-16	1	5	0	0	Level 1
PT-17	0	0	1	10	Level 3
PT-18	3	4	0	0	Level 1
PT-19	0	2	2	4	Level 3
PT-20	1	3	0	0	Level 1
Total	15	23	38	99	

*Level 0, no evidence or SMK
*Level 1, incorrect evidence or SMK
*Level 2, non-specific evidence or SMK
*Level 3, correct evidence or SMK

Table 25 is a summary of PTs rubric rated conversational turns. All of the PTs attended food additive discussions. The discussion lasted four hours. Presenters (PT-3, 10, 14, and PT-19) were responsible to lead the discussion, they organized the power point presentation for food additives issue and presented it in the classroom. The researcher also guided the discussion hours. 115 out of 290 dialogues were not rated. These “not rated” turns include; presenters’ probing questions, researcher’s leading questions, and some of the informal conversations between PTs’. Table 25 summarizes the numbers of rubric rated conversational turns and also gives the numbers of ‘not rated’ conversations for food additive issue.

Table 25 Numbers of Rubric-rated Conversational Turns: Food Additives.

Group	Level 0	Level 1	Level 2	Level 3	Not Rated	Total (N
Proponents	10	12	21	48	68	159
Opponents	5	11	17	51	47	131
Total	15	23	38	99	115	290

In total, there were 290 conversational turns in food additive debates. All participants attended the food additive discussion. Researchers rated each student’s contribution to the discussion. PTs food additive discussions were transcribed in verbatim. Bearing it in mind, 290 lines of dialogue were analyzed for this issue. Table 26 examples of PTs’ reasoning on food additives issue. The researcher aimed to give examples of Level-0, Level-1, Level-2 and Level-3 argumentations for food additives issue. Direct quotations from PTs’ explanations, their argumentation categories and researchers rationale for rating those PTs as Level-0 or Level-3 was explained in the table. The frequency of each level, out of 290 turn, was also given.

Table 26 Examples of Rubric-rated Conversational Turns: Food Additives.

Level	Excerpts	Argument Category	Researcher's Rationale	Freq.
0	People no right to change the nature of anything, even foods.	Personal opinion.	The statement includes no evidence claims or SMK.	15
1	They [processed food] lost their nutritional value. For example, experts warn people `don't use a knife for your vegetables use your hands to make them small`. This explains everything, even knife reduces the nutritional value; additives do much more.	Claim (foods lost nutritional value) Ground (knife reduces the nutritional value, then food additives must reduce)	The student makes incorrect interpretation; her lines of reasoning are not correct. Because; vitamins and minerals are added to many processed foods such as milk, flour, cereal and margarine to make up for those likely to be lacking in a person's diet or lost in processing.	23
2	They [additives] put too many chemicals into your body which should not be there.	Claim (additives includes chemicals) Ground (chemicals should not be taken into body)	Student has a claim and ground; however, she lacks giving a particular example and evidence to her claim.	38
3	.. if the amount of additives are regulated, they provide enhanced vitamin's and minerals (enhanced dairy products); improves taste and appearance of the foods (colorful and attractive pastries). prevents bacteria growth (longer shelf life); provides flavor enhancement (fructose corn syrup). My only concern is the excess amount of additives	Claim (enhance flavor, improve taste and appearance, prevents bacteria growth). Ground (dairy products), warrant (longer shelf life). Backing (concern for the excess amount).	The student's considerations of evidence are correct. She use correct evidence to support her claims and she makes multiple lines of reasoning (not only focus on taste an appearance but also shelf life, she also realize the danger for excess amount of the additives)	99

4.2.1.2 Alternative energy sources

In the eighth week, alternative energy sources were discussed. Group-2 was responsible for reviewing the articles, magazines, and news for this issue. There are lots of energy sources but the PTs had only four hours to discuss the issue. Therefore, selected energy sources were discussed during the presentation. Presentation covers nuclear, hydroelectric, geothermal, wind, and solar energy sources. Advantages and disadvantages of each source were addressed during the discussion. PTs presented different point of views for the energy issue. during the discussion, PTs were opponents for one energy source on the other hand s/he was proponents for another source, there were some PTs (balanced views) who have both negative and positive thoughts about each source and can not support or opposition any type of source. Table 27 summarizes the numbers of PTs who are opponents, proponents or neither of two (balanced views) for each energy source discussed in the classroom.

Table 27 Numbers of Proponents and Opponents of Alternative Energy Sources

Types of Energy	Proponents	Opponents	Balanced views	No Response
Nuclear energy	1	1	5	13
Hydroelectric	0	10	1	9
Geothermal	4	5	3	8
Wind	3	8	1	8
Solar	7	2	1	10

During the discussion, PTs were aware of that many alternative sources of energy are still being researched. Technologies are continually being developed to improve energy sources. The PTs compared the sources whether they are renewable or not, what is their set up and ongoing operation costs, what size of energy storage is needed, and what impact will they have on the environment. They discussed the limited amounts of fossil fuels, increase in the amount of greenhouse gases because of burning of fossil fuels, and rapid change in climate.

For nuclear energy, the PTs were not sure about the safety of this source. PT-2, 17, 9, 5, and PT-20 were highly interested in this issue and provided multiple perspectives for this issue. It was not possible to label these PTs for or against the nuclear energy; they just aimed to evaluate the negative and positive effects of nuclear energy sources in a critical way, therefore, the researcher categorized them as balanced view PTs. They challenged their peers' opinions; the discussion was fruitful for the PTs to understand others' points of view and gave them a chance to reevaluate their opinions. These five PTs did not take a certain position but just discussed the issue, for example, student 2 compared the energy gained from the same amount of burning coal and uranium, and she claimed that the nuclear energy is the cleanest and cheapest way. On the other hand, she criticized the government policy on constructing nuclear power plants. She stated her concern about the Chernobyl disaster, how close it is to Turkey (Black Sea region), and she called attention to the number of people who died from thyroid cancer because of the explosion and fire (large quantities of radioactive particles were released into the atmosphere) which spread over much of the northeast of Turkey. In sum, the PTs have very little implicit faith in nuclear energy; therefore, they critically evaluated the issue. PT-3 was the only one who is totally against nuclear energy, and PT-7 was the only one who is for nuclear energy. The remaining of the PTs was not sure about the usage of nuclear energy and hold balanced views about it.

For hydroelectric energy, the most common energy source of Turkey, most of the PTs were against them. These plants are common in Black-sea region of Turkey, one of the PTs who is from Rize (a City in Black sea region) experienced the hydroelectric power plant construction from beginning to the end. She was opponents of these plants. She claimed that in order to construct a hydroelectric power plant, they cut thousands of trees, the endemic plants were affected some of them endangered, natural water sources were restricted, and people had to face water deficiency. On the other hand, there was a PT who has balanced views about HEPs' pointed out there is no waste, it is cheap to construct a HEP, and at the end there is high efficient energy production.

The discussion continued with geothermal, wind, and solar energy sources. There were proponents and opponents of these energy sources too. PTs' pros and cons for these sources were summarized in Table 28. They generally compared each energy source with a previously discussed source; they discussed the cost of each source, the amount of energy, waste, and risks of these sources.

Table 28 PTs' Pros and Cons for Alternative Energy Sources

Types of Energy	Pros	Freq.	Cons	Freq.
Nuclear	lower greenhouse gases	5	high known risk (Chernobyl disaster)	6
	low operating cost	4	target for terrorism	5
	large power generating	6	nuclear waste	4
Hydroelectric	Proper for black sea region	1	Environmental damage (cut tree, disrupt the natural flow of rivers)	8
	Reliable & stable	1	Caused drought.	5
	high efficiency	3		
	low cost	4		
	no waste.	1		
Geothermal	proper for Aegean region	6	Expensive to build	3
	no product of combustion	2	can not be transported	4
	natural source	5	superheated water can be dangerous	5
	not only heating but also cooling	1	location specific	3
Wind	Proper for Aegean region	4	Noisy	2
	operational cost low	2	disrupts migratory birds	4
	no waste	5	unpredictable	8
	natural	3	location specific	7
Solar	Proper for Mediterranean region	5	Unpredictable	7
	natural	7	not proper for nights	4
	no pollution,	6	visual pollution (solar cells on every roof)	3
	no need to extra space.	8		

The researchers rated the PTs' use of evidence, evaluating alternative views, and critical reasoning for each energy source. Table 29 summarizes the number of level-0 to level-3 arguments of PTs revealed in classroom discussions.

Table 29 PTs' Levels of Argumentation: Alternative Energy

PTs	Level 0	Level 1	Level 2	Level 3	Final Position
PT-1	2	1	4	7	Level 3
PT-2	0	0	1	8	Level 3
PT-3	0	1	10	6	Level 2
PT-4	4	1	1	5	Level 3
PT-5	1	0	5	9	Level 3
PT-6	4	3	0	6	Level 3
PT-7	3	2	4	4	Level 3
PT-8	2	1	5	2	Level 2
PT-9	3	1	4	6	Level 3
PT-10	4	2	3	4	Level 3
PT-11	8	6	0	1	Level 1
PT-12	3	2	5	1	Level 2
PT-13	5	1	4	6	Level 3
PT-14	2	3	0	5	Level 3
PT-15	3	3	6	2	Level 2
PT-16	3	6	0	5	Level 1
PT-17	2	1	10	3	Level 2
PT-18	4	1	6	2	Level 3
PT-19	2	2	3	8	Level 3
PT-20	1	1	3	7	Level 3
Total	56	38	74	97	

*Level 0, no evidence or SMK
*Level 1, incorrect evidence or SMK
*Level 2, non-specific evidence or SMK
*Level 3, correct evidence or SMK

Table 30 is a summary of PTs rubric rated conversational turns. All of the PTs attended alternative energy sources discussions. The discussion lasted four hours. The table includes four "not rated" preservice teachers. These PTs were responsible to lead the discussion, they organized the power point presentation for alternative energy sources and presented it in the classroom. Presenters (PT-12, 13, 15, and PT-18) and the researcher guided the discussion hours. 115 out of 380 dialogues were not rated. These “not rated” turns include; presenters’ probing questions, researcher’s leading questions, and some of the informal conversations between PTs’. Table 30 summarizes the numbers of rubric rated conversational turns and also gives the numbers of ‘not rated’ conversations for food additive issue.

Table 30 Numbers of Rubric-rated Conversational Turns: Alternative Energy

Group	Level 0	Level 1	Level 2	Level 3	Not Rated	Total (N)
Proponents	27	25	54	61	17	184
Opponents	29	13	20	36	98	196
Total	56	38	74	97	115	380

In total, there were 380 conversational turns in energy week. Numbers of conversational turns for energy issue were higher than the previous issue (food additives, 290 turns). PTs were familiar with energy issue since the issue is hot debated in Turkey, PTs were sensitive to this issue due to governments energy politics, the effects of HEPs’ on cities, PTs personal experiences (people died from cancer due to Chernobyl) on the effects of nuclear power plants and etc. The increase in SMK and the increase in personal experiences of the issue may cause the increase of PTs participation to the discussions. All participants attended the discussion hours. As previously indicated, classroom discussions does not always include a formal line of argument, sometimes informal conversations may happen. The researcher did not rate these informal conversations and reported the amount of those “not rated” turns in previous table. Table 31 presents some examples of the PTs’ reasoning on alternative energy issue. The frequencies of each level (out of 380 turns) and direct quotations from PTs conversational turns were reported in the table.

Table 31 Examples of Rubric-rated Conversational Turns: Alternative Energy

Level	Transcript dialogue	Argument Category	Researcher's Rationale	Freq.
0	Other countries use nuclear energy so we can use also.	Personal opinion.	The student did not use any subject matter knowledge or did not make any cost-product evaluation or etc.	56
1	I experienced Chernobyl disaster; my family members suffered from cancer my uncle died because of it. I against the use of nuclear power plant. It makes people die.	Claim (nuclear plants kill people) evidence (her uncles death)	The student makes over generalization, her personal experience affects her decision, has the limited SMK about nuclear plants she uses personal experience as evidence to her claim, which is fallacious reasoning.	38
2	In general, developing countries are dependent to developed countries for energy. We live in a global world so we can not be totally independent.	Claim (totally independence is not possible) Ground (developing countries are dependent to developed countries, globalization is the reason)	Student has a claim and ground ; however, she lacks giving a specific example and evidence to her claim.	74
3	Nuclear plants emit fewer greenhouse gases during electricity generation than coal or other traditional power plants. (no sulfur, no carbon dioxide). We need predictable energy sources. Wind or solar energy are not stable; geothermal are location specific so the most efficient [energy source] is nuclear energy.	Claim (most efficient source is nuclear) backing (limitations of other energy sources) Claim (fewer greenhouse gas) Evidence (no sulfur, no carbon dioxide)	Student has sufficient SMK about the issue, compare and contrast alternative energy sources and use correct evidence to support her claims	97

4.2.1.3 The Climate change issue

The PTs discussed the climate change issue on tenth week of the investigation. The aim of the discussion was to deepen PTs' understanding of disputes over climate change and the human contribution to it. The question was: Is climate change man-made? Group-3 presented the issue by addressing the both side of the issue. The presenters' aim was to allow their peers to form their own judgments based on the best available information. The CC issue has been discussed in many articles, news, and blogs and there are diverse views about the issue. During the classroom discussions, the PTs also presented diverse views about the issue. 3 PTs, out of 20, claimed that CC is not real, and defended their positions. On the other hand, majority of the PTs, 14 out of 20, were proponents of the issue and claimed that CC is real. Table 32 presents the number of PTs who are against or for, and also who gave no response to CC issue during the discussions.

Table 32 Numbers of Proponents and Opponents of Climate Change Issue.

	Proponents	Opponents	No response
CC is real	14	3	3

PTs were familiar with the climate change issue. The PTs started to discuss the rapid changes in temperature that they observed in daily life. At the beginning of the discussion, most of the PTs agreed that climate change is real, and that we have to take precautions for that. However, the discussion was not solely focused on accepters of climate change. There were a few PTs (three of 20 PTs) who were deniers of climate change. Although deniers were outnumbered, these PTs dominated the classroom discussion. Pros, cons and their frequencies can be seen in Table 33.

Table 33 PTs' Pros and Cons for Climate Change Issue

Climate Change	Pros	Freq.	Cons	Freq.
	Increase in greenhouse gases	2	Historical climatic swings	3
	Sea Level Rise	5	No change in the long term.	2
	Drought	3	Natural cycles of warm and cold periods.	3
	Glacier melting	4	Presented graphs are computer models – not proven	3
	Changes in river flow	5		
	Temperature changes	7		
	Altering local climate	2	.	

Most of the PTs (14 out of 20) agreed that climate change is real, and that it has been caused by human beings. The major causes were asserted as greenhouse gases. They used the increase in temperature for the last 50 years as evidence for their claims. They claimed that the higher the concentration of greenhouse gases, like carbon dioxide in the atmosphere, the more heat energy is being reflected back to the Earth. The Intergovernmental Panel on Climate Change (IPCC) graphics were used as a data source. Sea level rise was used to support their claims. Changes in river flow and winter air temperature, as well as changes in the local climate were other aspects of climate change discussed in the classroom. PTs referred to IPCC and the ESA reports.

On the other hand, opponents argued that we should look at the long term values for CO_2 and temperature and that graphics have not shown any significant change in the long term rate of increase in global temperatures. Opponents also argued that proponents use computer prediction models; these are not proven facts. Climate change deniers highlighted that there are historical recorded climatic swings; therefore, it is normal to experience some changes, but we should keep in mind that the earth goes through natural cycles of warm and cold periods. PTs use of evidence and SMK, their levels of argumentation from zero to three, and the numbers of "not rated" conversations for climate change issue were reported in Table 34.

Table 34 PTs' Levels of Argumentation: The Climate Change

PTs	Level 0	Level 1	Level 2	Level 3	Final Position
PT-1					Missed
PT-2	0	2	6	2	Level 2
PT-3	0	1	1	5	Level 3
PT-4	2	4	0	0	Level 1
PT-5	0	1	4	3	Level 2
PT-6	1	1	3	0	Level 2
PT-7	1	0	3	4	Level 3
PT-8	4	3	0	2	Level 0
PT-9	0	2	5	0	Level 2
PT-10	0	0	4	2	Level 2
PT-11	0	1	4	5	Level 3
PT-12	0	1	4	7	Level 3
PT-13	0	1	3	6	Level 3
PT-14	2	0	3	2	Level 2
PT-15	3	4	3	1	Level 1
PT-16	0	0	4	4	Level 3
PT-17	0	1	5	0	Level 2
PT-18	0	0	5	5	Level 3
PT-19	1	0	1	7	Level 3
PT-20	0	0	1	6	Level 3
Total	14	22	59	61	

*Level 0, no evidence or SMK
*Level 1, incorrect evidence or SMK
*Level 2, non-specific evidence or SMK
*Level 3, correct evidence or SMK

Table 35 is a summary of PTs rubric rated conversational turns. One of the PTs (PT-1) was absent in climate change discussion, rest of them (19 PTs) attended the classroom. The discussion lasted almost four hours. The table includes four "not rated" preservice teachers who were presenters of the issue and one absent PT for climate change discussion. The four PTs were responsible to lead the discussion, they organized the power point presentation for food additives issue and presented it in the classroom. Presenters (PT-4, 6, 9, and PT-17) and the researcher guided the discussion hours. 41, out of 197 dialogues were not rated. These "not rated" turns include; presenters' probing questions, researcher's leading questions, and some of the informal conversations between PTs'. Table 35 summarizes the numbers of rubric rated conversational turns and also gives the numbers of 'not rated' conversations for climate change issue.

Table 35 Numbers of Rubric-rated Conversational Turns: The Climate Change.

Group	Level 0	Level 1	Level 2	Level 3	Not Rated	Total (N
Proponents	10	15	45	30	23	123
Opponents	4	7	14	31	18	74
Total	14	22	59	61	41	197

In total, there were 197 conversational turns in climate change week. The whole participants attended class hours, and all of them contributed to the discussion. There were three PTs (3, 12, 18) that accounted for the majority of the student dialogue. These PTs took different positions relative to the climate change issue from time to time during the discussion. They challenged their peers' view. Although the opponents were outnumbered, they presented level-3 argumentation. They had adequate subject matter knowledge and grounded their positions using accurate evidence. There were some informal conversations (41 out of 197 conversation turns) during the discussion which were not rated by the researcher.

Examples of each level, from zero to three, argumentation for climate change issue was presented in Table 36. The frequencies of each level were also presented. PTs ways of reasoning on climate change issue can be seen from direct quotations in table.

Table 36 Examples of Rubric-rated Conversational Turns: The Climate Change.

Level	Transcript dialogue	Argument Category	Researcher's Rationale	Freq.
0	How can deodorant affect the climate? I do not believe that there is a relationship.	No evidence and SMK	The student does not know a conventional deodorant has triclosan, parabens and formaldehyde. These chemicals have bad side effects for the environment.	14
1	If the ozone hole is maximum in polar region, maximum CC must occur in that region, but we know, people live in Equator region much more suffer from it [Climate Change]. Isn`t it a contradiction?	Claim (CC must occur in the polar region). Evidence (ozone hole is maximum in polar region)	The student has limited subject matter knowledge about the ozone hole and its effects on the earth. She develops fallacious reasoning. incorrect use of evidence makes the issue confusing for her.	22
2	These are expected scenarios (computer prediction for CO_2 level) we can block rapid increase, as a result, it is up to you to ignore it [CC] or regulate.	Claim (we can block rapid increase)	The student has a claim,but there is no specific evidence to support his claim. His SMK about CC let him make a claim about blocking excess amount of CO_2 releasing will have positive affect to regulate CC.	59
3	We can see the CC on NASA photographs, surface area of Arctic sea ice has declined rapidly over the last several decades. Where does ice goes? Melting! Unsurprisingly, sea level rise.	Claim (arctic ice melting) Evidence (decline in arctic sea ice) Warrant (sea level rise)	Student has sufficient SMK about CC; she develops multiple reasoning.	61

4.2.1.4 The Industrial revolution

The industrial revolution was the last but not the least issue. PTs became familiar with the developments in the food sector, the alternative energy sources, and the climate change issue in previous weeks. Discussing the effects of the revolution on society gave a broader perspective to PTs about these issues due to the direct relationship between the Industrial Revolution and current socio-scientific issues (mobile phones, air pollution due to transportation, burning fossil fuels, releasing greenhouse gases, genetically modified foods). Undoubtedly, the revolution was major turning point in history; almost every aspect of daily life was influenced.

Four PTs were responsible for summarizing the Industrial Revolution issue, and to address both negative and positive effects of the revolution on society. There were significant numbers of pros and cons that were highlighted during the discussion; however, none of the groups (proponents and opponents of the issue) insisted on their position. At the end of the discussion, PTs’ statements converged to a general conclusion that the Industrial Revolution was a neutral thing as the bad things and the good things cancel each other out. Table 37 is a summary of the numbers of opponents, proponents and balanced views PTs for Industrialization issue.

Table 37 Numbers of Proponents and Opponents: The Industrial Revolution

The Industrial Revolution	Proponents	Opponents	Balanced views	No response
Initial Position	5	7	2	6
Final Position	0	0	17	3

The PTs started to discuss the history of the industrialization and the effects of it on life conditions. Five of the 20 PTs were proponents of the issue; on the other hand, seven of them were opponents. Both groups supported their positions from multiple perspectives. There were two PTs who declined to take a position (proponents or opponents) and challenged their peers’ opinions. These two PTs were labeled as balanced views. Pros and cons were presented by PTs in the classroom for the Industrial Revolution issue can be seen in Table 38.

Table 38 PTs' Pros and Cons for Industrial Revolution Issue

The Industrial Revolution	Pros	Freq.	Cons	Freq.
	New job opportunity	4	Child labor.	3
	Higher standards of living	3	Rapid increase in population- food crisis.	2
	Railways- faster travels	3	Air pollution.	4
	Output capacity of industry increased	5	Qualified workers replaced by the machines.	2
	Cheaper food & clothes	4	Conspicuous consumption, raw material shortage.	1
	Immigrate to major cities to find a job	5	Population explosion in major cities- (slum)	3
	Chemical fertilizers enhanced food capacity	3	Chemicals destroy the soil	2
	Women at work	4	Women were paid less.	1

Proponents of industrialization asserted that after the revolution, people found opportunities for specialized jobs. Especially women started to work at factories, which led eventually to their economic freedom. However, opponents objected to this and asserted that, after the revolution, the need for a large workforce was unnecessary since machines are capable of doing things in half the time. Women also started to work with inadequate wages. The opponents supported that the revolution increased life conditions, diversity of foods increased, transportation (ship, automobiles, and trains) and communication improved. On the contrary, opponents asserted that the easy life conditions caused the rapid increase in population, which caused a food crisis, forcing people to find new ways to produce food (i.e., genetically modified foods) which contributed to worldwide obesity and health problems. Table 39 summarizes the pros and cons for the Industrial Revolution. It is clear that the revolution has both negative and positive effects on social life. Towards to the end of the discussion the PTs accepted its undeniable contribution to human life, but felt that at the same time it leads to the development of numerous environmental hazards. PTs referred to previous discussions about food additives, the energy issue, and climate change in order to support their claims. Logical connections between these issues arose during the discussions. PTs SMK and use of evidence (rubric-rated conversational turns) are listed in Table 39.

Table 39 PTs' Levels of Argumentation: The Industrial Revolution

PTs	Level 0	Level 1	Level 2	Level 3	Final Position
PT-1	2	7	1	2	Level 1
PT-2	1	4	4	1	Level 2
PT-3	1	3	4	2	Level 2
PT-4	2	5	0	2	Level 1
PT-5	0	1	2	5	Level 3
PT-6	1	4	0	3	Level 1
PT-7	0	0	2	4	Level 3
PT-8	0	0	1	6	Level 3
PT-9	0	0	6	3	Level 2
PT-10	0	0	2	6	Level 3
PT-11	0	1	5	1	Level 2
PT-12	0	0	1	4	Level 3
PT-13	0	0	4	3	Level 2
PT-14	0	0	2	5	Level 3
PT-15	1	3	0	2	Level 1
PT-16	1	5	0	1	Level 1
PT-17	0	0	2	7	Level 3
PT-18	4	4	0	0	Level 2
PT-19	0	0	1	8	Level 3
PT-20	0	0	4	6	Level 3
Total	13	37	41	71	

*Level 0, no evidence or SMK
*Level 1, incorrect evidence or SMK
*Level 2, non-specific evidence or SMK
*Level 3, correct evidence or SMK

Table 39 is a summary of PTs rubric rated conversational turns. All of the PTs attended industrial revolution discussions. The discussion lasted four hours. The table includes four "not rated" preservice teachers. These PTs were responsible to lead the discussion, they organized the power point presentation for food additives issue and presented it in the classroom. Presenters (PT-5, 7, 8, PT-11) and the researcher guide the discussion hours. 21 out of 183 dialogues were not rated. These “not rated” turns include; presenters’ and researcher’s leading questions and some of the informal conversations between PTs’. Table 40 summarizes the numbers of rubric rated conversational turns and also gives the numbers of ‘not rated’ conversations for industrial revolution issue.

Table 40 Numbers of Rubric-rated Conversational Turns: Industrial Revolution.

Group	Level 0	Level 1	Level 2	Level 3	Not Rated	Total (N
Proponents	8	14	30	41	9	102
Opponents	5	23	11	30	12	81
Total	13	37	41	71	21	183

In total, there were 183 conversational turns for the Industrial Revolution issue. Twenty-one conversational turns were labeled out of content so they were “not rated” 5 turns of the opponents and 8 turns of the proponents did not include any reference to the information (rating= 0), 14 turns of the proponents and 23 turns of the opponents used incorrect consideration of the evidence or subject matter knowledge (rating= 1). The level 2 (41 turns) and level 3 (71turns) PTs have adequate subject matter knowledge and grounded their positions using accurate evidence. Examples of each level, from zero to three, argumentation for industrial revolution issue was presented in Table 41. The frequencies of each level were also presented. PTs ways of reasoning on the Industrial Revolution issue can be seen from direct quotations in table.

Table 41 Examples of Rubric-rated Conversational Turns: Industrial Revolution.

Level	Transcript dialogue	Argument Category	Researcher's Rationale	Freq.
0	Human being made the revolution, so human being can stop it. There is no need to concern about it.	Claim (the effects of revolution can be stopped)	The student has not adequate SMK, the effects of IR on environment and on the natural source (significant amount of chemicals were already released to the atmosphere) are irrecoverable.	13
1	The numbers of factories increased by the industrial revolution this increased employment opportunity and wealth of the society; people can be able to find a job easily.	Claim (new job opportunity, wealth) Ground (increase in the number of factories)	Student has inadequate SMK about the issue since machines were invented which replaced human labor and in a broad perspective qualified people lost their jobs.	37
2	The IR changed human life drastically.	Claim (drastically change)	Student has a strong argument but do not use a specific evidence to support his claim.	41
3	Well, the other side of the coin shows us the revolution polluted the air. I mean.. Factories use excess of coal and fuel. This is what we suffer from in today's world. Wars because of fuel, pollution, health problems…	Claim (revolution polluted the air) Ground (factories use excess of coal and fuel Backing (we suffer from pollution, health problems)	Student has adequate SMK and can able to look at both side of the IR.	71

4.3 Research Question 3

RQ3. Is there an association between RJM and argumentation scores of PTs revealed in SSI based-ILC?

4.3.1. Analysis of the association between RJM and argumentation scores

Socioscientific issues were discussed in the classroom and were investigated in the laboratory through experiments. The PTs laboratory manuals were used as data source to analyze their reflective judgments. PTs' three digit score and average scores were calculated independently and represented in table format. Argumentation scores were presented in four level (from level-0 to level-3), the highest level and the highest frequency identify the final argumentation position of a PT. PTs average scores for RJM and final positions in argumentation discussions were used as data source to explore the association between RJM and argumentation scores.

4.3.1.1. Food additives issue

In order to explore the association, if any, between RJM and argumentation skills of PTs revealed in food additives issue, Chi-square Test for Independence was performed. To perform a Chi-square Test for Independence to investigate research question 3, the general assumptions that apply to all of the non-parametric techniques, random sampling and independence of observations, were assumed to be satisfied. The cross tabulation table (Table 42), which was provided as a part of chi-square analysis, presents the frequencies of PTs reflective judgment stages in terms of pre-reflective, quasi-reflective, reflective stage and argumentation skills in terms of three different levels of argumentation. The frequencies showed that there might be a possible association between RJM and argumentation skills of PTs; 12 of the participants seemed to have the similar understanding level in both of them.

Table 42 Cross tabulation of RJM and Argumentation Scores: Food Additives

		Argumentation Levels			
		Level 1	Level 2	Level 3	Total
RJM Stages	Pre-reflective	6	0	0	6
	Quasi-reflective	0	3	8	11
	Reflective	0	0	3	3
	Total	6	3	11	20

Chi-square Test for Independence was investigated in order to find out whether there is a statistically significant difference in distribution of frequencies between RJM and argumentation. Due to the 8 of the expected cell frequencies are smaller than 5, the distribution of the sample did not meet the assumption of Chi-square analysis such that at least 80 per cent of cells have expected frequencies of 5 or more, the researcher used Fisher's exact test results. The analysis of chi square results indicated that the frequency distribution of argumentation skills of PTs was not homogenous among PTs with different levels of RJM understanding; levels of argumentation were clustered around some levels of RJM stages, X^2 (4, n = 20) = 21.49, p = .000). Cramer's V value was calculates to be .73 which is accepted as an indication of large effect size for variables with three categories (Pallant, 2007). In sum, it can be concluded that reflective PTs tend to have of highest level argumentation (Level-3) whereas prereflective PTs tend to have lowest level argumentation (Level-0 or Level-1) skills revealed in food additives issue.

4.3.1.2. Alternative energy sources

In order to explore the association, if any, between RJM and argumentation skills of PTs revealed in alternative energy sources, Chi-square Test for Independence was performed. To perform a Chi-square Test for Independence to investigate research question 3, the general assumptions that apply to all of the non-parametric techniques, random sampling and independence of observations, were assumed to be satisfied. The cross tabulation table (Table 43), which was provided as a part of chi-square analysis, presents the frequencies of PTs reflective judgment stages in terms of pre-reflective, quasi-reflective, reflective stage and argumentation skills in terms of three different levels of argumentation.

Table 43 Cross tabulation of RJM and Argumentation Scores: Alternative Energy

		Argumentation Levels			
		Level 1	Level 2	Level 3	Total
RJM Stages	Pre-reflective	1	0	1	2
	Quasi-reflective	1	4	11	16
	Reflective	0	1	1	2
	Total	2	5	13	20

Chi-square Test for Independence was investigated in order to find out whether there is a statistically significant difference in distribution of frequencies between RJM and argumentation scores revealed in alternative energy source issue. However, since the distribution of the sample did not meet the assumption of Chi-square analysis such that at least 80 per cent of cells have expected frequencies of 5 or more, Fisher's exact test results were used. The results of Chi-square analysis indicated that the frequency distribution of RJM stages of PTs was homogenous among PTs with different levels of argumentation understanding; levels of argumentation were not clustered around same RJM stages, X^2 (4, n = 20) = 4.8, p = .332). Therefore, frequency distribution and chi-square analysis results showed that there is no significant association between PTs’ argumentation skills and RJM skills revealed in alternative energy sources.

4.3.1.3. The climate change issue

In order to explore the association, if any, between RJM and argumentation skills of PTs revealed in climate change issue, Chi-square Test for Independence was performed. To perform a Chi-square Test for Independence to investigate research question 3, the general assumptions that apply to all of the non-parametric techniques, random sampling and independence of observations, were assumed to be satisfied. The cross tabulation table (Table 44), which was provided as a part of chi-square analysis, presents the frequencies of PTs reflective judgment stages in terms of pre-reflective, quasi-reflective, reflective stage and argumentation skills in terms of four different levels of argumentation.

Table 44 Cross tabulation of RJM and Argumentation Scores: Climate Change

		Argumentation Levels				
		Level 0	Level 1	Level 2	Level 3	Total
RJM Stages	Pre-reflective	0	1	0	0	1
	Quasi-reflective	1	1	7	4	13
	Reflective	0	0	0	5	5
	Total	1	2	7	9	19

Chi-square Test for Independence was investigated in order to find out whether there is a statistically significant difference in distribution of frequencies between RJM and argumentation scores revealed in climate change issue. Due to the 11 of the expected cell frequencies are smaller than 5, the distribution of the sample did not meet the assumption of Chi-square analysis such that at least 80 per cent of cells have expected frequencies of 5 or more, the researcher used Fisher's exact test results. The analysis of chi square results indicated that the frequency distribution of argumentation skills of PTs was not homogenous among PTs with different levels of RJM understanding; levels of argumentation were clustered around some levels of RJM stages, X^2 (6, n = 19) = 16.07, p = .023). Cramer's V value was calculates to be .65 which is accepted as an indication of large effect size for variables with three categories (Pallant, 2007). In sum, it can be concluded that reflective PTs tend to have highest level argumentation (Level-3) whereas prereflective PTs tend to have lowest level argumentation (Level-0 or Level-1) skills revealed in climate change issue.

4.3.1.4. The industrial revolution

In order to explore the association, if any, between RJM and argumentation skills of PTs in SSI based ILC revealed in industrial revolution issue, Chi-square Test for Independence was performed. To perform a Chi-square Test for Independence to investigate research question 3, the general assumptions that apply to all of the non-parametric techniques, random sampling and independence of observations, were assumed to be satisfied. The cross tabulation table (Table 45), which was provided as a part of chi-square analysis, presents the frequencies of PTs reflective judgment stages in terms of pre-reflective, quasi-reflective, reflective stage and argumentation skills in terms of four different levels of argumentation. The frequencies showed that there might be a possible association between RJM and argumentation skills of PTs; 10 of the participants seemed to have the similar understanding level in both of them.

Table 45 Cross tabulation of RJM and Argumentation Scores: Industrial Revolution

		Argumentation Levels			
		Level 1	Level 2	Level 3	Total
RJM Stages	Pre-reflective	0	1	0	1
	Quasi-reflective	5	3	2	10
	Reflective	0	2	7	9
	Total	5	6	9	20

Chi-square Test for Independence was investigated in order to find out whether there is a statistically significant difference in distribution of frequencies between RJM and argumentation. Due to the 9 of the expected cell frequencies are smaller than 5, the distribution of the sample did not meet the assumption of Chi-square analysis such that at least 80 per cent of cells have expected frequencies of 5 or more, the researcher used Fisher's exact test results. The analysis of chi square results indicated that the frequency distribution of argumentation skills of PTs was not homogenous among PTs with different levels of RJM understanding; levels of argumentation were clustered around some levels of RJM stages, X^2 (4, n = 20) = 10.80, p = .016). Cramer's V value was calculates to be .51 which is accepted as an indication of large effect size for variables with three categories (Pallant, 2007). In sum, it can be concluded that reflective PTs tend to have highest level argumentation (Level-3) whereas prereflective PTs tend to have lowest level argumentation (Level-0 or Level-1) skill revealed in industrial revolution issue.

4.4 Summary of Results

The present study explored PTs' reflective judgment skills and development of their argumentation skills across contextually varied SSI-based ILC. Five different SSI (transportation issue, food additives, energy, climate change, the Industrial Revolution) were discussed during the discussion weeks, and emerging ideas about debated issues were tested in inquiry-based laboratories in the following weeks. The PTs volunteered to participate in this study as the study was conducted in an elective course, and they were free to drop the course on add-drop week. PTs' volunteer participation was believed to affect positively the result of the study. PTs' active engagement with SSI not only during classroom discussions but also in experimentation weeks allowed the researcher to triangulate the data.

Reflective judgment was tested through two different instruments: the PRJI protocol as well as laboratory manuals enriched by reflective judgment probing questions. The RJM scores varied across different SSI contexts. The rubric developed by King and Kitchener (1994) was used to analyze PTs' semi-structured interviews and laboratory manuals. Overall, the PTs' average RJM scores increased slightly from 4.1 (quasi-reflective) to 5.3 (quasi-reflective) over the 13 weeks of implementation. PTs' overall stage was stable, which is quasi-reflective. But, if we look at the results one by one, it is seen that PTs' scores and stages are contextually varied. For example, one student was labeled as quasi-reflective for the food additive issue, but she was pre-reflective for alternative energy sources, and she was highly reflective for the climate change issue. This dramatic change in PTs' reflective judgment scores across different SSI contexts shows the importance of context and of content knowledge to be able to make high level reflective judgments.

The PTs' classroom discussions were rated by their use of evidence and their SMK for debated issue; the aim of the researcher was to explore the types of variation, if any, in argumentation skills exist across contextually varied SSI-based ILC. It emerged that PTs' level 0 scores were at the very least. This means that PTs tended to use evidence to support their claims. However, in some turns, their use of evidence was incorrect. Incorrect use of evidence was rated as Level 1 argument.

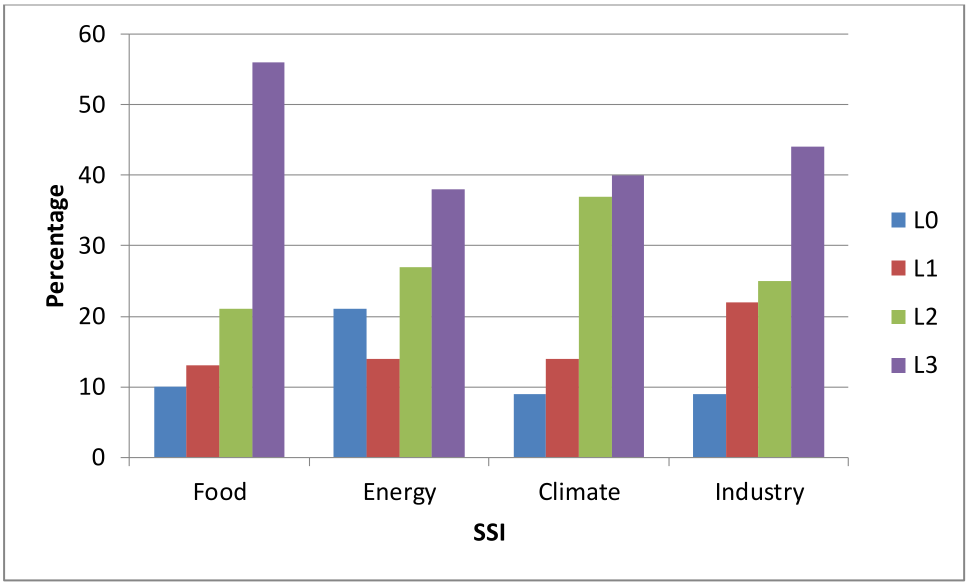

Figure 17 The Percentage of Argumentation Scores across Different SSI

The percentage of Level 1 scores was at its minimum, 13 %, in food additives week and the maximum, 22%, in the Industrial Revolution week. The PTs' use of evidence, either nonspecific use of evidence (Level 2) or correct use of evidence (Level 3) was also presented in Figure 17. It is surprising that PTs' use of correct evidence, level 3 scores, was maximum in the first week. More than half of the claims (56%) were supported by correct evidence. The following weeks, the percentage of Level 3 arguments decreased; 38% for Energy, 40% for climate change week and 44 % for the industrial revolution week.

The association between argumentation and reflective judgment scores of PTs across different SSI were explored by using chi square results. Three of the four chi square analysis results showed there is significant association between RJM and argumentation scores which are; food additives, climate change and the industrial revolution. On the contrary, the results of alternative energy sources were found to be no significant which implies there is no association between RJM and argumentation scores.

To sum up, an SSI-based inquiry laboratory gave PTs a chance to engage in daily life issues in the laboratory. As this SSI research is aimed at engaging learners with scientific problems that are directly relevant to their lives, it is inferred that an SSI based inquiry-oriented science laboratory experience promoted pre-service teachers' scientific literacy. The investigation assessed the development of two key factors that contributed to scientific literacy: reflective judgment and argumentation.

CHAPTER 5

5. DISCUSSION

In chapter four, the presentations of results were conducted. The review of the findings, implications for educational practice, recommendations for further research, and conclusions are discussed below in chapter five. This chapter aimed to expand the analysis and related discussion from chapter four, make direct links between research and practice and give additional suggestions for future research studies.

5.1 Discussion of the Findings

This study investigated SSI those were personally meaningful and strongly connected to PTs' lives (e.g., food additives, climate change etc.), in an inquiry laboratory course. The SSI movement addresses the incorporation of science issues with social relevance. PTs were exposed to SSI in a laboratory environment; these issues are thought to prepare them as participant citizens (Lee et al., 2013). The students socially engaged in science experiments, found the opportunity to improve their reflective reasoning ability and become enmeshed in collective evidence-based decision-making experiences. Fowler, Zeidler and Sadler (2009) have argued that students' active and social engagements in real life issues promote scientific literacy (SL), which is a long-standing goal of science education. It is also highlighted in present literature that socioscientific decision making is an important part of scientific literacy. Therefore, I aimed to investigate how PTs resolve and negotiate with SSI in context of a laboratory setting.

Socioscientific issues, addressed in this laboratory, were personally meaningful and engaging to students, demands the use of evidence-based reasoning, and maintained a context for understanding scientific information. The primary goal of this study was to explore the relationship between SSI and two outcome variables (RJM and Argumentation) related to scientific literacy. Thus, this study is different from other attempts in terms of activities in SSI (based on interview results). The study was applied in science laboratory course and the inquiry approach guided the study, activities included SSI content-embedded. In light of the findings of the present study and socioscientific literature, the implications of utilizing an SSI-based inquiry laboratory course were discussed successively in this chapter.

Reflective judgment model is a way of analyzing uncertain situations when applying a formula and deriving a correct solution is not possible. The PTs' reasoning on ill-structured issues (i.e., food additives, climate change, energy, industrialization) were assessed by using the model was developed by King and Kitchener (1994) to examine how individuals defend their judgments and how their views of knowledge change (King, 1992). Reflective judgment was tested in this study using two different instruments: the PRJI protocol as well as laboratory manuals including prototypical reflective judgment questions. The average mean scores of PTs across five experiments tended to increase from 4.1 to 5.2. Although the minimum and the maximum class average fell into the quasi-reflective stage for all experiments, there were some group differences and individual differences across different experiment context. Therefore, it is better to make a close look these contextual differences.

The individuals' averages were changeable and it was difficult to infer their performance by looking at their previous averages. For example, group 5 got the minimum score for the experiment 1(group average= 2.2, class average= 4.1) and experiment 2 (group average= 3.9, class average=4.5), however they got the maximum score for experiment 3 (group average=5.2, class average=4.9). Group-5 was below the class average for two experiments; however they were above the class average for the third experiment. To deeper view, it is better to look at individual differences. As previously mentioned PT-4 and PT-11graded as quasi-reflective (average=4.8) for food additive issues. However, PTs average scores for energy experiment were distinctly different from each other. In this experiment, while PT-4's score increased (Average=5.5), PT-11's scores sharply decreased (Average=1.8).

The score changes for the last experiment was still unpredictable since PT-4 average decreased while PT-1's average increased. This can be explain by the effect of context on PTs' reasoning. Contextual differences would be expected in the literature (Zeidler et al., 2009). PTs' personal interest to the debated issue may also be the reason for these rapid changes in their RJM scores. Reflective judgment is considered a construct that represents individuals' views on knowledge and justification of knowledge. PTs' subject matter knowledge about debated issue may be inadequate therefore their grades can be change from experiment to experiment. Effect of subject matter was discussed in previous literature (Walker & Zeidler, 2007; Zeidler et al., 2009).

Zeidler et al., (2009) have attributed low essay scores to decreased motivation and the subject matter. Similar to Zeidler et al.(2009), the contextual differences of individual's scores for this study may be attributed to inadequate SMK or low motivation to the issue. It could be reasonably inferred that teacher candidates' SMK, motivation, emotional factors may have effect on their reflective reasoning. Time and context effects the motivation types (Schunk, Pintrich, & Meece, 2008). Different people can differently motivate (extrinsically or intrinsically) to the same issue. If student motivated to an issue, s/he attend learning, listen carefully, rephrase learning, organize knowledge and relate it what he already know (Bandura, 1986). Motivational factors and personal interest also affected the PTs scores. For example in energy week, there were two PTs (PT-15 and PT-19) who are from black sea region, who suffer from hydroelectric energy plants, they listened PPT carefully, they took notes, they criticized some issues about HEP, they told their personal experiences and they guided the classroom discussion. In following week their laboratory reports were clear, understandable, well designed so they categorized as reflective (PT-15 average=5.8, PT-19 average=6.2). On the other hand, for the next week experiment, climate change experiment, these two PTs scores fell into quasi-reflective stage (PT-15 average=4.8, PT-19 average=5.0). There is more than 1.0 point decrease in these two PTs' RJM scores from one experiment to another. Therefore one could argue that personal experiences and motivational factors may have effect on PTs reasoning. In last few decades, there is consensus on that personal and motivational variables have impact on learning (Gaudry & Spielberger; 1971).

Harter and Connell (1984) addressed that intrinsically motivated individuals pay attention for own interest and curiosity, their judgments are independent, they do not pay attention to please the teacher (authority) and to obtain good grade, there is no dependence on teacher, no reliance on teacher's judgments. In present study, reflective students showed similar characteristics those are listed by Harter and Connell (1984). The PTs unpredictable scores and rapid changes from one experiment to another can be explained by their intrinsic motivation and personal experiences. If an SSI is directly related with the PTs own life (i.e., one of the PT's grandmother was diabetic and she was sensitive to food additives, one of them was sensitive to HEP etc.) they were curious to the issue during the classroom discussions and these curiosity increased their attention, their reflective judgments were independent to authority. As a result, their score fell into reflective stage. On the other hand, experience and individuals' familiarity with the task changes level of aspiration (Pintrich & Schunk, 2002). PTs past experiences may shape their perceptions and judgments; they may perceive and interpret the same SSI inadifferent way. If the PTs were not curious about the issue, or they did not have adequate SMK, they did not personally engaged with the issue, their judgments fell into pre-reflective stage.

Including reflective judgment into the curriculum provide some advantages for teachers. King and Kitchener (2002) suggested that teachers should respect their students' assumptions in order to support their developmental progression. This support may increase students' willing to engage in challenging discussions. In the present study, I aimed to give a chance to the PTs to experience reflective judgment, the researcher did not criticize their reflections, support them to present their ideas, to engage them in challenging discussions. The study is thought to be an example for teacher candidates how to negotiate SSI in their classrooms. Present study assigned PTs to develop their research questions and design their own experiments requiring data collection, evaluation and interpretation of data, including reflective judgment questions. These procedures are suggested by the developers of RJM, King and Kitchener suggested teaching students strategies for systematically gathering data, assessing the relevance of the data, evaluating data sources, and making interpretive judgments based on the available data. They also addressed that teachers should help students explicitly highlight ill-structured issues and uncertainty in judgment-making and to examine students' assumptions about knowledge and how it is gained. This study aligned with these suggestions by engaging PTs in ill-structured issues, by exploring their knowledge about these issues, their source of knowledge, their degree of uncertainty etc. The implementation enabled PTs to increase their average reflective scores by 1.1 points. The next question explored the argumentation skills of PTs across different socioscientific issues.

Argumentation has been the emphasis of many studies during the past few decades. These studies indicate that student engagement in scientific argumentation can support a better understanding of scientific process. Argumentation is one of the ways to help teaching and learning science (Duschl, Schweingruber, & Shouse, 2007). Argumentation is the process of asking questions, supporting claims with appropriate evidence, and evaluating counter claims. Bricker and Bell (2008) stated argumentation as a core practice of scientific discourse. In present study, I attempted to create a flexible learning environment where PTs can socially construct their scientific claims via challenging conflicting claims during the argumentation processes and test them in the inquiry oriented science laboratory.

Classroom discussions let PTs to realize that all knowledge claims are open to challenge and they have to use reasonable evidence to support their claims. In this study, discussion topics have some significant characteristics in order to be an SSI unit such as, their being controversial, challenging, debated across different media sources, suitable for classroom discussions. PTs challenged core beliefs of their classmates during the presentations by highlighting the common misconceptions of that issue; sometimes presentation included some formal information, group presentations helped PTs to engage in the topic and to discuss the issue in the classroom. The aim of the discussion weeks was to attract PTs attention to SSI and to cover intriguing issues during the discussions. Analyzing the content of PTs' reasoning on SSI were assessed utilizing Toulmin's (1958) model of argument. The researcher used an adapted version of TAP, used by Walker & Zeidler (2007) in order to analyze the students' use of claims, grounds, warrants, backings, and rebuttals to support their debate position.

The PTs level of arguments was rated from Level 0 to Level 3 arguments for each issue. Level 3 was the dominant stage for all issues, whereas level 0 was the least observed stage. The highest percentage of all for Level-0 arguments belonged to energy issue, 21% of the turns were rated as Level-0 (10 % for food additives, 9 % for climate change and industrial revolution. It is also important to note that there were 380 conversational turns occurred in energy week which is the highest of all week. This means that PTs were comfortable to express their ideas about energy sources but those ideas have lack of evidence. The possible reason of level-0 scores for energy issue can be the governments' politics about energy issue. The PTs were anxious about the energy politics. The energy issue was popular on media source, PTs have knowledge about it but they don't have adequate information, so they couldn't support their claims with appropriate evidence (no evidence labeled as level-0). They have concern about nuclear energy, a similar concern revealed in Kılınc, Stanisstreet, and Boyes (2008) results, but they have limited knowledge.

On the other hand, PTs used their everyday knowledge to support their claims; their use of prior knowledge directs them to use common conceptions as evidence which may provide detailed but inaccurate source of knowledge. A possible reason for PTs reliance on personal statements instead of scientific evidence may be their being inexperienced in argumentation. Sampson and Blanchard (2012) stressed the importance of teachers' participation in argumentation and stressed that inexperienced teachers did not seek an alternative source to support their claims relied on their personal understanding about a phenomenon. Present study also shed some light on the importance of education especially teacher education in engaging argumentation and evidence based reasoning about global environmental issues such as climate change, alternative energy sources, and the effects of industrial revolution on environment.

Integrating SSI into the classroom has been proposed as a critical issue over the past few decades (Sadler, 2004). These issues provide students to see the interactions between science technology and society. As previously mentioned, PTs designed their own manual regarding selected SSI. Engaging in argumentation thanks to classroom discussions helped PTs to encounter controversial issues before the laboratory and gave them a critical eye regarding these issues before conducting the experiments. Argumentation contributes to students' reasoning process, to organization of knowledge, to share ideas, and to evaluate the opposite views.

Barnett and Tyson (1999) highlighted that throughout the classroom discussions PTs expected to construct knowledge, discover new knowledge, and gain different perspectives. The context in the present study promises such opportunities for preservice teachers in the sense that the participants had chances to engage in argumentation, discuss controversial issues related to everyday life issues, had to form a research question and to pose alternative explanations. Additionally, they had opportunities to test their ideas in the laboratory.

The PTs' laboratory reports were used as data source to evaluate their reflective judgment skills. It is of utmost important to recognize that affective variables, such as anxiety, affect learning and performance in laboratory situations (Bowen, 1999). Most of the PTs reported that the classroom discussions were helpful for them to figure out the next week experiment. They proposed that discussing the issue in both aspects, challenging core beliefs, negotiating opposing ideas in the classroom enhanced their point of view and help them during the experiments while engaging with RJM questions. At this point, the use of classroom discussions in SSI based-ILC comes to the fore. The PTs referred to this news, videos, and articles in their laboratory manual. They used classroom discussions as evidence to answer reflective judgment questions in the laboratory. Engaging discussions increases PTs' knowledge about SSI and having prior knowledge about these issues reduces their stress or anxiety. Reducing stress in laboratory conditions may improve learning of complex laboratory and problem-solving skills (Bowen, 1999). In sum, the PTs laboratory manuals were affected by the classroom discussions, an interesting new, a YouTube video or a challenging article revealed as a source of knowledge in the laboratory manuals. There is a concrete evidence PTs used classroom discussions in their laboratory manuals. The researcher wonders whether is there is an association between PTs individual argumentation scores and RJM scores or not. The third research question aimed to shed on light to this association.

As well as argumentation, RJM is also highlighted in the literature and asserted to develop higher order thinking skills. The similarities of King and Kitchener's Reflective Judgment Model (RJM) and Dewey's (1933, 1938) thoughts on reflective thinking points out a possible relationship between reflective judgment and formulating and argument. Dewey claimed that in order to exercise reflective reasoning, one must realize that the situation is truly problematic, and there is no chance to apply a formula to get a correct solution. Furthermore, the reflective judgment process includes identifying relevant facts, data, and theories to aid in the generation of potential solutions by making a claim. Common characteristics of reflective judgment and argumentation, similar contributions of these outcome variables to higher order thinking and multiple reasoning make the researcher to think about is there association between argumentation scores and reflective judgment stages of PTs or not.

A review of the literature confirms that students need to be engage with complex problems and create solutions that optimize benefits for all affected (Moody & Estep, 2010). Association of American Collage (AAC, 2008) asserted that the world is far more complex than it is appeared and suggested to students to make interpretive arguments and reflective judgments to entail the consequences of these complex issues (i.e., real-life dilemmas). Friedman and Schoen (2009) affirmed that participants' capacity to address uncertainty, to recognize the complexity of claims, justification of evidence and ability to make reflective judgments improve with using real-life dilemmas.

The researcher used real life dilemmas to create a learning environment where students are not afraid of making mistakes. AAC (2008) strongly emphasize schools must teach students to find and evaluate evidence and to take into account competing perspectives while making judgments. Ill-structured issues were embedded into course content in order to teach students to find and evaluate evidence. Classroom discussions help the PTs to gain different perspectives. Ill-structured problems were covered in detail during these discussions; there were opposing views and PTs shared these views via interacting with each other through the discussions. Opposing views facilitate the discussions, helped PTs to discover, motivate to reasoning, to connect science with real life issues. Course assistants and group presenters probing questions help the PTs to make reflective judgment about ill-structured issues.

The analysis of PTs classroom discussions, their argumentation structures, and the laboratory scores with respect to RJM stages were utilized to assess to fill the gap between associations of these two outcome variables by using chi square analysis. The chi square analysis results showed that there is a significant association between RJM and argumentation scores of PTs across three out of four investigations. Significant results belonged to food additives, the climate change issue and the industrial revolution issue. In the light of available results, it is expected from high reflective PTs to compose a valid argument using formal logic, make reasonable inference. Results of the present study showed that there is an association between argumentation and RJM scores, the researcher interprets that classroom discussions initiated the reasoning process,and inquiry laboratory activities enhanced the reflective judgment.

5.2 Implications for Science Education

In numerous science education programs across the world, there is an increasing emphasis on the inclusion of argumentation and SSI in science education. However; there is still significant gap between theoretical objectives and practical applications. In order to create a more sustainable and conscious society, it is important to educate future teachers for the coming generations. This study shows that the SSI based ILC course can contribute toward this end. SSI based ILC is valuable in the teacher education settings as a way of improving PT's knowledge about global environmental issues. Unfortunately, such courses where students engage and negotiate with SSI are comparatively less placed in current teacher education programs. In order to increase PTs' active participation in the science classroom, knowledge about ill-structured issues, help them to gain positive environmental attitudes and sophisticated knowledge about these issues in society as a whole, universities should include such courses and encourage all students to enroll in such classes. Future research is required to extend applications of SSI based ILC in science education and to translate their findings in teacher training programs as well as in service teacher education programs.

Current study provides an initial picture of the inclusion of SSI into science laboratory practices of PTs in Turkey. It has provided new evidences related to integration of ill-structured issues into science laboratory. It is emerged that SSI can be used in science laboratory in order to connect science and real life issues, to visualize PTs reasoning on these issues. Although the application of argumentation and SSI supported in significant amount of research, the literature provides insufficient information about reflective judgment process of students during science instructions. The results of this study indeed indicate that, PTs reflective judgment and argumentation can contribute their reasoning skills and there is an association between these two scores. Besides, PTs ability of making sound argument and reflective judgment tend to improve by experience. As a result, further classroom practice should consider the explicit indication of RJM in science education, including argumentation and SSI into curriculum.

Results highlighted that PTs can easily form plausible and supportable claims during classroom discussions and they also pose solvable and applicable research questions in order to test their claims in the laboratory. However, they lack of multiple lines of reasoning skills. On the other hand, PTs' judgment scores were in the range of quasi reflective stage, few of them could be able to reach reflective stages. Further researches will also need to examine why students, even at university level, struggle to reach reflective judgment stage with multiple line of reasoning during SSI based ILC process. Answers to this question will enable science education researchers to develop instructional practices to promote and support more productive learning engagements in science classrooms those are connected to everyday life issues.

5.3 Limitations of the Study

Limitations of a dissertation are potential weaknesses of the study that are out of researcher's control. Present study also has some limitations in the research design and methods of data analysis. It is far better for to identify and acknowledge the reader about the study's limitation. Therefore, readers should approach the current findings and conclusions with caution. First of all, DBR approach has been utilized in current study. Although the study research aims to give rich and thick description about a phenomenon rather than to generalize the research findings still it can be a limitation of the present study since the research findings cannot be generalized. Additional research would be needed to verify findings in similar conditions.

Second, as before mentioned, all the discussion sessions were audio-recorded, the classroom environments in the videos may not be reflecting the real classroom environments. PTs may alter their responses to please the facilitator. Third, the official language of the university, which is English, may be another factor that affected the findings of the present study. Although participants were not English first-language speakers, they had to discuss and write in English during the investigation. PTs incapability of speaking or writing in English can affect the final product.

Fourth, a small sample size is a limitation for the correlational research. Although the results were significant, it is still questionable due to the small sample size. Thus, as well as t value, the effect size was also reported exploring the correlation between the reflective judgment and argumentation. This may reduce the bias to significant scores of the small sample size.

Fifth, this study did not explicitly teach reflective judgment and argumentation to the PTs. This may be a limitation for the study since the explicit instruction may enhance the quality of the discussion and the quantitiy of high level argumentation.

5.4 Recommendations for Further Research

One of the unique characteristics of the present study is its design that includes five ill-structured issues in science laboratory. Although including SSI in science education is not new, including it into science laboratory is. Science laboratories are dominated by well-structured science experiments such as physics, chemistry or biology. The uniqueness of the present study is to challenge this tradition and designing an inquiry based laboratory that includes ill-structured experiments. Investigating ill-structured issues in the laboratory emerged the importance of content knowledge about these issues. Designing such a laboratory has some advantages and disadvantages those are emerged during the application phase.

First of all, classroom discussions let students share ideas, to coordinate different viewpoints, to communicate ideas, focus on alternative ideas (Stein & Miller, 1991). Discussing socioscientific issues in class, developing a position and defending it, weighing the pros and cons is more effective than listening them from a professor during a lecture. Still, discussions have some disadvantages. To begin with, it was difficult for the assistants to manage the discussions. PTs can easily start talking about off topic issues, but the investigators should be careful while interrupting off topic conversations as it may discourage students and they can avoid participation in future discussions. I suggest the practitioners to have an informal discussion plan such as explicitly inform the participants about the goals of the discussion, specifically emphasize the importance of the issue, have opening questions to capture participants' attention. These recommendations are thought to help researchers breaking the barriers and flowing the discussions easily. Subject matter knowledge found an important factor that effect classroom discussion, present study did not test PTs subject matter knowledge at the beginning of the investigation, I recommend future researcher it sgould be better to test SMK at the beginning.

I strongly recommend future researchers to use controversial discussions as the discussion is a natural and effective approach to engage learners in problem solving of real life issues that is necessary to be a good citizenship. However, the researcher must be careful during the classroom discussions. The facilitator role of the researcher should be clearly defined and the researcher should not be a dominant factor during the classroom discussions. Controlling the discussion is important, researcher's role has utmost importance during the investigation but their being dominant during the discussions may decrease the creativity of the participants. If the participants feel uncomfortable then they will avoid engaging discussions. Thus, the researcher's reactions to the off-task conversations are determinant factor in classroom discussions.

5.5 Conclusions

This study integrated SSI in science laboratory and attempted to explore argumentation, reflective judgment skills, and the association between these two outcome variables. The literature has significant examples that focus on students', PTs' or inservice teachers' argumentation quality (Driver et al., 2000; Jiménez-Aleixandre et al., 2000; Osborne, Erduran, & Simon, 2004); has many examples indicating the importance of reflective judgment on students' reasoning (Kolsto, 2001; Kember et al., 1999; Mezirov, 1990). Constructivist learning environments and inquiry oriented science laboratories were suggested as appropriate places to conduct such research (Chinn & Malhotra, 2002, Katchevich, Hofstein, Mamlok, and Naaman, 2013; McDonald, 2010).

Over the past few years significant amount of argumentation research have been conducted. However, only a few studies have examined the science laboratory as a context for facilitating or developing students' argumentation. (Katchevich et al., 2011). This study is one of the few to design an SSI-based ILC and to investigate all these variables in one research and to check the association between RJM and argumentation scores. Five socioscientific issues were utilized in this study. Each issue was scrutinized in the same format; starting with classroom discussions, formulating a research question, and designing an experiment to test the research question. PTs were expected to appreciate and understand how the interrelation of science, technology, society and environment affect their daily lives and their futures by this research.

Science education should be a part of contemporary life by engaging students and community members in meaningful activities related to their own lives (Tal & Kedmi, 2006). It should be kept in mind that SSI is an important concept that has direct relation with students everyday life and the topics covered in science classrooms. SSI could be used to provide a context for such investigations. The use of SSI in science laboratory may be challenging for instructors since it is common to test well-structured issues in science laboratories. Besides, it can be difficult to embed SSI into the curriculum because of the intense nature of the science curriculum where teachers had to cover so many issues throughout the semester. It is possible to cover all these issues with teacher centered education, but without students' active participation it is not easy to reach desired learning outcomes such as; multiple reasoning, constructing knowledge, defining problems, probing assumptions, evaluating multiple views and so.

As indicated previously, students' active participation promote scientific literacy (SL), which has become a long standing goal of national and international science education (Dillon, 2009). Explicit goals of the present study are developing scientific literacy, engaging PTs in real life issues, exploring their reflective judgment and argumentation skills through SSI in an inquiry based laboratory. The constructivist framework guided the present study while designing the course content. Constructivist theory assumes that knowledge is actively constructed by the learner (Anderson, Lucas, Ginns, 2003). Inquiry laboratory activities are emphasized as appropriate places to experience the goals of constructivist learning approaches in much research (e.g., Claugh, & Clark, 1994; Crawford, 2000). Present study attempted to reach desired learning outcomes by designing an inquiry based laboratory. PTs are allowed to develop research questions, devising means to collect data to answer those questions, interpreting data, and drawing conclusions in this course.

Qualitative research method was used to investigate the effects of multiple SSI on PTs' reflective judgment skills, to investigate PTs' development of argumentation skills and quantitative data analysis method was used to interpret there is a correlation between reflective judgment and argumentation scores. PTs' laboratory manuals, interviews and classroom discussions were analyzed qualitatively. In addition to qualitative descriptions, quantitative descriptions in terms of chi square, fisher exact test correlations were presented for the hypothesized relationships between reflective judgment stages and argumentation levels within socioscientific issues.

The findings of this research were explained in three parts; first, PTs RJM scores were reported. PTs were interviewed about five SSI during the investigation. As well as interview results, reflective judgment skills were explored with written laboratory reports including RJM questions. Results of the study showed that PTs'

RJM scores tended to increase from first experiment to last experiment. Second, PTs' argumentation scores were explored. Toulmin (1958) argument pattern, adapted by Walker and Zeidler (2007) was used to analyze classroom discussions. PTs' levels of argument varied across five SSI. Classroom discussions provided some examples about PTs' reasoning on ill-structured issues for example how they evaluate opposing views, how they use evidence to support their own ideas, and what are their pros and cons about these issues. Finally, the association between two outcome variables were explored which is significant. (i.e., three of the analysis out of four were found to be significant).

Although the link between argumentation and RJM was highlighted in the literature, there is a gap between theory and practice. There is little study that aims to document the association between two. Furthermore, inquiry learning environments are also theoretically supported but practically inadequate especially in the context of SSI. The current study attempted to engage pre-service teachers in SSI regarding global environmental problems connected to their daily lives. A semester long application provided evidence regarding pre-service teachers' reasoning progress on RJM and argumentation skills.

REFERENCES

Aikenhead, G.S. (2000). Cross-Cultural Science & Technology Units Project. http://capes.usask.ca/ccstu.

Albe, V. (2008). When scientific knowledge, daily life experience, epistemological and social considerations intersect: Students' argumentation in group discussions on a socio-scientific issue. *Research in Science Education*, *38*, 67–90.

Association of American Colleges. (1991). The Challenges of Connected Learning. Project on Liberal Learning, Study in-depth, and the Arts and Sciences Major. Washington, DC:

Aufschnaiter, C. V., Euduran, S., Osborne, J., & Simon, S. (2008). Arguing to learn and learning to Argue: case studies of how students' argumentation relates to their scientific knowledge. *Journal of Research in Science Teaching*, *45*(1), 101-131.

Baker, T.L. (1994), *Doing Social Research* (2nd Ed.), New York: McGraw-Hill Inc.

Bandura A. 1986. Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs, NJ: Prentice-Hall.

Barnett, C., & Tyson, P. (1999). Case methods and teacher change: Shifting authority to build autonomy. In M. Lundeberg, B. Levin, & H. Harrington (Eds.), Who learns what from cases and how? Mahwah, NJ: Lawrence Erlbaum Associates.

Bell, P. (2004). Promoting students' argument construction and collaborative debate in the science classroom. In M. C. Linn & E. A. Davis & P. Bell (Eds.), Internet environments for science education (pp. 115-143). Mahwah, NJ: Erlbaum

Bell, R.L. & Lederman, N.G. (2003). Understandings of the nature of science and decision making on science and technology based issues. *Science Education, 87*, 352-377.

Bell, P., & Linn, M. C. (2000). Scientific arguments as learning artifacts: Designing for learning from the web with KIE. *International Journal of Science Education*, *22* (8), 797-817.

Bell, P., & Linn, M. C. (2002). Beliefs about science: How does science instruction contribute? In B. K. Hofer & P. R. Pintrich (Eds.), Personal Epistemology: The Psychology of Beliefs about Knowledge and Knowing (pp. 321-346). Mahwah, NJ: Lawrence Erlbaum

Bell, R. L., Matkins, J. J., Gansneder, B. M. (2010). Impacts of contextual and explicit instruction on preservice elementary teachers' understandings of the nature of science. *Journal of Research in Science Teaching*, *48* (4), 414-436.

Bell, R. L., Smetana, L., & Binns, I. (2005). Simplifying inquiry instruction: Assessing the inquiry level of classroom activities. *The Science Teacher*, *72* (7), 30–33.

Benton, T. & Redclift, M. (1994). *Social Theory and the Global Environment*. Routledge Publisher. 280.

Berg, B. L. (2001). *Qualitative Research Methods for the Social Sciences* (4th edition). Needham Heights, MA: Allyn & Bacon.

Bogdan, R.C. & Biklen, S.K. (1992). *Qualitative research for education: An introduction to theory and methods* (2nd Ed.). Boston, MA: Allyn and Bacon.

Bowen, C. W. (1999). Development and score validation of a chemistry laboratory anxiety instrument (CLAI) for college chemistry students, *Educational and Psychological Measurement*,59 (1), 171-187.

Brown, A. L. (1992). Design Experiments: Theoretical and Methodological Challenges in Creating Complex Interventions in Classroom Settings. The Journal of the Learning Sciences, 2(2), 141-178.

Brown, T. L., & LeMay, H. E. (2000). *Bursten, B. E. Chemistry: The Central Science*, (8th ed.). Prentice Hall: Upper Saddle River, NJ.

Bricker, L. A., & Bell, P. (2008). Conceptualisations of argumentation from science studies and the learning sciences and their implications for the practices of science education. *Science Education*, 92, 473-498

Bybee, R. W. (1997). *Achieving scientific literacy: From purposed to practices*. Portsmouth, NH: Heinemann.

Bybee, R. W. (2000). Teaching science as inquiry. In, J. Minstrel & E. H. Van Zee (Eds), *Inquiring into Inquiry Learning and Teaching in Science* (pp. 20–46). Washington DC: American Association for the Advancement of Science (AAAS).

Bybee,R.W. (2006). Scientific Inquiry and Science Teaching. In Flick, L.B.& Lederman, N.G. (Eds.), *Scientific Inquiry and Nature of Science* (pp1-17). Dordrecht, Netherlands: Kluwer Academic.

Bybee, R. W., & DeBoer, G. (1994). Research on goals for the science curriculum. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 357–387). New York: Macmillan.

Bybee, R.W., Powell, J.C., & Trowbridge, L.W. (2008). *Teaching Secondary School Science: Strategies for Developing Scientific Literacy,* p. 108-109.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. Journal of the Learning Sciences, 13(1), 15-42. doi:10.1207/s15327809jls1301_2.

Clough, M.P., & Clark, R.L. (1994). Creative constructivism: Challenge your students with an authentic science experience. *The Science Teacher*, 61, 46-49.

Callahan, B.E., Zeidler, D.L., Cone, N. & Burek, K. (2005, October). *The effects of learning socioscientific issues on reflective judgment in high school science students*. Paper presented at the Annual Meeting of the Southeastern Association for Science Teacher Education, Athens, GA.

Callahan, B. E. (2009). Enhancing nature of science understanding, reflective judgment, and argumentation through socioscientific issues. (Doctoral Dissertation). Retrieved from http://scholarcommons.usf.edu/cgi/viewcontent.cgi?article=2885&context=etd

Crawford, B. A. (2000). Embracing the Essence of Inquiry: New Roles for Science Teachers. *Journal of Research in Science Teaching*, *37* (9), 916-937

Crippen, K. J. (2012). Argument as Professional Development: Impacting Teacher Knowledge and Beliefs About Science. *Journal of Science Teacher Education*, *23*(8), 847–866. doi:10.1007/s10972-012-9282-3.

Cicala, J. J. (1997). The relationship between student involvement and reflective judgement for students attending a community college. Dissertation Abstracts International Section A: Humanities and Social Sciences.

Cuccio-Schirripa, S. & Steiner, H. E. (2000). Enhancement and analysis of science question level for middle school students. Journal of Research in Science Teaching, 37, 210-224

DeBoer, G. E. (2000), Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. Journal of Research in Science Teaching, 37: 582–601.

DeBoer, G. E., & Bybee, R. W. (1995).The goals of science curriculum. In R.W. Bybee and J.D. McInerney (Eds.). *Redesigning the science curriculum*, (pp. 77-74). Colorado Springs, CO: Biological Sciences Curriculum Study.

Design-Based Research Collective. (2003). Design-based research: An emerging paradigm for educational inquiry. *Educational Researcher*, 32(1), 5-8, 35-37.

Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. Lexington, MA: Heath.

Dewey, J. (1938). *Logic: The theory of inquiry*. New York: Henry Holt and Co.

Dillon, J. T. (1994). Using discussion in classrooms. Buckingham, UK: Open University Press

Dillon, J. (2009). On Scientific Literacy and Curriculum Reform. *International Journal of Environmental & Science Education 4*,(3), 201-213

Driver, R., Asoko, H., Leach, J., Mortimer, E., & Scott, P. (1994). Constructing scientific knowledge in the classroom.*Educational Researcher, 23* (7), 5-12.

Driver, R., Newton, P., & Osborne, J. (2000). Establishing the norms of scientific argumentation in classrooms. *Science Education, 84*, 287–312.

DuFrene, D. D., & Lehman, C. M. (2004). Concept, content, construction, and contingencies: Getting the horse before the powerpoint cart. *Business Communication Quarterly*, 67(1), 84-88.

Duschl, R. (2007). Quality argumentation and epistemic criteria. In S. Erduran & M. Jimenez-Aleixandre, (Eds.), *Argumentation in Science Education: Perspectives from classroom-based research*. Dordecht Netherlands: Springer.

Duschl, R., Ellenbogen, K., & Erduran, S. (1999, April). *Understanding dialogic argumentation*. Paper presented at the annual meeting of American Educational Research Association, Montreal.

Duschl, R. A., & Osborne, J. (2002). Supporting and promoting argumentation discourse in science education. *Studies in Science Education, 38* (pp. 39–72).

Duschl, R. A., Schweingruber, H., & Shouse, A. (2007). Taking science to school: Learning and teaching science in grades K-8. Washington, DC: National Academies Press.

Eastwood, J.L., Sadler, T.D., Zeidler, D.L., Lewis, A., Amiri, L. & Applebaum, S. (2012). Contextualizing Nature of Science Instruction in Socioscientific Issues. *International Journal of Science Education, 34* (15), 2289-2315.

Ebenezer, J.,Kaya, O.N.,& Ebenezer, D.L. (2011). Engaging Students in Environmental Research Projects: Perceptions of Fluency with Innovative Technologies and levels of Scientific Inquiry Abilities. *Journal of Research in Science Teaching, 48* (1), 94-116.

Eijkelhof, H., (2001). Preface. In de Jong, O., Savelsbergh E. R., and Alblas, A.(Eds.) *Teaching for scientific literacy: context, competency and curriculum* (p.1). (38) Utrech CD-B Press, Utrech University.

Erduran, S., Ardaç, D., & Yakmacı-Güzel, B. (2006). Learning to teach argumentation: Case studies of pre-service secondary science teachers. *Eurasia Journal of Mathematics, Science and Technology Education, 2* (2), 1-14.

Erduran, S., & Jiménez-Aleixandre, M. P. (2007). *Argumentation in Science Education: Perspectives from classroom based research.* Dordrecht, London: Springer.

Erduran., S., & Jimenez-Aleixandre, J. M. (2012). Research on argumentation in science education in Europe. In, D. Jorde, & J. Dillon (Eds.). *Science Education Research and Practice in Europe: Retrospective and Prospective,* 253-289. Sense Publishers.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: developments in the application of Toulmin'sargument pattern for studying science discourse. *Science Education, 88* (6), 915-933.

Evagorou, M. & Osborne, J. (2013). Exploring young students' collaborative argumentation within a socioscientific issue. *Journal of Research in Science Teaching, 50*, 209–237. doi: 10.1002/tea.2107

Felton, M. (2004). The development of discourse strategy in adolescent argumentation. *Cognitive Development,19,* 39 – 58.

Fischer, K.W. (1980). A theory of cognitive development: The control and construction of hierarchies of skills. *Psychological Review, 87* (6), 477-531.

Flavell, J. (1977). *Cognitive development*. Englewood Cliffs, NJ: Prentice-Hall.

Flick, L. B., & Lederman, N. G. (2006). *Scientific Inquiry and Nature of Science*. Springer. The Netherlands: Kluwer Academic Publishers.

Friedman, A., Schoen, L. (2009). Reflective Practice Interventions: Raising Levels of Reflective Judgment. *Action in Teacher Education* , 31(2).

Forman, E. A. & Kraker, M. J. (1985). *The social origins of logic: The contributions of Piaget and Vygotsky. New Directions for Child and Adolescent Development*, (pp. 23–39). doi: 10.1002/cd.23219852904

Fowler, S.R., Zeidler, D.L., & Sadler, T.D. (2009). Moral sensitivity in the context of socioscientific issues in high school science students. *International Journal of Science Teacher Education, 31*(2), 279-296.

Gage, N. L., & Berliner, D. C. (1998). *Educational psychology* (6th ed.). Boston, MA: Houghton Mifflin.

Garcia-Mila, M., Gilabert, S., Erduran, S., & Felton, M. (2013). The Effect of argumentative Task Goal on the Quality of Argumentative Discourse. *Science Education, 97*, 497–523. doi: 10.1002/sce.21057

Garnett, P.J. Garnett, P.J. & Hacking, M.W. (1995). Refo-cusing the Chemistry lab: A case for laboratory-based inves-tigations. *Journal of Australian Science Teachers,41*, 26- 32.

Gaudry, E. & Spielberger, C. D. (1971). Anxiety and Educational Achievement. John Willey & Sons Australia.

Gerard, L. F., Spitulnik, M. & Linn, M. C. (2010). Teacher use of evidence to customize inquiry science instruction. *Journal of Research in Science Teaching, 47*, 1037–1063. doi: 10.1002/tea.20367

Germann, P. J., Aram, R. J. & Burke, G. (1996). Identifying patterns and relationships among the responses of seventh-grade students to the science process skill of designing experiments. *Journal of Research in Science Teaching*, *33*(1), 79-99.

Goldstone, J. A. (2002). "Efflorescences and Economic Growth in World History: Rethinking the "Rise of the West" and the Industrial Revolution." Journal of World History 13 (2): 323-389.

Green, W.J., Elliott, C. and Cummins, R.H. (2004). "Prompted" inquiry-based learning in the introductory chemistry laboratory. *Journal of Chemical Education, 81*, 239–241.

Harden, R. M. & Crosby, J. R. (2000). AMEE Education Guide No 20: The good teacher is more than a lecturer – the twelve roles of the teacher. Medical Teacher 22(4): 334-347.

Hart, P. & Nolan, K. (1999). A critical analysis of research in environmental education. *Studies in Science Education*, *34,* 1-69.

Harter, S., & Connell, J. P. (1984). A model of the relationship among children's academic achievement and their self-perceptions of competence, control, and motivational orientation. In J. Nichols (Ed.), *The development of achievement motivation* (pp. 219– 250). Greenwich, CT: JAI Press.

Hess, D. E. (2002) Discussing Controversial Public Issues in Secondary Social Studies Classrooms: Learning from Skilled Teachers, *Theory &Research in Social Education, 30*:1, 10-41, DOI: 10.1080/00933104.2002.10473177

Herron, M. D. (1971). The nature of scientific inquiry. *School Review*, *79*(2), 171–212.

Hodson, M. D. (1993). Re-thinking old ways: towards a more critical approach to practical work in school science. *Studies in Science Education, 22,* 85-142.

Hofstein A. & LunettaV. N. (1982). The role of the laboratory in science teaching: neglected aspects of research, *Review of Educational Research, 52,* 201-217.

Hofstein A. & Lunetta V. N. (2004). The laboratory in science education: foundation for the 21st century, *Science Education, 88,* 28-54.

Holbrook, J., & Rannikmae, M. (2009). The meaning of scientific literacy. *International Journal of Environmental and Science Education*, 4(3), 275-288 thinking patterns in social scientific decision making. *Science Education, 95,* 497-517.

Howard D. R., Miskowski J. A. (2005) Using a module-based laboratory to incorporate inquiry into a large cell biology course. *Cell Biology Education. (4),* 249–260.

Hughes, G. (2000). Marginalization of socio-scientific material in science-technology-society science curricula: some implications for gender inclusivity and curriculum reform, *Journal of Research in Science Teaching, 37* (5), pp. 426–40.

Herron, M.D. 1971. The nature of scientific inquiry. *School Review*. 79(2). 171–212.

Jensen, M. C. (1993). The Modern Industrial Revolution, Exit, and the Failure of Internal Control Systems. *The Journal of Finance, 48,* 831–880. doi: 10.1111/j.1540-6261.1993.tb04022.x

Jimenez-Aleixandre, M. P., & Pereiro- Munoz, C. (2002). Knowledge producers or knowledge consumers? Argumentation and decision making about environmental management. *International Journal of Science Education, 24* (11), 1171-1190.

Jimenez-Aleixandre, M. (2007). Designing argumentation learning environments. In S. Erduran & M. Jimenez-Aleixandre (Eds.). *Argumentation in science education: Perspectives from classroom-based research.* Dordrecht: Springer Academic Publishers.

Jimenez-Aleixandre, M., Rodriguez, M., & Duschl, R. A. (2000). 'Doing the lesson' or 'doing science': Argument in high school genetics. *Science Education, 84* (6), 757- 792.

Jin, H. & Anderson, C. W. (2012). A Learning Progression for Energy in Socio-Ecological Systems. *Journal of Research in Science Teaching, 49*(9), doi:.10.1002/tea.21051

Joseph, D. (2004). The practice of design-based research: Uncovering the interplay between design, research, and the real-world context. Educational Psychologist, 39(4), 235-242.

Karisan, D. & Topcu, M. S. (2011). An Exploration Of Preservice Science Teachers' Written Argumentation Skills Regarding The Effects Of Climate Change Issue On The Earth. *National Association for Research in Science Teaching* , NARST, Orlando, United States of America, April 3-6.

Kasa, S. (2009). Confluence. *Interdisciplinary Communications 2007/2008,* Centre for Advanced Study, Oslo, February 2009,Retrieved from: http://www.cas.uio.no/Publications/Seminar/Confluence_Kasa.pdf

Kegan, R. (1982). *The evolving self*. Cambridge, MA: Harvard University Press.

Kelly, G. J., Chen, C., & Prothero, W. (2000). The epistemological framing of a discipline: writing science in university oceanography. *Journal of Research in Science Teaching*, *37*, 691–718.

Kelly, G. J., Druker, S., & Chen, C. (1998). Students' reasoning about electricity: Combining performance assessment with argumentation analysis. *International Journal of Science Education, 20*(7), 849–87.

Kelly, G. J. & Takao, A. (2002). Epistemic levels in argument: An analysis of university oceanography students' use of evidence in writing. *Science Education, 86,* 314–342.

Keys C. W., Hand, B., Prain, V., & Collins, S. (1999). Using the Science Writing Heuristic as a tool for Learning from Laboratory Investigations in Secondary Science, *Journal of Research In Science Teaching, 36* (10), 1065-1084.

Khisfe, R. (2012). Relationship Between Nature of Science Understandings and Argumentation Skills: A Role for Counterargument and Contextual Factors. *Journal of Research in Science Teachin. 49* (4). 489-514.

Khisfe, R. (2013). Explicit Nature of Science and Argumentation Instruction in the Context of Socioscientific Issues: An effect on student learning and transfer. *International Journal of Science Education. DOI: 10.1080/09500693.2013.832004.*

King, P.M. (Ed.) (1992). Special issue on Reflective Judgment, *Journal of Liberal Education*, *78*,(1).

King, P.M., & Kitchener, K.S. (1994). *Developing Reflective Judgment: Understanding and Promoting Intellectual Growth and Critical Thinking in Adolescents and Adults*. San Francisco: Jossey-Bass.

King, P.M. & Kitchener, K.S. (2002). The Reflective Judgment model: Twenty years of research on epistemic cognition. In B. K. Hofer and P. R. Pintrich (Eds.). *Personal epistemology: The psychology of beliefs about knowledge and knowing,* (pp. 37-61). Mahway, NJ: Lawrence Erlbaum, Publisher.

King, P.M., & Kitchener, K.S. (2004). Reflective judgment: Theory and research on the development of epistemic assumptions through adulthood. *Educational Psychologist, 39*(1), 5-18.

King, P., Kitchener, K. S., & Wood, P. K. (1994). Research on the reflective judgment model. In P. M. King & K. S. Kitchener (Eds.), *Developing Reflective Judgment: Understanding and Promoting Intellectual Growth and Critical Thinking in Adolescents and Adults*. San Francisco: Jossey-Bass.

King, P. M., Kitchener, K. S., Wood, P. K., & Davison, M. L. (1989). Relationships across developmental domains: A longitudinal study of intellectual, moral and ego development. In M. L. Commons, J. D. Sinnott, F. A. Richards & C. Armon (Eds.), *Adult development: Vol. I: Comparisons and applications of developmental models*(pp. 57-72). New York: Praeger.

Kılınç, A. (2010). Can project based learning close the gap? Turkish student science teachers and proenvironmental behaviours. *International Journal of Environmental & Science Education*, 5(4), 495-509.

Kılınç, A., Boyes, E., & Stanisstreet, M. (2012). Turkish school students and globalwarming: beliefs and willingness to act. *Eurasia Journal of Mathematics, Science & Technology Education,* 7(2), 121-134.

Kılınç, A, Stanisstreet, M., & Boyes, E. (2008). Turkish students' ideas about global warming. *International Journal of Environmental and Science EducationScience Education*, *3*(2), 89–98.

Kılınç, A., Stanisstreet, M., & Boyes, E. (2009). Incentives and disincentives for using renewable energy: Turkish students' ideas. *Renewable and Sustainable Energy Reviews*, *13*(5), 1089-1095.

Kolstø, S. D. (2001). Scientific literacy for citizenship: tools for dealing with controversial socio-scientific issues. *Science Education, 85* (3), 291-310.

Kortland, K. (1996). An STS case study about students' decision making on the waste issue. *Science Education, 80*, 673–689.

Köseoğlu, F., Tümay, H., & Budak, E. (2008). Bilimin Doğası Hakkında Paradigma Değişimleri Ve Öğretimi Ile İlgili Yeni Anlayışlar. (Turkish). Gazi University Journal of Gazi Educational Faculty (Gujgef), 28(2), 221-235.

Kuhn, D. (1991). *The skills of argument*. Cambridge, UK: Cambridge University Press. 324

Kuhn, D., & Udell, W. (2003). The development of argument skills. *Child Development, 74* (5), 1245–1260.

Lai, G., Calandra, B., & Ma, Y. (2009). Leveraging the potential of design-based research to improve reflective thinking in an educational assessment system. *International Journal of Technology in Teaching and Learning, 5*(2), 119-137.

Lawson, A. E. (1995). *Science teaching and the development of thinking. Belmont.* CA: Wadsworth Publishing Company.

Lederman, N., Abd-El-Khalick, F., Bell, R., & Schwartz, R. (2002). Views of Nature of Science Questionnaire: Toward Valid and Meaningful Assessment of Learners' Conceptions of Nature of Science. *Journal of Research in Science Teaching, 39*(6). 497-521.

Lee, H., Yoo, J., Choi, K., Kim, S., Krajcik, J., Herman, B., & Zeidler, D.L. (2013). Socioscientific Issues as a Vehicle for Promoting Character and Values for Global Citizens. *International Journal of Science Education, 35*(12), pp. 2079-2113.

Lee, H., Chang, H., Choi, K., Kim, S.W. & Zeidler, D.L. (2012). Developing character and values for global citizens: Analysis of pre-service science teachers' moral reasoning on socioscientific issues. *International Journal of Science Education, 34*(6), 925-953.

Lee, H., Yoo, J., Choi, K., Kim, S., Krajcik, J., Herman, B., & Zeidler, D.L. (2013). Socioscientific Issues as a Vehicle for Promoting Character and Values for

Global Citizens. *International Journal of Science Education, 35*(12), pp. 2079-2113.

Lemke, J. L. (2002). Teaching all the languages of Science: words, symbols, images, and actions. In M. Benlloch, *La educacion en ciencias*. Barcelona: Paidos. 159-186.

Leigh, P. R. (2003). Infusing technology in educational foundations: Does powerpoint count?

Linn, M. C., disessa, A,, Pea, R. D., & Songer, N. B. (1994). Can research on science learning and instruction inform standards for science education? *Journal of Science Education and Technology*, 3(1), 7-15.

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry*. Thousand Oaks, CA: Sage.

Liu, S. Y., Lin, C. S., & Tsai, C. C. (2011). College students scientific epistemological views and thinking patterns in social scientific decision making. *Science Education*, 95, 497- 517.

Lunetta,V. N. (1974). Computer- based dialogs: Asupplement to the physics curriculum. *The Physics Teacher*,*12*, 355-356.

Mahin, L. (2004). Powerpoint pedagogy. *Business Communication Quarterly, 67*(2), 219-222.

Mason, L., & Scirica, F. (2006). Prediction of students argumentation skills about controversial topics by epistemological understanding: *Learning and Instruction, (16)*, p. 492-509.

Matek, B. (2013). Geothermal Power. International Market Overview. Geothermal Energy Association. Retrieved from http://geo-energy.org/events/2013%20International%20Report%20Final.pdf

Matthews, B. (2004). Promoting emotional literacy, equity and interest in science lessons for 11-14 year olds; the ‘Improving Science and Emotional

Development' project. *International Journal of Science Education*, *26*(3), 281-308.

McBurney, D.H. (1995). The problem method of teaching *research* methods. *Teaching of Psychology, 22(*1), 36-38.

McDonald, C. V. (2010). The influence of explicit nature of science and argumentation instruction on preservice primary teachers' views of nature of science. *Journal of Research in Science Teaching, 47,* 1137–1164. doi: 10.1002/tea.20377

McNeill, K. L., & Krajcik, J. (2007). Middle school students' use of appropriate and inappropriate evidence in writing scientific explanations. In M. C.Lovett & P.Shah (Eds.), *Thinking with data: The proceedings of the 33rd Carnegie Symposium on Cognition*(pp. 233–265). Mahwah, NJ: Erlbaum.

McNeill, K. L. & Krajcik, J. (2009). Synergy between teacher practices and curricular scaffolds to support students in using domain specific and domain general knowledge in writing arguments to explain phenomena. *The Journal of the Learning Sciences, 18*(3), 416-460.

Messick, S. (1992). The interplay of evidence and consequences in the validation of performance assessments. *Educational Researcher, 23*(2), 13–23.

Merriam, S. B. (1998). *Qualitative research and case study applications in education*. San Francisco, CA: Jossey-Bass.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation*. San Francisco, CA: Jossey-Bass.

Mezirow, J. (1981). "A Critical Theory of Adult Learning and Education." *Adult Education* 32 (1981): 3–23.

Mitchell, J. F. B. (1989), The "Greenhouse" effect and climate change, *Reviews of Geophysics., 27*(1),115–139, doi:10.1029/RG027i001p00115.

Ministery of National Education. (2005). Ilköğretim fen ve teknoloji ders öğretim programi (6, 7 ve 8. siniflar). Ankara.

Ministery of National Education. (2013). Ilköğretim fen ve teknoloji ders öğretim programi (6, 7 ve 8. siniflar). Ankara.

Ministry of Energy and National Resources. (2013). Geothermal Energy. Retrieved From http://www.enerji.gov.tr/index.php?dil=en&sf=webpages&b=jeotermal_EN&bn=234&hn=&nm=40717&id=40735.

Moody, N. B., & Estep, K. K. (2010). Problem Solving with Reflective Judgment A Quality Enhancement Plan Proposal. http://www.tusculum.edu/academics/qep/DRAFTJAN20.pdf

Moll, L. C. (1992). Literacy research in community and classrooms: A sociocultural approach. In R. Beach, J. Green, M. Kamil, & T. Shannahan (Eds.), Multidisciplinary perspectives in literacy research (pp. 211-244). Urbana, IL: National Conference on Research in English. [Reprinted in R. Rudell, M. Rapp Rudell, & H. Singer (Eds.). (in press). Theoretical models and processes of reading. Newark, DE: International Reading Association.]

Monk, M. and Osborne, J. (1997), Placing the history and philosophy of science on the curriculum: A model for the development of pedagogy. Science Education, 81: 405–424.

Motschnig-Pitrik, R., & Holzinger, A. (2002). Student-Centered Teaching Meets New Media: Concept and Case Study. Journal of Educational Technology & Society, 5(4), 160-172.

Mueller, M. P. & Zeidler, D. L. (2010). Moral-ethical character and science education: Ecojustice ethics through socioscientific issues (SSI). In D. Tippins, M. Mueller, M. van Eijck & J. Adams (Eds.), *Cultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems* (pp. 105-128). New York: Springer.

Mueller, M.P., Zeidler, D.L., & Jenkins, L.L. (2011). Earth's role in moral reasoning and functional scientific literacy. In J. DeVitis & T. Yu (Eds.). *Character and moral education: A reader* (pp. 382-391). New York: Peter Lang.

Mueller, M. P. & Zeidler, D. L. (2010). Moral-ethical character and science education: Ecojustice ethics through socioscientific issues (SSI). In D. Tippins, M. Mueller, M. van Eijck & J. Adams (Eds.), *Cultural studies and environmentalism: The confluence of ecojustice, place-based (science) education, and indigenous knowledge systems* (pp. 105-128). New York: Springer.

National Research Council. (1996). National science education standards. National Academy Press, Washington, DC. 262.

National Research Council. (2012). National science education standards. National Academy Press, Washington, DC. 262.

Next Generation Science Education Standards. (2012). *Next Generation Science Education Standards: For States, By State*s. Washington, DC: The National Academies Press.

Newton, P., Driver, R., & Osborne, J. (1999). The place of argumentation in the pedagogy of school science**.** *International Journal of Science Education, 21*(5), 553–576.

Nuffield Foundation, Twenty First Century Science (2013) Scientific literacy. Retrieved from: http://www.nuffieldfoundation.org/twenty-first-century-science/scientific-literacy.

Nussbaum, J. (1989). Classroom conceptual change: philosophical perspectives. *International Journal of Science Education, 11*(5), 530-540.

Okpala, N. P.& Onocha, C. O. (1988). The relative effects of two instructional methods on students' perceived difficulty in learning physics concepts. Kenya Journal of Education, 4(1),147-161.

Organisation for Economic Co-operation and Development. (2012). OECD Programme for International Student Assessment (PISA). Retrieved from http:/ /www.pisa.oecd.org on August 21, 2013

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections*. London: The Nuffield Foundation.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. *Journal of Research in Science Teaching*, *82*(10), 63-70.

Ozdemir, O., (2010). Fen ve Teknoloji Öğretmen Adaylarının Fen Okuryazarlığının Durumu. *Turkish Science Education,* 7 (3).

Pallant, J. (2007). SPSS Survival Manual, 3rd Edition, Crows West, New South Wales.

Patronis, T., Potari, D., & Spiliotopoulou, V. (1999). Students' argumentation in decision-making on a socio-scientific issue: implications for teaching. *International Journal of Science Education,* 21:7, 745 – 754. DOI: 10.1080/095006999290408.

Patton, M. Q. (2002). *Qualitative research and evaluation methods*. Thousand Oaks, CA: Sage.

Perry, W.G. Jr. (1981). Cognitive and ethical growth: The making of meaning. In A.W. Chickering et al. (Eds.). *The modern American college: Responding to the new realities of diverse students and a changing society*. San Francisco: Jossey-Bass.

Piaget, J. (1973). *Main Trends in Psychology*. London: George Allen & Unwin.

Piaget, J. (1974). Stages of intellectual development in the child and adolescent. In J. Piaget (Ed.). *The child and reality (A. Rosin, Trans.).* New York: Viking. (Original work published 1956).

Plomp, T. (2007). Educational design research: An introduction. In T. Plomp & N. Nieveen (Eds.), An introduction to educational design research. Enschede: SLO

Pouliot, C. (2008). Students' inventory of social actors concerned by the controversy surrounding cellular telephones: A case study. *Science Education*, *92*(3), 543-559.

Program For International Student Assesment. (2013). Retrieved from http://nces.ed.gov/surveys/pisa/

Reiser, B. J., Tabak, I., Sandoval, W. A., Smith, B. K., Steinmuller, F., & Leone, A. J. (2001). BGuILE: Strategic and conceptual scaffolds for scientific inquiry in biology classrooms. In S. M. Carver & D. Klahr (Eds.), Cognition and instruction: 25 years of progress. Mahwah, NJ: Lawrence Erlbaum.

Reiff, R., Harwood, W. S., Phillipson, T. "A scientific method based upon research scientists' conceptions of scientific inquiry." Proceedings of the 2002 Annual International Conference of the Association for the Education of Teachers in Science, eds. Peter A. Rubba, James A. Rye, Warren J. Di Biase, Barbara A. Crawford. ERIC Document Reproduction Service No. ED (465 602).

Rescher, N. (1988). *Rationality: A Philosophical Inquiry Into the Nature and the Rationale of Reason.* Oxford University Press.

Rescnik, L. B. (2010). Nested Learning Systems for the Thinking Curriculum. *Educational Researcher, 39* (3), 183-197.

Rivard, L. P., & Straw, S. W. (2000). The effect of talk and writing on learning science: an exploratory study. *Science Education, 84,* 566–593.

Roberts, D. A. (2007). Scientific literacy/Science literacy. In S.K. Abell & N.G. Lederman, (Eds.). *Handbook of research on science education* (pp. 729–780). Mahwah, NJ: Lawrence Erlbaum.

Ryder, J. (2001). Identifying science understanding for functional scientific literacy. *Studies in Science Education, 35,* 1-44.

Sadler, T. D. (2004). Moral and ethical dimensions of socioscientific decision-making as integral components of scientific literacy. *The Science Educator, 13,* 39-48.

Sadler, T. D. (2006). Promoting Discourse and Argumentation in Science Teacher Education. *Journal of Science Teacher Education, 17*(4), 323-346.

Sadler, T. D. (2011). *Socio-scientific Issues in the Classroom: Teaching, Learning and Research.* Springer.375.

Sadler, T. D., Barab, S. A., & Scott, B. (2007). What do students gain by engaging in socioscientific inquiry? *Research in Science Education, 37* , 371-391.

Sadler, T. D., Chambers, F. W., & Zeidler, D.L. (2004) Student conceptualizations of the nature of science in response to a socioscientific issue, *International Journal of Science Education*, *26*(4), 387-409.

Sadler, T. D., & Donnelly, L. A. (2006). Socioscientific argumentation: The effects of content knowledge and morality. *International Journal of Science Education, 28*, 1463-1488.

Sadler, T. D., & Fowler, S. (2006). A threshold model of content knowledge transfer for socioscientific argumentation. *Science Education, 90*, 986-1004.

Sadler, T. D., & Zeidler, D. L. (2005). Patterns of informal reasoning in the context of socioscientific decision making. *Journal of Research in Science Teaching, 42*, 112-138.

Sadler, T.D. & Zeidler, D.L. (2009). Scientific literacy, PISA, and socioscientific discourse: Assessment for progressive aims of science education. *Journal of Research in Science Teaching*, 46(8), 909-921.

Sahin, U. (2013). The Classroom Teachers' Skills to Organıze Constructivist Learning Environment, International Journal of Elementary Education, 2(2), 16-22. doi:10.11648/j.ijeedu.20130202.11

Sahin, E., Ertepınar, H. & Teksöz, G. (2012). University Students' Behaviors Pertaining to Sustainability: A Structural Equation Model with Sustainability-related attributes. *International Journal of Environmental and Science Education, 7*, p.459-478.

Saltmarsh, M. & Insall, L. (2013). Food Additives and Why They Are Used. In M. Saltmarsh (Eds.). *Essential Guide to Food Additives,* (4th Ed.), Royal Society of Chemistry, www.rsc.org.

Sampson, V. & Blanchard, M. R. (2012). Science teachers and scientific argumentation: Trends in views and practice. *Journal of Research in Science Teaching, 49,* 1122–1148. doi: 10.1002/tea.21037.

Sampson, V. & Clark, D. (2008). Assessment of the ways students generate arguments in science education: Current perspectives and recommendations for future directions. *Science Education, 92*(3), 447-472.

Sandoval, W. A., & Millwood, K. (2005). The quality of students' use of evidence in written scientific explanations. *Cognition & Instruction, 23*(1). 23-55.

Sari, E., & Lim, C. P., (2012). Design-based Research: Understanding its Application in a Teacher Professional Development Study in Indonesia. *Asia-Pacific Education Researcher, 21*(1). 28-38.

Sayre, A. (1975). *Rosalind Franklin and DNA,* New York: W.W. Norton and Company, ISBN 0-393-32044-8.

Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation in education: Theory, research, and applications* (3rd ed.). Upper Saddle River, NJ: Pearson/Merrill Prentice Hall.

Schraw, G. (2001). Current themes and future directions in epistemological research: A commentary. *Educational Psychology Review, 14,* 451-464.

Schwarz, C. (2009). Developing preservice elementary teachers' knowledge and practices through modeling-centered scientific inquiry. *Science Education, 93,* 720–744. doi: 10.1002/sce.20324

Schwartz, R., & Crawford, B. (2006). Authentic scientific inquiry as context for teaching nature of science. In L. Flick & N. Lederman (Eds.). *Scientific inquiry and the nature of science: Implications for teaching, learning and teacher education*. (pp. 331-356). Dordrecht, The Netherlands.

Serpen, U., Aksoy, N., Öngür, T., Korkmaz D. E. (2008). Geothermal energy in Turkey: 2008 update. *Geothermics, 38,* (2), 227–237.

Seethaler, S., & Linn, M. C. (2004). Genetically modified food in perspective: An inquiry- based curriculum to help middle school students make sense of tradeoffs. *International Journal of Science Education, 26* (14)

Shamos, M. H. (1995). *The myth of scientific literacy*. New Brunswick, NJ: Rutgers University Press.

Shiland, T.W. (1999). Constructivism: The Implications for Laboratory Work, *Journal of Chemical Education, 76*(1), 107-109

Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage.

Stein, N.L. and Miller, C. A. (1991) I win-You lose: The development of Argumentative Thinking. In J.F. Voss, D.N. Perkins, and J.W. Segal (eds) *Informal Reasoning and Education.* (Hillsdale, New Jersey, Lawrence Erlbaum Associates) pp. 265-290

Sönmez, A., & Kılınç, A. (2012). Preservice science teachers' self-effiacy beliefs about teaching GM Foods: The potential effects of some psychometric factors. *Necatibey Journal of Science and Mathematics Educatio*n (in Turkish). 6(2), 49-76.

Tal, T. & Kedmi, Y. (2006). Teaching socio-scientific issues: Classroom culture and students' performances. *Cultural Studies in Science, 1*. 615–644.

Tamir, P. (1983). Inquiry and the science teacher. *Science Teacher Education, 67*, 657- 672.

Tobin K.G. (1990). Research on science laboratory activities; in pursuit of better questions and answers to improve learning, *School Science and Mathematics, 90,* 403-418.

Topcu, M. S., Sadler, T. D., & Yilmaz-Tuzun, O. (2010). Preservice Science Teachers' Informal Reasoning about Socioscientific Issues: The influence of issue context. *International Journal of Science Education.1, 1-21.*

Toulmin, S. (1958). The uses of argument. Cambridge: Cambridge University Press.

Tuncer-Teksoz, G. (2011). Managing Air Pollution: How Does Education Help?,. "The Impact of Air Pollution on Health, Economy, Environment and Agricultural Sources. Retrieved from http://www.intechopen.com/books/the-impact-of-air-pollution-on-health-economy-environment-and-agricultural-sources/managing-air-pollution-how-does-education-help-

Turkish Atomic Energy Authority, (TAEA, 2013). http://www.taek.gov.tr/en/home.html/

United Nations. 2008. *2006 Energy Statistics Yearbook*. United Nations Department for Economic and Social Information and Policy Analysis, Statistics Division, New York.

United Nations Educationals Scientific and Cultural Organizations. (1977). Final Report, Intergovernmental Conference on Environmental Education organized by Unesco in co-operation with UNEP, Tbilisi (USSR).

United Nations Environment Programme. (2012). 21 Issues for the 21st Century: Result of the UNEP Foresight Process on Emerging Environmental Issues. Nairobi, Kenya.

United States General Accounting Office. (1990). Case Study Evaluations. Transfer Paper 10.1.9. Program Evaluation and Methodology Division. Washington DC

Vik, G. N. (2004). Breaking bad habits: Teaching effective powerpoint use to working graduate students. *Business Communication Quarterly*, 67(2), 225-228.

Walker, J. & Sampson, V**.** (2013). Learning to argue and arguing to learn in science: Argument-Driven Inquiry as a way to help undergraduate chemistry students learn how to construct arguments and engage in argumentation during a laboratory course. *Journal of Research in Science Teaching, 50*(50), 561-596.

Walker, K.A. & Zeidler, D.L. (2007). Promoting discourse about socioscientific issues through scaffolded inquiry. *International Journal of Science Education, 29*(11), 1387-1410.

Wilen, W. W. (2004). Refuting misconceptions about classroom discussion. *The Social Studies, 95*(1), 33-39.

Wilson, K., M. (2000). Communicating climate change through the media: Predictions, politics, and perceptions of risks. In Allan S, Adam B, Carter C (Eds.). *Environmental Risks and the Media,* pp 201–217. New York, NY, USA: Routledge.

World Health Organization. (2001). Estimated deaths & DALYs attributable to selected environmental risk factors, Retrieved from http://en.wikipedia.org/wiki/Air_pollution

van Eemeren, F. H., Grootendorst, R. (2004). *A systematic theory of argumentation: The pragma-dialectical approach.* Cambridge University Press, New York. 215.

Voss, J.F. & Van Dyke, J.A. (2001). Argumentation in Psychology. *Discourse Processes, 32(2&3),* 89-111.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Yacoubian, H. A. & BouJaoude, S. (2010). The effect of reflective discussions following inquiry-based laboratory activities on students' views of nature of science. *Journal of Research in Science Teaching, 47*, 1229–1252. doi: 10.1002/tea.20380

Yager, R. E., Engen, H. B., & Snider, B. C. (1969). Effects of the laboratory and demonstration methods upon the outcomes of instruction in secondary biology. *Journal of Research in Science Teaching*, *6* (5), 76-86.

Yetişir, M.İ. (2007). İlköğretim fen bilgisi öğretmenliği 1. sınıfta okuyan öğretmen adaylarının fen ve teknoloji okuryazarlığı düzeyleri. Yayınlanmamış Doktora Tezi, Gazi Üniversitesi Eğitim Bilimleri Enstitüsü, Ankara.

Yin, R. K. (2003). *Case study research: Design and methods (3rd ed.).* Applied Social Research Methods Series, 5. Thousand Oaks, CA: Sage Publications, Inc.

Yin, R. K. (2011). *Qualitative research from start to finish*. New York, NY: The Guilford Press.

Yılmaz-Tüzün, Ö., Teksöz-Tuncer, G., & Aydemir, M. (2008). An Investigation on the Elementary Teachers' Knowledge about Air Pollution Issues. *Hacettepe University Journal of Education, 35,* p.374-385.

Zacharia, Z. (2003). The effects of an interactive computer-based simulation prior to performing a laboratory inquiry-based experiment on students' conceptual understanding of physics. *American journal of physics, 71,*618.

Zeidler, D. L. (2001). Participating in program development: Standard F. In D. Siebert & W. McIntosh (Eds.), *College pathways to the science education standards* (pp. 18 – 22). Arlington, VA: National Science Teachers Press.

Zeidler, D. L. (2003). *The Role of Moral Reasoning on Socioscientific Issues and Discourse in science education*. Kluwer Academic Publishers. 311.

Zeidler, D.L. (In Press). Socioscientific Issues as a Curriculum Emphasis: Theory, Research and Practice. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. xxx-xxx). Mahwa, New York: Routledge, Taylor and Francis.

Zeidler, D.L., Applebaum, S.M. & Sadler, T.D. (2011). Enacting a socioscientific issues classroom: Transformative transformations. In T. D. Sadler (Ed.), *Socio-scientific issues in science classrooms: Teaching, learning and research* (pp. 277-306). The Netherlands: Springer.

Zeidler, D.L., Berkowitz, M. & Bennett, K. (2014). Thinking (scientifically) responsibly: The cultivation of character in a global science education community**.** In M.P. Mueller,D.J. Tippins & A.J. Steward (Eds.), *Assessing schools for generation R (Responsibility): A guide to legislation and school policy in science education*. (pp. 83-99). The Netherlands: Springer.

Zeidler, D.L. & Keefer, M. (2003). The role of moral reasoning and the status of socioscientific issues in science education: Philosophical, psychological and pedagogical considerations. In D.L. Zeidler (Ed.), *The role of moral reasoning on socioscientific issues and discourse in science education* (pp. 7-38). The Netherlands: Kluwer Academic Press.

Zeidler, D.L. & Lewis, J. (2003). Unifying themes in moral reasoning on socioscientific issues and discourse. In D.L. Zeidler (Ed.), *The role of moral* *reasoning on socioscientific issues and discourse in science education*. The Netherlands: Kluwer Academic Press. (pp. 289-306).

Zeidler, D.L. & Nichols, B.H. (2009). Socioscientific issues: Theory and practice. *Journal of Elementary Science Teacher Education, 21*(2), 49-58.

Zeidler, D.L., Sadler, T.D., Applebaum, S. & Callahan, B.E. (2009). Advancing reflective Judgment through socioscientific issues. *Journal of Research in Science Teaching, 46*(1), 74-101.

Zeidler, D.L., Sadler, T.D., Simmons, M.L. & Howes, E.V. (2005). Beyond STS: a research-based framework for socioscientific issues education. *Science Education, 89*(3), 357-377.

Zeidler, D.L., Applebaum, S.M. & Sadler, T.D. (2011). Enacting a socioscientific issues classroom: Transformative transformations. In T. D. Sadler (Ed.), *Socio-scientific issues in science classrooms: Teaching, learning and research* (pp. 277-306). The Netherlands: Springer.

Zhong, Y., & Power, G. (1996). Environmental impacts of hydroelectric projects on fish resources in China Regulated Rivers. *Research & Management*, *12* (1), 81–98.

Zohar, A., & Nemet, F. (2002). Fostering students‟ knowledge and argumentation skills through dilemmas in human genetics. *Journal of Research in Science Teaching, 39*(1), 35-62.

APPENDICES

Appendix A: Courses Taken in ECE Program in METU

FIRST YEAR

First Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
PSY100	GENERAL PSYCHOLOGY	3	3	0	5.0
ECE100	INTRODUCTION TO EARLY CHILDHOOD EDUCATION	3	3	0	5.0
ECE120	ANATOMY AND PHYSIOLOGY	3	3	0	5.0
EDS200	INTRODUCTION TO EDUCATION	3	3	0	5.0
ENG101	ENGLISH FOR ACADEMIC PURPOSES I	4	4	0	6.0
IS100	INTRODUCTION TO INFORMATION TECHNOLOGIES AND APPLICATIONS	0	0	2	1.0
Any 1 of the following set ..					
TURK103	WRITTEN EXPRESSION	2	2	0	4.0
TURK201	ELEMENTARY TURKISH	0	4	0	2.0

Secand Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
ECE104	MATERNAL AND CHILD HEALTH AND FIRST AID	3	3	0	5.0
ECE110	CHILD DEVELOPMENT AND PSYCHOLOGY	4	4	0	6.0
ECE126	MATERNAL AND CHILD NUTRITION	2	2	0	4.5
ENG102	ENGLISH FOR ACADEMIC PURPOSES II	4	4	0	6.0
Any 1 of the following set ..					
TURK104	ORAL COMMINICATION	2	2	0	4.0
TURK202	INTERMEDIATE TURKISH	0	4	0	2.0
Any 1 of the following set ..					
SOC100	PRINCIPLES OF SOCIOLOGY	3	3	0	5.0
SOC104	INTRODUCTION TO SOCIOLOGY	3	3	0	6.0

SECOND YEAR

Third Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
ECE201	MUSIC I	2	1	2	4.5
ECE215	PLAY IN EARLY CHILDHOOD	3	3	0	5.0
ECE250	BASIC SCIENCE	3	3	0	5.0
CEIT100	COMPUTER APPLICATIONS IN EDUCATION	3	2	2	4.0
EDS220	EDUCATIONAL PSYCHOLOGY	3	3	0	5.0
ENG211	ACADEMIC ORAL PRESENTATION SKILLS	3	3	0	4.0
	ELECTIVE				

Fourth Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
ELE240	PROBABILITY AND STATISTICS	3	2	2	4.0
ECE202	MUSIC II	3	2	2	5.0
ECE206	MENTAL HEALTH AND ADAPTATION DISORDERS	3	2	2	5.0
ECE208	CHILDREN S LITERATURE	3	3	0	5.0
ECE214	TEACHING SCIENCE IN EARLY CHILDHOOD	3	2	2	6.0
ECE220	PHYSICAL EDUCATION AND GAMES	3	2	2	5.0
ECE230	CURRICULUM IN EARLY CHILDHOOD EDUCATION	3	3	0	6.0

THIRD YEAR

Fifth Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
ELE301	RESEARCH METHODS	3	3	0	8.0
ELE329	INSTRUCTIONAL TECHNOLOGY AND MATERIAL DEVELOPMENT	3	2	2	5.5
ECE213	TEACHING MATHEMATICS IN EARLY CHILDHOOD	3	3	0	5.0
ECE303	SCHOOL EXPERIENCE	3	1	4	6.0
ECE306	VISUAL ARTS AND MATERIAL DEVELOPMENT	3	2	2	5.0
ECE326	METHODS OF TEACHING IN EARLY CHILDHOOD EDUCATION	3	2	2	5.0
ECE340	CLASSROOM MANAGEMENT AND DISCIPLINE IN ECE	3	2	2	6.0
Any 1 of the following set ..					
HIST2201	PRINCIPLES OF KEMAL ATATÜRK I	0	2	0	2.0
HIST2205	HISTORY OF THE TURKISH REVOLUTION I	0	2	0	2.0

Sixth Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
ELE310	COMMUNITY SERVICE	2	1	2	4.0
ECE302	DRAMA IN EARLY CHILDHOOD EDUCATION	3	2	2	5.0
ECE315	CHILDREN WITH SPECIAL NEEDS	2	1	2	4.5
ECE325	PARENT INVOLVEMENT AND EDUCATION	3	3	0	6.0
ECE466	INSTRUCTIONAL PRINCIPLES AND METHODS	3	3	0	5.0
Any 1 of the following set ..					
HIST2202	PRINCIPLES OF KEMAL ATATÜRK II	0	2	0	2.0
HIST2206	HISTORY OF THE TURKISH REVOLUTION II	0	2	0	2.0
	ELECTIVE				

FOURTH YEAR

Seventh Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
ECE409	CREATIVITY AND CHILDREN	3	2	2	6.0
ECE410	ASSESSMENT AND EVALUATIN IN ECE	3	3	0	6.0
ECE411	PRACTICE TEACHING I	5	2	6	11.0
ENG311	ADVANCED COMMUNICATION SKILLS	3	3	0	4.0

Eighth Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
ECE430	PRACTICE TEACHING II	5	2	6	11.0
ECE480	SCHOOL READINESS AND TRANSITION TO ELEMENTARY SCHOOL	2	2	0	4.5
EDS416	TURKISH EDUCATIONAL SYSTEM AND SCHOOL MANAGEMENT	3	3	0	5.0
EDS424	GUIDANCE	3	3	0	5.0

Appendix B: Courses Taken in ESE Program in METU

FIRST YEAR

First Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
PHYS181	BASIC PHYSICS I	5	4	2	6.5
CHEM101	GENERAL CHEMISTRY I	5	4	2	7.5
MATH117	CALCULUS I	5	5	0	7.5
EDS200	INTRODUCTION TO EDUCATION	3	3	0	5.0
ENG101	ENGLISH FOR ACADEMIC PURPOSES I	4	4	0	6.0
IS100	INTRODUCTION TO INFORMATION TECHNOLOGIES AND APPLICATIONS	0	0	2	1.0

Secand Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
PHYS182	BASIC PHYSICS II	5	4	2	6.5
CHEM102	GENERAL CHEMISTRY II	5	4	2	7.5
MATH118	CALCULUS II	5	5	0	7.5
CEIT100	COMPUTER APPLICATIONS IN EDUCATION	3	2	2	4.0
ENG102	ENGLISH FOR ACADEMIC PURPOSES II	4	4	0	6.0

SECOND YEAR

First Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
PHYS283	OPTICS AND MODERN PHYSICS	4	4	0	7.0
CHEM281	FUND.OF ANAL.AND INORG.CHEMISTRY	3	3	0	5.0
BIOL101	GENERAL BIOLOGY I	6	4	4	9.0
ELE240	PROBABILITY AND STATISTICS	3	2	2	4.0
EDS220	EDUCATIONAL PSYCHOLOGY	3	3	0	5.0
ENG211	ACADEMIC ORAL PRESENTATION SKILLS	3	3	0	4.0
Any 1 of the following set ..					
HIST2201	PRINCIPLES OF KEMAL ATATÜRK I	0	2	0	2.0
HIST2205	HISTORY OF THE TURKISH REVOLUTION I	0	2	0	2.0

Secand Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
CHEM282	FUND.OF ORGANIC CHEMISTRY	3	3	0	5.0
BIOL102	GENERAL BIOLOGY II	6	4	4	9.0
ELE221	INSTRUCTIONAL PRINCIPLES AND METHODS	3	3	0	6.0
ELE225	MEASUREMENT AND ASSESSMENT	3	3	0	5.0
ASTR201	ASTRONOMY I	3	3	0	5.0
Any 1 of the following set ..					
HIST2202	PRINCIPLES OF KEMAL ATATÜRK II	0	2	0	2.0
HIST2206	HISTORY OF THE TURKISH REVOLUTION II	0	2	0	2.0

THIRD YEAR

First Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
BIOL252	PHYSIOLOGY	3	3	0	7.0
ELE329	INSTRUCTIONAL TECHNOLOGY AND MATERIAL DEVELOPMENT	3	2	2	5.5
ELE331	LABORATORY APPLICATIONS IN SCIENCE I	3	2	2	5.5
ELE343	METHODS OF TEACHING SCIENCES I	3	2	2	6.0
Any 1 of the following set ..					
TURK201	ELEMENTARY TURKISH	0	4	0	2.0
TURK305	ORAL COMMUNICATION	2	2	0	4.0
	ELECTIVE				

Secand Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	ECTS
BIOL317	MOLECULAR BIOLOGY	3	3	0	6.0
ELE310	COMMUNITY SERVICE	2	1	2	4.0
ELE344	METHODS OF TEACHING SCIENCE II	3	2	2	6.0
EDS304	CLASSROOM MANAGEMENT	3	3	0	5.0
GEOE231	ELEMENTS OF GEOLOGY	3	3	0	5.0
Any 1 of the following set ..					
TURK202	INTERMEDIATE TURKISH	0	4	0	2.0
TURK306	WRITTEN EXPRESSION	2	2	0	4.0

FOURTH YEAR

First Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)
ELE411	ENVIRONMENTAL SCIENCES	3	3	0
ELE435	SCHOOL EXPERIENCE	3	1	4
ELE440	SCIENCE, TECHNOLOGY, AND SOCIETY	3	3	0
	ELECTIVE			
	ELECTIVE			
	ELECTIVE			

Secand Semester

Course Code	Course Name	METU Credit	Contact (h/w)	Lab (h/w)	EC
BIOL433	INTRODUCTION TO EVOLUTION	3	3	0	6.
ELE420	PRACTICE TEACHING IN ELEMENTARY EDUCATION	5	2	6	12
EDS416	TURKISH EDUCATIONAL SYSTEM AND SCHOOL MANAGEMENT	3	3	0	5.
EDS424	GUIDANCE	3	3	0	5.

Appendix C: Example Laboratory Manual for Transportation Issue

Name :   Date:

Group no:

Transportation ıssue: Incomplete Combustion

Introduction:

Clean air contains only the gases and water vapor needed to keep the Earth's environment healthy. Pollutants are substances, or even energy, that harm living — and some non-living — things. A high concentration of pollutants in the air is called air pollution.

Air pollution can destroy our environment and can cause humans and other living things to become sick. Sometimes, air pollution can cause rashes, eye/nose irritation, headaches, sleepiness, coughing, sneezing and dizziness. If you breathe in too much air pollution, of a very high concentration, it can cause severe illnesses, such as cancer, asthma, kidney failure, liver damage and even birth defects. Air pollution negatively affects the plants and animals in our environment as well. In this lab we are going to conduct an experiment which is a kind of combustion.

Research Question: *Do you think that engineers create technology that reduce exhaust gas and reduce the effects of transportation issue on air pollution?*

Materials:

- Candle
- Tin
- Paper Towel

Procedure:

Incomplete combustion in cars is one of the leading sources of air pollution. This experiment can be used to introduce students to this common source of pollution.

1. Light the candle.

2. Place the bottom of the tin can directly over the flame for a few seconds. The top of the flame should be almost touching the can.

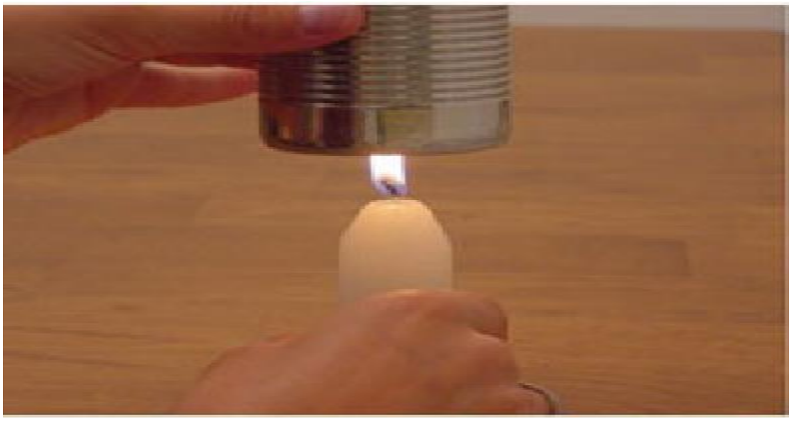

Figure 1

1. Look at the bottom of the can. What do you see? Write your observations.

2. Clean off the bottom of the can with a paper towel. Write your observations what do you see on the towel?

3. Generally, most cars burn gasoline (a fossil fuel), what do you think about these statements, do they cause air pollution?

4. How did you come to hold that point of view?

5. On what do you base that point of view? (your view on previous question)

6. Some cars release remarkably seen black exhaust gas similar as your observation on first step, some cars do not. What do you think about those cars that do not release "remarkably seen" exhaust gas, do they cause air pollution?

7. How sure you are about your statement, related to previous question, is true? How or why not?

8. Repeat the procedure, but use the straw to gently blow air on the bottom of the can. Be careful not to blow the flame out.

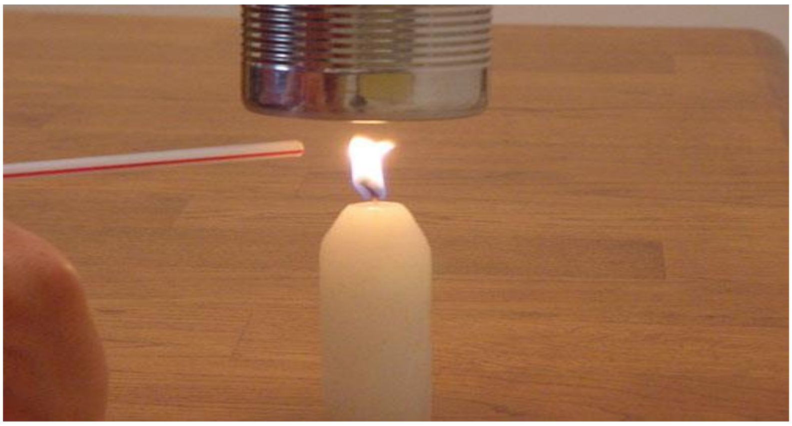

Figure 2

9. Look at the bottom of the can and write your observations. Do you see any pollutants?

10. How the additional air affected the combustion of the candle. Write your responses.

11. Do you think that engineers create technology that reduce exhaust gas and clean up air pollution?

12. Some people claim that engineers create technology to help industry clean up their air pollution therefore there is no need to concern for this. Opponents asserts industry itself is a major reason of air pollution. When two people differ about matters such as this, is it the case that one opinion is right and one is wrong?

If yes, what do you mean by ‘‘right’’?

If no, can you say that one opinion is in some way better than the other? What do you mean by ‘‘better’’?

13. How is it possible that people have such different points of view about this subject?

14. How is it possible that experts in the field disagree about this subject?

Appendix D: Example Laboratory Manual for Food Additives

Name :   Date:

Group no:

Emulsifiers and stabilizers

Introduction:

Stabilizers and emulsifiers are food additives. They, and other similar additives, are numbered from E331(c) to E495. They are widely used in the food industry in products such as salad dressings, processed cheese, preserves, margarine, yoghurt, instant desserts, ice cream, low fat products and others.

Emulsifiers and stabilizers are used to help to retain the physical qualities of products. Emulsifiers make water and oil mix together evenly. Stabilizers give products good texture and mouth feel.

When you make food at home, such as some of the items mentioned above, there is often no need to add extra emulsifiers or stabilizers to the recipe. So why does the food industry use emulsifiers and stabilizers so often? To answer this question you should think about the differences between producing food for the home and food for sale in shops and supermarkets.

Home-made foods such as salad dressings, yoghurt and ice cream are excellent and nutritious products. However, nowadays more of these products are bought from shops rather than made at home. Think of as many reasons as you can to explain this trend.

Research Question: *How does an emulsifier effect food industry?*

Matarials:

- Test tubes
- Test tube rack
- 5 cm3 tap water
- 5 cm3 cooking oil
- 1 cm3 whisked egg yolk.

Procedure:

1. Pour about 2 cm depth of tap water into a test tube. Carefully add an equal depth of cooking oil to the same tube. Note down what the contents of the tube look like.

2. Pour about 2 cm depth of water into another test tube. Carefully add an equal depth of cooking oil to the same tube. Add 1 cm depth of egg yolk. Put a bung in each tube and then shake both of the tubes for 30 seconds. Leave the tubes to stand in a test tube rack. Look carefully at the tubes over the next few minutes.

a. Note down what the tube looks like.

b. Does it matter the amount of egg yolk added into solution?

3. What will happen if you add large amount of egg yolk into solution?

4. Do you think that emulsifiers have the same effect on two liquid that do not mix each other?

5. Emulsifiers have a big effect on the structure and texture of many foods. What do you think about these statements? Do they cause health problems?

6. How did you come to hold that point of view?

7. On what do you base that point of view?

8. Can you ever know for sure that your position on this issue is correct? How or why not?

9. Some people claim that emulsifiers help to maintain food freshness and quality. Opponents assert that natural emulsifiers like soy, milk and eggs can be dangerous to allergic reaction. When two people differ about matters such as this, is it the case that one opinion is right and one is wrong?

A) If yes, what do you mean by ‘‘right’’?

B) If no, can you say that one opinion is in some way better than the other? What do you mean by ‘‘better’’?

a) How is it possible that people have such different points of view about this subject?

b) How is it possible that experts in the field disagree about this subject?

Appendix E: Example Laboratory Manual for Alternative Energy

Name :   Date:

Group no:

Energy Sources: Wind power

Introduction:

There are different energy sources using in the world. Nuclear energy, hidroelectric, jeotermal, wind power, and solar energy are some of them. Wind power is used in different part of Turkey such as İstanbul, Çanakkale, Balıkesir, Hatay, Manisa, and so on. Turkey's 1.7 % of electric energy is obtained from wind.

In this lab, we are going to make an experiment in order to understand wind power with this experiment, we want to learn to build a wind turbine and test it to see how much energy is created. We can build a variety of wind blades, test a variety of wind speeds and see what effect these have on the energy created.

Research question: *How can we use wind as an energy source?*

Materials

- Three PVC pipes, one about 30 cm long and the others at least 15 cm long
- Three PVC T-joints
- One PVC elbow joint
- Motor
- Wire (about two feet long)
- Wire cutters
- Hub
- Wood dowels
- Multimeter
- Alligator clips
- Scissors
- Tape
- Hair dryer or fan
- Materials for blades, such as balsa wood, aluminum foil , construction paper, popsicle sticks, etc

Procedure:

Insert a 15-cm PVC pipe into the middle hole of a PVC T-joint. Repeat with another 15-cm PVC pipe and T-joint. Join the two pieces together by inserting the free ends of the pipes into the sides of a third T-joint, with the middle hole facing up. Insert the remaining PVC pipe into the T-joint hole that is facing up, so that the pipe stands upright. Place the final T-joint on the free end of the tower. Attach two wires to the motor. Place the motor securely into the joint at the top of the tower. Run the wires down the tower pipe and out one of the T-joints on the base. If needed, use duct tape to keep the motor in place securely.

Attach the plastic, round piece called the hub to the straight, metal piece on the outside of the motor. Connect the wires to the multimeter using the alligator clips. Set the multimeter to 20 volts. Place a few small, wooden dowels into the holes of the hub. Create wind using a hair dryer or fan. Check the multimeter to see how much energy is generated.

Using a variety of materials, design different blades for the wind turbine. Consider the weight, smoothness of surface and number of blades needed. Attach the blades to the dowels using tape.
Turn on the hair dryer or fan again and test the turbine with each type of blade you design. Test the turbine with different wind speeds, such as low, medium and high fan settings.

1. What do you observe when you used cardboard?

2. What the speed of the cardboard?

3. What could happen if you would change the speed of fan?

4. How does the electrical output differ when you use different materials instead of cardboard? Why?

5. What was its result about speed on the multimeter?

6. What is your point of view about most beneficial energy source of Turkey?

7. How did you come to hold that point of view?

8. In which areas we can use wind power?

9. Some people claim that we can use wind power for provide electricity and some others say wind power not enough to provide our needs? When two people have different opinion about matters such as this, is it the case that one opinion is right and one is wrong? If your answer is yes, what do you mean by ‘‘right’’? If your answer is no, can you say that one opinion is in some way better than the other? What do you mean by ‘‘better’’

10. Why people have such different points of view about energy sources? How is it possible?

11. How is it possible that experts in the field disagree about using wind power is enough when others agree?

Appendix F: Example Laboratory Manual for Climate Change

Name : Date:

Group no:

Climate Change: Acid Rain

Introduction:

"Acid rain" is a mixture of wet and dry deposition from the atmosphere containing higher than normal amounts of nitric and sulfuric acids. Acid rain is a serious environmental problem and damaging to lakes, streams, and forests and the plants and animals that live in these ecosystems. Acid rain result from both natural sources, such as volcanoes and decaying vegetation, and man-made sources, primarily emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_x) resulting from fossil fuel combustion.

Acid rain occurs when these gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds. The result is a mild solution of sulfuric acid and nitric acid. Acid rain causes acidification of lakes and streams and contributes to the damage of trees and many sensitive forest soils. In addition, acid rain accelerates the decay of building materials and paints. There are several ways to reduce acid rain ranging from societal changes to individual action. There can be used alternative energy sources and take action for exhaust and smoke from factories.

Now we are going to make an experiment to see acid rain's effects. We will use marble to see how acid rain will damage it.

Research Question: *Does acidic rain has a negative effect on our life and how acid rain can affect our world.*

Materials;

Vinegar, Lemon water, 0.1 molar nitric acid, 0.1 molar sulphuric acid, pH meter, 5 number of breaker, 5 number of marble which are cut to equal shape and size, and electronic weighing machine

Procedure:

100 ml liquids which are vinegar, Lemon water, 0.1 molar nitric acid, 0.1 molar sulphuric acids is put into 5 number of breaker. Firstly, all solutions' pH value is measured with pH meter. Equal marbles are weighed with measurement tool. It has some numbers on it. After that marbles are put into the breakers. And then, breakers which have a marble are put to laboratory for one week. After one week, marbles are picked up and left for drying out for 4 hour.

1. What is the pH value of the solutions?

2. What are the marbles' weights?

3. What is your observation about before waiting one week?

4. What did you observe after one week later? What was the differences between the before and after period?

5. Which acidic solution caused the most abrasion on marble? Why do you think so?

6. What is the relationship between acid rains and climate change issue?

7. On what do you base that point of view?

8. How did you come to hold this point of view?

9. Do you think that acid rain can be reduced? If you say yes how can be reduced?

10. Some people claim that there is no climate change but some others say that there is climate change and we have to take action about this. When two people have different opinion about matters such as this, is it the case that one opinion is right and one is wrong?

If your answer is yes, what do you mean by ‘‘right’’?

11. How is it possible that people have such different points of view about this subject?

12. How is it possible that experts in the field disagree about this subject?

Appendix G: Example Laboratory Manual for Industrial Revolution

Name: Date:

Group no:

Industrial Revolution: Soil Pollution

Introduction:

With the industrial revolution, the technology improved and the material, which is used, started to change. However, the released wastes turned to include heavy metals. These heavy metals are a reason of decrease of fertility of the soil. Also the pH and temperature are affected by the heavy metals.

The most important ingredients of soil are nitrogen, potassium and phosphate. These three elements show that how we can use the soil for.

Nitrogen:

This element is important material for the plants. And they can work best in the pH: 6-8. If it is so acidic, which means $pH<5$, the possibility of fertilize decreases dramatically.

Potassium:

This element has the vital important for the plants. With this element the quality of the product increases, fertility increases.

Phosphate:

This element helps the plant germinate, and it is the energy source for the some plants.

With the releasing heavy metals, the quality of the soil decreases. In this experiment, students will be able to measure the effects of industrial wastes on soil by measuring, pH, nitrogen, potassium and phosphate.

To understand the effects students will take a sample from OSTİM and from METU.

Research question: *How the soil pollution, caused by industrial wastes, can be resolved?*

Materials:

- 5 g soil sample from the OSTİM
- 5 g soil sample from METU
- The kit for the measure degree of NPP

Prodocure?

Experiment: Please follow the instruction in the measurement kit packet.

1. Explain the differences between sample OSTİM and sample METU.?

2. What can be the source of difference?

3. How did you come to hold that point of view?

4. On what do you base that point of view?

5. Can you ever know for sure that your position on this issue is correct? How or why not?

6. When two people differ about matters such as this, is it the case that one opinion is right and one is wrong? If yes, what do you mean by ‘‘right’’? If no, can you say that one opinion is in some way better than the other? What do you mean by ‘‘better’’?

7. How is it possible that people have such different points of view about this subject?

8. How is it possible that experts in the field disagree about this subject?

Appendix H: Reflective Judgment Interview Standard Probe Questions

1. What do you think about these statements? (Note: If no particular point of view is endorsed, ask: 1a) Could you ever say which was the better position? How? Why not? How would you go about making a decision about this issue? Will we ever know for sure which is the better position? How/Why not?	To allow participant to share an initial reaction to the problem presented. Most state which point of view is closer to their own.
2. How did you come to hold that point of view?	To find out how the respondent arrived at the point of view, and whether and how it has evolved from other positions on the issue.
3. On what do you base that point of view?	To find out about the basis of the respondent's point of view, such as a personal evaluation of the data, consistency with an expert's point of view, or a specific experience This provides information about the respondent's concept of justificatioN.
4. Can you ever know for sure that your position on this issue is correct? How or why not?	To find out about assumptions concerning the certainty of knowledge (e.g. whether issues like this can be known absolutely and what the respondent would do in order to increase the certainty, or why that would not be possible.
5. When two people differ about matters such as this, is it the case that one opinion is right and one is wrong? If yes, what do you mean by "right"? If no, can you say that one opinion is in some way better than the other? What do you mean by better"?	Assesses the adequacy of alternative interpretations; to see if dichotomous either/or view of the issue (characteristic of the early stages) is held; to allow the participant to give criteria by which she or he evaluates the adequacy of arguments (information that helps differentiate high-from middle-level stage responses).
6. How is it possible that people have such different points of view about this subject?	To elicit comments about the respondent's understanding of differences in perspectives and opinions (what they are based on and why there is such diversity of opinion about the issue).
7. How is it possible that experts in the field disagree about this subject?	To elicit respondent's understanding of how he or she uses the point of view of an expert or authority in making decisions about controversial issues

Appendix I: Summary of the Reflective Judgment Stages

Epistemic Cognition	**Stages**	**Major characteristic**	**Role of authority**	**Role of evidence**	**View of knowledge**	**Concept of justification**
Pre-reflective	Stage 1	Belief is concrete and single-category (there are no alternatives)	Authority and observation are the source of knowledge	Disconfirming evidence is denied. Belief does not depend on evidence.	Knowledge is absolute and concrete.	Beliefs do not need justification
	Stage 2	There is a true reality, but not everyone knows it.	Authorities know the truth, those who disagree are wrong.	Evidence is not needed to confirm belief, and can not be used to disconfirm belief.	Knowledge is absolute, but not apparent to everyone at every time.	Justification by agreement with authority figure.
	Stage 3	Belief that authorities may not know the truth, but will someday.	Authority is the source of right answers, but there is no way to justify claims in areas of uncertainty	Evidence must be concrete and lead to a single answer.	Knowledge is certain in areas that are known, or temporarily uncertain in areas that are unknown	Right answers are provided by authority, other areas are unclear and defended by personal opinion.
Quasi-reflective	Stage 4	Understanding that one can not know with certainty	Authority is often biased, they fit the evidence to their beliefs.	Evidence is used to confirm subject's prior beliefs	Knowledge is uncertain, there is always some ambiguity.	Justification provided by evidence that supports prior belief.
	Stage 5	Understanding that people can no t know directly, but can within a context based on subjective interpretation of evidence	Authorities are seen as experts in their field, perhaps limited by their perspective.	Evidence can be compared for different beliefs, but can not integrate the evidence.	Knowledge is contextual because it is filtered through a person's perspective.	Beliefs are justified by evidence as it pertains to a particular context.
Reflective	Stage 6	Knowing is a process that requires action on part of the listener.	Authorities are involved in constructing solutions.	Plausibility of evidence and argument can be used to base beliefs for self.	Knowledge is based on information from a variety of sources.	Justification provided by comparing evidence and opinion, utility of solution.
	Stage 7	Interpretations of evidence and opinion can be synthesized into justifiable conjectures.	Subject is involved in constructing knowledge, and is aware that knowledge changes in light of new evidence.	Evidence provides logical solutions to problems, but may change in face of new or better evidence.	Knowledge is constructed by critical inquiry and evaluating evidence.	Beliefs are justified on the basis of probability, we can't know for sure, but wealth of evidence supports view

Appendix J: Ethical Committee

Appendix K: Consent Form

Öğrenci gönüllü katılım formu

Bu çalışma ODTÜ ilköğretim bölümü öğretim üyelerinden Doçent Dr. Özgül Yılmaz-Tüzün yöneticiliğinde yürütülen araştırma görevlisi Dilek Karışan'ın tez çalımasıdır. Bu çalışmanın amacı eğitim fakültesinde öğrenim gören öğretmen adaylarının sosyobilimsel konulara dayalı fen laboratuvar uygulamaları dersindeki reflektif muhakeme yetenekleri ve argümantasyon becerilerini incelemek, ve bu iki değişken arasındaki hipotetik ilişkiyi test etmektir.

Bu amacı gerçekleştirmek için seçmeli fen bilgisi laboratuar uygulamaları dersi için en uygun metotlardan biri olan sorgulayıcı öğretime dayalı laboratuvar yöntemi kullanılacaktır. Bu çalışmaya katılım tamamen gönüllülük temeline dayalıdır. Yapılacak uygulamalarda sizden kimlik belirleyici hiçbir bilgi istenmeyecektir. Cevaplarınız tamamıyla gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir. Elde edilecek bulgular bilimsel yayımlarda kullanılacaktır.

Uygulamalar genel olarak kişisel rahatsızlık verecek soruları içermemektedir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz katılım sürecini yarıda bırakabilirsiniz. Böyle bir durumda araştırmacıyı haberdar etmeniz yeterli olacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz. Çalışma hakkında daha fazla bilgi almak için Dilek Karışan (tel: 210 7516; email; dilekkarisan@gmail.com) ile iletişim kurabilirsiniz.

Bu çalışmaya tamamen gönüllü olarak katılıyorum ve istediğim zaman yarıda bırakabileceğimi biliyorum. Verdiğim bilgilerin bilimsel amaçlı yayımlarda Kullanılmasını kabul ediyorum. (formu doldurup imzaladıktan sonra uygulayıcıya geri veriniz).

Adı & Soyadı Tarih İmza Alınan ders

Appendix L: Turkish summary

ÖĞRETMEN ADAYLARININ REFLEKTİF MUHAKEME VE ARGÜMANTASYON YETENEKLERİNİN SOSYOBİLİMSEL KONULARA VE SORGULAYICI ÖĞRETIME DAYALI LABORATUVAR DERSİNDE İNCELENMESİ

Giriş

Fen eğitiminin genel hedefleri arasında bireylerin bilime karşı meraklarını uyandırmak, bilimin güzelliklerini görmelerini sağlamak, toplum içinde tartışılan konular hakkında yeterli bilgi sahibi olmalarını sağlamak, bilimsel ve teknolojik gelişmelerden haberdar olmalarını ve bu gelişmelerin günlük yaşantılarına etkisinin farkında olmalarını sağlamak vardır. Öğrencilerin, gerçek hayatla direkt bağlantısı olan bu konularla aktif olarak meşgul olmalarının "bilim okuryazarlığına" katkı sağladığı düşünülmektedir.

Milli Eğitim Bakanlığı'nın (2012) Fen Bilgisi müfredatı'nda açıkça belirlediği hedefler arasında bilim okuryazarlığını artırabilecek bazı kazanımlar hedeflenmiştir. Bu kazanımlar; bilimin doğasını anlama, teknolojinin fenle ilişkisini anlama, anahtar kavramları anlama, bilimsel süreç becerilerine sahip olma, fen-teknoloji-toplum ilişkisini kavrayabilme, bilimsel ve teknolojik psikomotor becerilere sahip olma, bilimin önemini kavrama ve fen dersine karşı tutum ve değerlerini olumlu yönde değiştirme olarak listelenmiştir. Bu hedefe ulaşmak için, öğrencilerin fen eğitiminde karşılaştıkları etkinliklerin kendi yaşamları ile ilgili olması ve çağdaş yaşamın bir parçası olması gerekmektedir.(Tal & Kedmi, 2006). Bilim ve teknolojinin, insan hayatını hemen hemen her açıdan etkilediği bilinmektedir. Dolayısıyla temel bilimsel kavramları okuyup anlayabilen (bilim okuryazarı) vatandaşlara ihtiyaç vardır (NRC, 2012).

Bilim okuryazarlığı için literatürde iki büyük görüş hakimdir. Bunlardan ilki (vizyon I) bilimsel süreç ve sonuçlara odaklanır, ikincisi ise (vizyon II) bilime daha geniş perspektiften yaklaşır ve bilim öğrenme esnasında bireyleri toplumun bir parçası olarak ele alır, bilimin bireylerin kişisel ve sosyal yaşamlarına etkisi olduğunu, kişisel karar alma aşamsında etkili olduğunu varsaymaktadır. Bu çalışma bağlamında, bilim okuryazarlığını öğrencilere bilim içeriğini öğretmenin yanı sıra ahlaki gelişimleri için de bir fırsat olarak gören Vizyon II yaklaşımı benimsenmiştir.

Bilim okuryazarlığına ilave olarak, MEB'in (2013) belirlemiş olduğu hedef ve kazanımlar arasında eleştirel düşünme becerisi, problem çözme becerisi, karar verme, işbirlikçi öğrenme ve sosyobilimsel konular hakkında belirli bilgi seviyesinde olma vurgulanmıştır. Fen eğitiminin öncelikli amaçlarından biri öğrencileri toplumun bir parçası olarak yetiştirmektir (Lee ve ark. , 2013). Bu amaç doğrultusunda, fen derslerinin öğrencilerin günlük yaşantıları ile bağlantılı olması ve öğrencilerin reflektif muhakeme yeteneklerini geliştirici düzeyde, kanıtlara dayalı argümantayson yapabilecekleri aktivitelere yer vermesi gerekli görülmektedir (Sadler ve Zeidler, 2005). Bu süreçte öğretmenlere, öğrencilerin aktif katılımlarının desteklendiği, bilim okuryazarlığını geliştirmeye yönelik öğrenme aktiviteleri geliştirmek gibi çok önemli görevler düşmektedir (Fowler , Zeidler & Sadler , 2009). Bu hedef ve kazanımlara ulaşmak için "öğrenme ortam"ı çok önemlidir. Son yıllarda sıkça vurgulanmakta olan yaparak yaşayarak öğrenme, yapılandırmacı öğrenme yaklaşımları, fen öğretimine de etki etmiştir ve laboratuvarının önemini artırmıştır. Laboratuvarda da, özellikle sorgulayıcı öğrenme (inquiry) ile kurgulanmış olan, öğrencilerin daha aktif olduğu öğrenme ortamları önem kazanmıştır.

Bu çalışmanın amacı, öğretmen adaylarının yurt içi ve yurt dışı literatürde önemi sıklıkla vurgulanan bu becerilere ulaşmasına katkı sağlayacağını düşündüğümüz bazı değişkenleri incelemektir. Bu değişkenler öğretmen adaylarının sosyobilimsel konular hakkındaki reflektif yargılama becerileri ve argümantasyon yetenekleridir. Bu değişkenlerin incelenmesi için belirlenen araştırma soruları şu şekildedir:

1-) Sosyobilimsel konulara ve sorgulayıcı öğretime dayalı laboratuvar eğitiminin öğretmen adaylarının reflektif muhakeme yeteneklerine etkisi nedir?

2-) Öğretmen adaylarının sosyobilimsel konulara ve sorgulayıcı öğretime dayalı laboratuvar dersinde reflektif muhakeme kullanımı ile ortaya çıkan argümantasyon becerileri nedir?

3-) Öğretmen adaylarının sosyobilimsel konulara ve sorgulayıcı öğretime dayalı laboratuvar dersinde ortaya çıkan reflektif muhakeme ve argümantasyon yetenekleri arasında bir ilişki var mıdır?

Kaynak Bildirişleri

Son yarım yüzyıl içinde, bilim felsefecileri ve sosyologlar arasında pozitivist görüşten postpozitivist bakış açısına doğru bir yönelim olmuştur. Postpozitivist felsefe, bilgiyi keşfedilen değil de öğrencilerin öznel olarak inşa ettikleri bir kavram olarak vurgulamaktadır (Nussbaum, 1989). Bu felsefe, bilimi saf deneysel bir süreç olarak değil, öğrencilerin aktif olarak bilgiyi yapılandırdıkları sosyal bir süreç olarak kabul etmektedir. Öğretmenlerin bilgiyi aktaran, öğrencilerin de pasif alıcılar olduğu görüş eleştirilmektedir. Bu öğrenme süreci literatürde bir çok araştırmacı tarafından incelenmiş olup yapılandırmacı (constructivist) teori olarak vurgulanmaktadır (Moll , 1992; Piaget , 1973; Vygotsky , 1978). Bu çalışmanın temeli, öğrencilerin bilgiyi yapılandırırken aktif bir şekilde yer aldıklarını ileri süren constructivist teoriye dayanmaktadır. Öğrencilerin bilgiyi yapılandırmaları bireysel olabildiği gibi, diğer öğrencilerle interaktif iletişimde oldukları durumlarda sosyal öğrenme şeklinde de gerçekleşebilir.

Mevcut çalışma Amerika Ulusal Fen Eğitimi Birliği (NRC, 1996) tarafından tavsiye edilen laboratuvar temelli öğrenme ortamında, öğrencilerin yaparak yaşayarak öğrenmelerine olanak sağlayacak şekilde kurgulanmıştır. Son yıllardaki literatür kaynakları öğrencilerin bilgiyi yapılandırırken aktif bir şekilde rol almalarının önemini vurgulamaktadır. Öğrencilerin bilimsel aktivitelerde aktif rol almaları “bilim yapmak” olarak literatürde birçok çalışmada yerini almıştır. Bu çalışmalarda öğrencilerin aktif yer aldıkları laboratuvar aktiviteleri ile “bilim yapmak” kavramı birbiri ile ilişkilendirilmektedir ve bu süre zarfında bilginin yapılandırıldığı düşünülmektedir (Tobin, 1990). Hodson (1993) bilim yapmayı fen eğitiminin önemli bir parçası olarak tanımlamış ve laboratuvarların belli başlı konuların öğretildiği yerler olmasından ziyade öğrencilerin sorgulayıcı öğretime dayalı aktivitelerle meşgul oldukları ve aktif olarak bilimsel sürecin içinde yer aldıkları yerler olması gerektiğini vurgulamıştır.

Bu çalışma, öncelikli olarak öğrencilerin laboratuvar ortamında yaparak yaşayarak bilim öğrenme sürecinde, aktif olarak yer aldıkları bir durum çalışmasıdır. Öğrenciler sorgulamaya dayalı (inquiry-based) fen laboratuvarında, sadece fen konularını değil aynı zamanda toplumu yakından ilgilendiren sosyobilimsel konuları da tartışarak, deney yaparak öğrenme fırsatı bulmuşlardır. Örneğin, bir laboratuvarda ev yapımı mayonez ile marketlerde satılan katkı maddeli iki farklı mayonez analiz edilebilir, tekrar eden ölçümler sayesinde içerik farklılıkları kayıt altına alınabilir. Daha sonra da elde edilen değerler bilimsel olarak yorumlanabilir. Fakat burada iki mayonezin sadece biyolojik içeriğine odaklanıp, sosyobilimsel yönünün göz ardı edilmesi öğrencilerin bilimi günlük hayatla özdeşleştirmelerine engel olmaktır. Bu deneyde öğrenciler gıda katkı maddeleri hakkında bilgilendirilirse, ya da kendi yapacakları araştırmalar sonucu gıda katkı maddelerin gerekliliği, zararları, faydaları konusunda birbirleriyle tartışma olanağı sağlanılırsa, öğrencilerin fen derslerinde görmüş oldukları konuları günlük hayatla ilişkilendirmeleri daha kolay olacaktır. Diğer bir anlatımla, öğrencilerin kişisel olarak tecrübe ettikleri ve sosyal anlamda da içerisinde olduklarını düşündükleri konuları daha kalıcı şekilde öğrenecekleri düşünülmektedir.

Özet olarak, bu çalışma yapılandırmacı öğretim yöntemlerinin ışığında kurgulanan sorgulayıcı öğretime ve sosyobilimsel konulara dayalı fen laboratuvarı uygulamaları dersinde gerçekleştirilmiştir. Çalışmanın temel hedefleri arasında literatürde bilim okur yazarlığı ile çokca ilişkilendirilmiş olan ve bilimsel düşünme becerilerine katkı sağladığı iddia edilen iki değişken (argümantasyon, reflektif muhakeme) incelenmiştir. Fen laboratuvar uygulamalarının yalnızca fen konularına dayandırılması eleştirilerek sosyobilimsel konularla da zenginleştirilmesi gerekliliği belirtilmiştir. Bu amacı gerçekleştirmek için "tasarım tabanlı öğrenme" modeli kullanılarak fen laboratuvarı yeniden tasarlanmıştır.

Yeniden tasarlanan laboratuvar uygulamaları dersi kapsamında, günlük yaşamla birebir bağlantısı olan birden çok sosyobilimsel konu laboratuvar uygulamalarına dâhil edilmiştir. Bu konular öğretmen adaylarının reflektif muhakeme ve argümantasyon becerilerini ortaya koyması açısından önemli birer araç olarak kullanılmıştır.

Sosyobilimsel konular (SBK) günlük hayatın gerçeklerini içermesi ve genel olarak kesin çözümü olmayan konular olması nedeniyle öğrencilerin ilgisini çekmektedir (Sadler, 2011). SBK temelli öğretim dünya genelinde birçok ülkede araştırılmaktadır (örneğin: Avustralya, İsrail, Güney Kore, İspanya, Türkiye, İngiltere, Amerika Birleşik Devletleri vb.) ve bu konular ülkemizde de Fen Teknoloji Toplum (FTT) dersleri ve Fen Teknoloji Toplum Çevre (FTTÇ) hareketi sayesinde önem kazanmıştır. Fen derslerinin toplum içerisindeki yeri göz önüne alınarak topluma fen öğretmeyi amaçlayan temel yaklaşımlar fen derslerinin sosyobilimsel konular çerçevesinde öğretilmesine olanak sağlamaktadır (Zeidler, Sadler, Simmons, & Howes, 2005).

SBK konularının temel özellikleri Zeidler (2003) tarafından şu şekilde listelenmiştir: (a) temelinde bilimsel bilgi vardır; (b) öğrenciler kendi düşüncelerini ve kişisel tercihlerini belirlemek zorundadırlar; (c) belirsizlik içerirler ve çelişkili görüşler hakimdir; (d) kişisel, yerel, global sorunların etik ve ahlaki değerler çerçevesinde analiz edilmesine olanak sağlar; ve (e) bu konular hakkında maliyet-fayda, potansiyel risk analizlerinin yapılmasına olanak sağlar (Zeidler, 2003). Bu beş özellik SBK'yı tüm yönleriyle temsil etmese de, fen derslerinde SBK'nın uygulanması için anahtar kavramların özeti olarak düşünülebilir.

Literatür incelendiğinde birçok SBK ya rastlanmaktadır ve hepsi tartışmaya açık konulardır. Fakat bu çalışmanın amacı SBK'yı yalnızca tartışmak değil aynı zamanda laboratuvar ortamında test etmek olarak belirlendiği için ders kapsamında işlenecek konular bu amaca yönelik seçilmiştir. Global çevre sorunları karşıt görüşlerin hâkim olduğu konular olması nedeniyle ve laboratuvarda test edilebilir konular olduğundan bu ders kapsamında ele alınması uygun görülmüştür. Global çevre sorunları yalnızca fen teknoloji ve çevre dersi kapsamında değil, günlük yaşam, sosyal, politik ve ekonomik alanlara etkisi göz önünde bulundurularak ele alındığı için önem arz etmektedir. Bu konular toplumun bütününü ilgilendirdiği için literatürde önemli ölçüde yer almaktadır. Örneğin, küresel iklim değişikliği (Wilson, 2000), hava kirliliği (Tuncer-Teksoz, 2011), nükleer enerji (Kilinc, Boye & Stanisstreet, 2012), hidroelektirik santralleri (Zhong & Power, 1996), yenilenebilir enerji kaynakları (Kılınç, Stanisstreet, & Boyes, 2009), biyolojik çeşitlilik, genetiği değiştirilmiş organizmalar (Sonmez & Kılınç, 2012).

Bilimsel çalışma sonuçları göstermektedir ki; toplumun geneli çevresel felaketler konusunda endişelidir. Benton ve Redclift (1994), küresel iklim değişikliğinden kaynaklı sorunları, ozon tabakasındaki deliği, dünya genelindeki besin krizi ve enerji kaynaklarının tükenmesini toplumu endişelendiren konular olarak görmektedir. Toplum, küresel çevre sorunlarını sınırlamanın mümkün olmadığının farkında olduğu için bu konular hakkında ciddi endişeye sahiptir. Örneğin buzul bölgesinde gerçekleşen erime sadece Antarktika Kıtası'nı etkilememektedir, buzul erimesinden kaynaklı su seviyesindeki artış denizlere kıyısı olan birçok ülkeyi de olumsuz etkilemektedir. Ya da Ukrayna'da meydana gelen Çernobil nükleer felaketinin etkileri Türkiye, İsviçre, Hollanda hatta İngiltere'ye kadar ulaştığı bilinmektedir. Küresel konular hakkındaki endişeler, öğrencilerin bu konular hakkında bilinçlendirilmesi açısından SBK temelli eğitimin önemini artırmaktadır (Lee ve ark., 2013). SBK temelli öğrenim hareketi öğrencilerin bu konular hakkındaki görüşlerini şekillendirmesine yardımcı olmakla birlikte dünyanın geleceğine ışık tutması açısından da önemlidir (Sadler, 2004).

SBK çalışmalarını incelediğimizde, temel fen konularını bilimin doğası (Bell & Lederman, 2003), argümantasyon (Mason & Scirica, 2006) ve reflektif muhakeme (Zeidler et. al, 2009) bağlamlarında ele aldığı görülmektedir. Bu çalışmalarda SBK'nın öğrencilerin muhakeme becerilerine, kanıtlara dayalı argümantasyon yapma becerilerine katkı sağladığı görülmektedir. Fakat literatürdeki kısa dönem SBK uygulamaları öğrencilerin bu becerilerini anlık olarak ele aldığı için eleştirilmekte ve daha uzun soluklu uygulamalar yapma gerekliliği vurgulanmaktadır (Zeidler et al., 2009). Bu bilgiler doğrultusunda mevcut çalışma, farklı SBK'ların bir dönem boyunca ele alındığı ve öğretmen adaylarının bu konular hakkındaki reflektif muhakeme ve argümantasyon becerilerinin uzun soluklu araştırıldığı bir durum tespit çalışmasıdır. Çalışmanın bir diğer özelliği ise; laboratuvar uygulamaları esnasında iyi yapılandırılmış (well-structured) fen deneylerinden ziyade belirsiz yapılandırılmış (ill-structured) konular ele alınmıştır ve literatürde bu açıdan bir ilk teşkil etmektedir. Öğrencilerin fizikte klasik bir elektrik devresini test ettiği, kimyada termodinamik yasalarını araştırdığı, ya da biyoloji de hipotonik ortamla hipertonik ortamı kıyasladığı iyi yapılandırılmış deneyler ders kapsamından çıkarılarak, fen dersinde öğrenmiş oldukları ve aynı zamanda toplumsal konuları da kapsayan belirsiz yapılandırılmış konular ele alınmıştır.

Yöntem

Bu çalışmada tasarım tabanlı araştırma modeli kullanılmıştır. Tasarım tabanlı araştırma yaklaşımında bir yöntemin derinlemesine incelenmesi ve incelenen olayın betimleyici ya da açıklayıcı bir şekilde tasvir edilmesi önem arz etmektedir. Son yıllarda eğitim bilimleri alanında yaygın olarak kullanılan tasarım tabanlı öğrenme modelinin bir örneği olan bu çalışmanın nitel veri kısmında öğrencilerin laboratuvar raporları, yarı yapılandırılmış görüşme kayıtları ve sınıf tartışmaları analiz edilmiştir. Nicel veri analizi kısmında ise argümantasyon ve reflektif muhakeme becerileri arasındaki ilişki ki-kare testi ile incelenmiştir.

Katılımcılar

Araştırmanın örneklemi Ankara'daki bir devlet üniversitesinde öğrenim görmekte olan 20 öğretmen adayından oluşmaktadır. Çalışma; ilk kayıtta sayıları 23 olan öğretmen adayı arasından, 13'ü okul öncesi, 7'si fen bilgisi öğretmenliğinde öğrenim görmekte olan toplam 20 öğretmen adayının gönüllü katılımıyla gerçekleştirilmiştir. Çalışmada yer alan katılımcılar, lisans eğitimleri boyunca alan bilgisi ve pedagoji derslerinin yanı sıra çevre eğitimi, sürdürülebilir çevre konularına yönelik dersler almışlardır.

Araştırma dizaynı

Çalışmada ele alınan durum "sosyobilimsel konuların incelendiği sorgulayıcı öğrenime dayalı (inquiry) olarak dizayn edilmiş seçmeli laboratuvar dersidir. Çalışma bir dönemlik uygulama ile sınırlandırılmıştır. Ders, sosyobilimsel konularda ve epistemoloji alanında çalışmaları olan bir öğretim üyesi ve farklı araştırma alanları olan 5 adet doktora 1 adet de yüksek lisans düzeyinde öğrenim görmekte olan toplam 6 araştırma görevlisi ile yürütülmüştür. Klasik laboratuvar derslerine eleştirel bakış açısıyla yaklaşılan ve bu derslere sosyobilimsel konuların da eklenmesi gerekliliğini savunan bu çalışmada tasarım tabanlı araştırma (design based research) deseni kullanılmıştır. Bu tür dizaynlar var olan araştırma desenlerinin yetersiz kaldığı durumlarda (Kuzu, Çankaya ve Abidin-Mısırlı, 2011) kullanılmak üzere ortaya çıkmıştır. Joseph (2004), tasarım tabanlı araştırma dizaynlarının kendi içerisinde kurgulanmış keskin sınırları olmadığını ve halen gelişmekte olan bir yaklaşım olduğunu vurgulamıştır. Bu çalışmada da keskin sınırları olmayan, araştırmacının sürekli olarak katılımcılarla etkileşim içerisinde olduğu döngüsel bir süreç izlenmiştir. Tasarım tabanlı öğrenme dizaynları için tek bir yöntem bulunmamaktadır, bu çalışmada Plomp (2007) un önermiş olduğu üç aşamalı tasarım süreci model olarak alınmıştır.

Sürecin ilk aşamasında bir dönemlik ön-araştırma yapılmış olup, laboratuvarda test edilebilecek olan sosyobilimsel konular belirlenmiştir. Dersin içeriği ve teorik çerçevesi bu süreçte kararlaştırılmıştır. Çalışmanın ikinci basamağında ise ön-araştırma sürecinde kararlaştırılan konuların uygulanmasına başlanmış ve her uygulama sonucunda gerek duyulan düzenlemeler, değişiklikler belirlenmiştir. Bu süreçte "hava kirliliği" konusu incelenmiştir. Bu uygulama esnasında öğrenciler, sınıf içi tartışması, sunum yapacak öğrencilerin görevleri ve dikkat etmeleri gereken hususlar, dinleyicilerin aktif katılımı, ders asistanlarının tartışmayı daha verimli hale getirmek için soracağı sorular gibi konulara dikkat edilmiştir. Uygulamanın laboratuvar kısmında ise, temelinde hava kirliliği ile ilgili bir deney olan, klasik deney sorularına ilave olarak öğrencilerin reflektif yargılama becerilerini ölçmeye yönelik soruları içeren örnek föy dağıtılmıştır. Bu föy öğrencilerin ilerleyen haftalarda kendilerinin hazırlaması gereken laboratuvar föyüne örnek teşkil etmektedir. Öğrencilere dağıtılan bu föyün hazırlanması aşamasında sosyobilimsel konular hakkında uzman iki öğretim üyesinin "uzman görüşleri" alınmıştır. Föyde kullanılan reflektif yargılama becerilerini ölçen sorular ise King ve Kitchener (1992) tarafından geliştirilmiş olup incelenen konuyla ilişkilendirilerek kullanılmıştır. Hava kirliliği uygulaması sonucunda tespit edilen eksiklikler rapor edilmiş ve gerekli düzenlemelere gidilmiştir.

Uygulamanın son basamağında ise laboratuvar föylerinin ve sınıf içi tartışmalarının öğretmen adaylarının reflektif muhakeme yeteneğini ve argümantasyon yeteneğini ölçmek için uygun olup olmadığına yönelik farklı sosyobilimsel konularla (gıda katkı maddeleri, enerji sorunu, iklim değişimi ve endüstri devriminin çevreye etkileri) uygulamalar gerçekleştirilmiş ve bu uygulamalar haftalık olarak değerlendirilmiştir. Her bir uygulama için iki hafta ayrılmıştır. Birinci haftada öğretmen adayları, belirlenen sosyobilimsel konu hakkında sınıf içi tartışmalar yapmıştır. İkinci haftada ise öğrenciler 5 erli gruplara ayrılarak, her bir grup kendi belirledikleri araştırma sorusunu laboratuvarda test etmiştir. Laboratuvar öncesi, öğrenciler hazırladıkları föyleri grup asistanlarına göstermişler ve gerekli düzenlemeleri yapmışlardır. Uygulama haftasında adaylar arasından rastgele seçilmiş öğrencilerle yarı yapılandırılmış mülakatlar yapılmıştır. Bu mülakatlarda, öğrencilerin fen dersine yönelik tutumları, tartışılan sosyobilimsel konular hakkındaki reflektif yargılama stilleri öğrenilmeye çalışılmıştır.

Çalışmanın güvenirlik geçerliği için veri üçlemesi, araştırmacı üçlemesi ve detaylı anlatım gibi yöntemlerden yararlanılmıştır. Etik uygunluk için, ODTÜ Etik Kurulu'ndan onay alınmıştır. Öğretmen adaylarına çalışmanın doktora tezi araştırması olduğu, veri toplanacağı, derslerin video ile kayıt altına alınacağı önceden anlatılmış ve gönüllü katılım formu imzalatılmıştır.

Veri toplama araçları

Bu çalışma öğretmen adaylarının sosyobilimsel konular hakkındaki reflektif muhakeme ve argümantasyon yeteneklerini ölçmek için nitel araştırma yöntemlerinden yararlanmıştır. Çalışmanın güvenirliğini artırmak için veri üçlemesi yapılarak, mülakat, yazılı döküman ve video kayıtlarından yararlanılmıştır. Tablo 1, araştırmada kullanılan veri toplama araçlarının bir listesini oluşturmaktadır.

Tablo 1: Veri toplama araçları

Değişken	Veri toplama aracı
Reflektif muhakeme	Laboratuvar föyleri ve mülakat soruları
Argümantasyon	Sınıf içi tartışmaları (video analizi)

Veri analizi

Öğretmen adaylarının reflektif muhakeme yeteneklerini incelemek için King ve Kitchener'in (1994) geliştirmiş olduğu Reflektif Muhakeme Modelinden (RMM) yararlanılmıştır. Analizin nasıl yapıldığı bir sonraki başlıkta detaylı olarak anlatılmıştır. Öğretmen adaylarının argümantasyon becerileri ise Toulmin (1958) argümantasyon modeli esas alınarak Walker ve Zeidler'ın (2007) geliştirmiş oldukları analiz yöntemi ile hesaplanmıştır. İki değişken arasındaki ilişki ise önceki bölümlerde de belirtildiği gibi ki-kare testi ile analiz edilmiştir.

Ağırlıklı puan hesaplama:

King ve Kitchener (1994) reflektif muhakeme modelini anlattıkları çalışmalarında, öğrencilerin sadece tek bir seviyede olmadıklarını, farklı sorulara farklı cevaplar verdiklerini ve verdikleri cevaplarda bilgiyi yapılandırma şekillerinin, otoriteye bağlılık derecelerinin, subjektiflik ve objektiflik düzeylerinin farklı olduğunu belirtmişlerdir. Aynı öğrencinin konuyla ilgili birinci soruda 4.seviyede cevap veriyorken, ikinci soruda 4.seviye, diğer soruda 5.seviyede, dördüncü soruda ise yine 4. seviyede cevap verebildiği belirtilmektedir. Bu tür durumlarda öğrencinin reflektif muhakeme seviyesi üç basamaklı sayı ile (4-4-5) ile gösterilmiştir. Burada ilk basamak en sık tekrar eden seviyeyi, ikinci ve üçüncü basamak da sırasıyla en çok tekrar eden seviyeleri göstermektedir. King ve Kitchener, 20 yılı aşkın sürede yaptıkları reflektif muhakeme modeli araştırmalarının sonucunda öğrencilerin üç basamaklı skorlarının genel olarak bir ya da iki puan farklılık gösterdiğini tespit etmişlerdir. Yani öğrencilerin skorları genel olarak tutarlılık göstermektedir. Öğrencilerin tutarsız skorlar aldığı ise (örneğin 4-5-3) çok nadir olarak karşılaşılan bir durum olarak belirtilmiştir. Üç basamaklı sayı ile ifade edilen skorları reflektif modeldeki 1 den 7 ye kadar olan puan aralığındaki üç ayrı seviyeden (reflektif öncesi, yarı reflektif, reflektif) biri ile ifade edebilmek için ağırlıklı puan hesabı yapılmıştır. Bu dönüşüm yapılırken en fazla tekrar eden basamak % 50, ikincisi % 30, üçüncüsü ise % 20 katsayısı ile çarpılarak son değer hesaplanmıştır. Örneğin 4-5-3 olarak kodlanmış bir öğrencinin ağırlıklı puanı 4(.50) + 5(.30) + 3(.20) = 4.10 olarak hesaplanmış ve yarı reflektif olarak ifade edilmiştir. Bu çalışmada da her bir öğretmen adayının reflektif puanları bu şekilde hesaplanmış olup ortalama puanlarının hangi seviyeye karşılık geldiği tablo ile gösterilmiştir. Ayrıca, her bir sosyobilimsel konu için sınıf ortalaması da hesaplanmış olup dönem sonunda sınıf ortalamasındaki artış nicel olarak rapor edilmiştir.

Argümantasyon puanı hesaplama

Öğretmen adaylarının farklı sosyobilimsel konular hakkındaki sınıf içi tartışmaları video ile kayıt altına alınmış ve ders sonrası bu videolar yazıya dökülerek her bir öğrencinin sınıf tartışmasına katılımı analiz edilmiştir. Analiz sonucunda diyaloglar sayılmış, argümantasyon örüntüsü olan katılımlar değerlendirilmeye alınırken argümantasyon örüntüsü olmayan katılımlar sayıca rapor edilmiş fakat değerlendirmeye alınmamıştır. Değerlendirilmeye alınmayan katılımlar araştırmacıların tartışmayı aktive etmek için sordukları sorular ya da ortaya attıkları iddialar, öğrencilerin konu dışı diyaloglarıdır. Değerlendirilmeye alınan diyaloglar sıfırla üç arasında notlandırılmıştır. Level-0, kanıt kullanılmayan diyaloglar için; Level-1 yanlış kanıt kullanılan diyaloglar için, Level-1 yetersiz kanıt kullanılan durumlar, Level-3 ise doğru kanıt kullanılan durumlar için belirlenmiştir (Walker ve Zeidler, 2007). Tartışma boyunca öğretmen adaylarının çeşitli seviyelerde argüman ortaya koydukları görülmüştür. Reflektif muhakeme seviyeleri belirlenirken olduğu gibi burada da öğretmen adaylarının her bir argümantasyon örüntüsü kaydedilmiş ve sonrasında en sık gözlemlenen ve aynı zamanda çıkabildikleri en yüksek argümantasyon seviyesi göz önünde bulundurularak son durumları rapor edilmiştir. Örneğin iklim değişimi tartışmaları esnasında farklı seviyelerde [Level-0: 5 tane, Level 1: yok, Level-2: 5 tane, Level-3: 2 tane] argüman geliştiren bir adayın son durumu Level 2 olarak ifade edilmiştir. Çünkü öğretmen adayının en sık tekrar eden argümantasyon seviyesine baktığımızda Level 0 ve Level 2 görülmekte bu durumda öğrencinin en yüksek hangi seviyede argüman geliştirebildiği göz önünde bulundurularak son durumunun Level-2 olduğuna karar verilmiştir.

SONUÇ ve TARTIŞMA

Bu bölümde, araştırma soruları ve bu sorular ışığında elde edilen sonuçlar sunulmuştur. Çalışma sonuçları nitel ve nicel olmak üzere iki alt başlıkta verilecektir. Öğretmen adaylarının sınıf içi tartışmaları, laboratuvar föyleri ve yarı yapılandırılmış mülakat sorularına vermiş oldukları cevaplar nitel olarak analiz edilmiştir ve sonuçlar birinci alt başlıkta rapor edilmiştir. Daha sonra reflektif muhakeme ve argümantasyon becerisi arasında ilişki olup olmadığı non-parametrik yöntemlerden biri olan ki-kare testi ile araştırılmıştır. Araştırmanın örneklem sayısı 20 ile sınırlıdır, örneklem sayısının sınırlı sayıda olması Ki-kare testi yapılırken kontrol edilmesi gereken varsayımlardan biri olan her hücreye 5 farklı skor düşme varsayımına engel teşkil ettiği için değişkenler arası farkı araştıran ki-kare testi sonuçları verilirken fischer exact testten yararlanılmıştır.

1-) Sosyobilimsel konulara ve sorgulayıcı öğretime dayalı laboratuvar eğitiminin öğretmen adaylarının reflektif muhakeme yeteneklerine etkisi nedir?

2-) Öğretmen adaylarının sosyobilimsel konulara ve sorgulayıcı öğretime dayalı laboratuvar dersinde reflektif muhakeme kullanımı ile ortaya çıkan argümantasyon becerileri nedir?

3-) Öğretmen adaylarının sosyobilimsel konulara ve sorgulayıcı öğretime dayalı laboratuvar dersinde ortaya çıkan reflektif muhakeme ve argümantasyon yetenekleri arasında bir ilişki var mıdır?

Reflektif muhakeme yetenekleri: Gıda katkı maddeleri

Birinci araştırma sorusu için öğretmen adaylarının kendi hazırlamış oldukları laboratuvar raporları, ve yarı yapılandırılmış görüşme kayıtları analiz edilmiştir. Her bir sosyobilimsel konu için reflektif muhakeme becerileri araştırılmış ve sonuçlar ayrı ayrı rapor edilmiştir. Öğretmen adaylarının gıda katkı maddeleri deneyinde reflektif muhakeme modelinin 3 ana başlıkta vermiş olduğu reflektif öncesi (pre-reflektive), yarı reflektif (quasi-reflektive), ve reflektif (reflective) seviyede olan aday sayısı rapor edilmiştir. Modelde tanımlanan 1 den 7 ye kadar olan skorlar ağırlıklı puan hesaplama yöntemi ile hesaplanmış olup öğretmen adaylarının konulara göre ağırlıklı puanları ve sınıf ortalamaları rapor edilmiştir. Tablo-2 gıda katkı maddeleri deneylerinde her bir öğretmen adayının reflektif muhakeme puanını ve sınıf ortalamasını göstermektedir.

Tablo 2- Öğretmen adaylarının gıda katkı maddeleri hakkındaki RMM skorları.

Aday	Üç basamaklı skor			Ağırlıklı puan	Seviye
1	5	5	6	5.2	Yarı Reflektif
2	1	1	2	1.2	Reflektif öncesi
3	5	5	6	5.2	Yarı Reflektif
4	5	5	4	4.8	Yarı Reflektif
5	6	6	5	5.8	Reflektif
6	5	5	4	4.8	Yarı Reflektif
7	5	5	3	4.6	Yarı Reflektif
8	6	6	7	6.2	Reflektif
9	5	5	4	4.8	Yarı Reflektif
10	3	3	2	2.8	Reflektif öncesi
11	5	5	4	4.8	Yarı Reflektif
12	5	5	4	4.8	Yarı Reflektif
13	4	4	5	4.2	Yarı Reflektif
14	5	5	6	5.2	Yarı Reflektif
15	1	1	4	1.6	Reflektif öncesi
16	1	1	2	1.2	Reflektif öncesi
17	6	6	7	6.2	Reflektif
18	3	3	5	3.4	Reflektif öncesi
19	3	6	5	4.3	Yarı Reflektif
20	1	1	1	1	Reflektif öncesi
Sınıf ortalaması				4.1	

Tablo 2'de görüldüğü üzere gıda katkı maddeleri deneyinde öğretmen adaylarının 6 tanesi reflektif öncesi, 11 tanesi yarı reflektif ve 3 tanesi de reflektif seviyede muhakeme yaptıkları tespit edilmiştir. Sınıf ortalaması 4.1 olarak hesaplanmış olup sınıfın genelinin yarı reflektif seviyede olduğu görülmektedir. Bu skorlar gruplara göre incelendiğinde en düşük ortalama grup-5, en yüksek ortalama Grup-3 e aittir.

Reflektif muhakeme yetenekleri: alternatif enerji kaynakları

Öğretmen adaylarının farklı alternatif enerji kaynaklarının çalışma prensiplerini (örn: rüzgar tribünü, güneş enerjisi, biomass enerjisi vb.) deneyimlemeye çalıştıkları bu laboratuvarda da her bir öğrencinin reflektif muhakeme skorları hesaplanmış ve tablo 3'te sunulmuştur.

Tablo 3- Öğretmen adaylarının alternatif enerji kaynakları hakkındaki RMM skorları.

Aday	Üç basamaklı skor			Ağırlıklı puan	Seviye
1	5	5	6	5.2	Yarı Reflektif
2	Devamsız			0	
3	6	6	5	5.8	Yarı Reflektif
4	5	6	6	5.5	Yarı Reflektif
5	5	5	5	5	Yarı Reflektif
6	5	5	4	4.8	Yarı Reflektif
7	5	5	6	5.2	Yarı Reflektif
8	5	5	4	4.8	Yarı Reflektif
9	5	5	4	4.8	Yarı Reflektif
10	4	4	5	4.2	Yarı Reflektif
11	2	2	1	1.8	Reflektif öncesi
12	5	5	4	4.8	Yarı Reflektif
13	1	1	3	1.4	Reflektif öncesi
14	5	5	6	5.2	Yarı Reflektif
15	6	6	5	5.8	Reflektif
16	5	5	5	5	Yarı Reflektif
17	5	5	6	5.2	Yarı Reflektif
18	5	5	5	5	Yarı Reflektif
19	6	6	7	6.2	Reflektif
20	5	5	6	5.2	Yarı Reflektif
Sınıf ortalaması				4.5	

Tablo 3’te görüldüğü üzere alternatif enerji kaynakları deneyinde öğretmen adaylarının 2 tanesi reflektif öncesi, 15 tanesi yarı reflektif ve 2 tanesi de reflektif seviyede muhakeme yaptıkları tespit edilmiştir. Öğretmen adaylarının alternatif enerji kaynaklarınının çalışma prensiplerini test ettikleri bu laboratuvarda sınıf ortalamasının 4.5’e yükseldiği görülmektedir. Ancak bu yükseliş seviye değişimine neden olacak bir yükseliş değildir. Sınıf geneli halen yarı reflektif muhakeme seviyesindedir. Bu skorlar gruplara göre incelendiğinde en düşük ortalama yine Grup-5 (3.9) en yüksek ortalamanın ise Grup-2’deki (5.4) öğretmen adaylarına ait olduğu görülmektedir.

Reflektif muhakeme yetenekleri: iklim değişikliği

Öğretmen adayları, iklim değişikliğinin dünyamıza etkilerini anlamaya çalıştıkları bu laboratuvarda beş ayrı ve grup beş farklı deney geliştirmişlerdir. Adayların ilgili hafta hazırlamış oldukları raporlar incelendiğinde Tablo-4’teki sonuçlar elde edilmiştir.

Tablo 4- Öğretmen adaylarının iklim değişikliği hakkındaki RMM skorları.

Aday	Üç basamaklı skor			Ağırlıklı puan	Seviye
1	3	4	5	3.7	Yarı reflektif
2	5	5	5	5	Yarı reflektif
3	6	6	5	5.8	Reflektif
4	2	2	3	2.2	Reflektif öncesi
5	5	5	6	5.2	Yarı reflektif
6	5	5	6	5.2	Yarı reflektif
7	5	5	5	5	Yarı reflektif
8	4	4	3	3.8	Yarı reflektif
9	5	5	6	5.2	Yarı reflektif
10	5	5	6	5.2	Yarı reflektif
11	5	5	4	4.8	Yarı reflektif
12	6	6	5	5.8	Reflektif
13	5	5	5	5	Yarı reflektif
14	4	4	6	4.4	Yarı reflektif
15	5	5	4	4.8	Yarı reflektif
16	6	6	5	5.8	Reflektif
17	5	5	6	5.2	Yarı reflektif
18	5	5	6	5.2	Yarı reflektif
19	6	6	5	5.8	Reflektif
20	6	6	7	6.2	Reflektif
Sınıf ortalaması				4,925	

Tablo 4'te görüldüğü üzere iklim değişikliğinin dünyamıza etkileri deneylerinde öğretmen adaylarının 1 tanesi reflektif öncesi, 16 tanesi yarı reflektif ve 3 tanesinin de reflektif seviyede muhakeme yaptıkları tespit edilmiştir. Sınıf ortalaması 4.9 olarak hesaplanmıştır. Sınıf geneli halen yarı reflektif muhakeme seviyesindedir. Bu skorlar gruplara göre incelendiğinde en düşük ortalamanın Grup-1 (4.5), en yüksek ortalamanın ise Grup-4 & 5'deki (5.2) öğretmen adaylarına ait olduğu görülmektedir.

Reflektif muhakeme yetenekleri: endüstri devrimi

Farklı sosyobilimsel konuların ele alındığı bu çalışmanın son araştırma konusu endüstri devriminin çevreye etkileri olarak belirlenmiştir. Bu deneyde öğretmen adayları endüstri devriminin çevreye etkilerini araştırmışlardır. Deney raporlarının analizi Tablo-5 te verilmiştir.

Tablo 5- Öğretmen adaylarının endüstri devrimi hakkındaki RMM skorları

Aday	Üç basamaklı skor			Ağırlıklı puan	Seviye
1	4	4	5	4.2	Yarı reflektif
2	5	5	6	5.2	Yarı reflektif
3	5	5	6	5.2	Reflektif
4	5	5	5	5	Yarı reflektif
5	5	5	5	5	Yarı reflektif
6	5	5	6	5.2	Yarı reflektif
7	6	6	5	5.8	Reflektif
8	6	6	7	6.2	Reflektif
9	6	6	5	5.8	Reflektif
10	6	6	6	6	Reflektif
11	4	4	4	4	Yarı reflektif
12	6	6	7	6.2	Reflektif
13	5	5	5	5	Yarı reflektif
14	6	6	6	6	Reflektif
15	5	5	6	5.2	Yarı reflektif
16	5	5	6	5.2	Yarı reflektif
17	6	6	6	6	Reflektif
18	3	3	3	3	Pre Reflective
19	6	6	6	6	Reflektif
20	5	5	6	5.2	Yarı reflektif
Sınıf ortalaması				5.27	

Tablo 5'te görüldüğü üzere endüstri devriminin çevreye etkilerinin incelendiği deneylerde öğretmen adaylarının 1 tanesi reflektif öncesi, 10 tanesi yarı reflektif, ve 9 tanesi de reflektif seviyede reflektif muhakeme yapmışlardır. Sınıf ortalaması ise 5,27 olarak hesaplanmıştır. Bu skorlar gruplara göre incelendiğinde en düşük ortalama Grup-4 (4,9) en yüksek ortalamanın ise Grup-2'deki (5,8) öğretmen adaylarına ait olduğu görülmektedir.

Reflektif muhakeme skorlarına genel olarak bakıldığında sınıf ortalamalarının 4,1'den 5,3'e yükseldiği görülmektedir. Her ne kadar sınıf ortalaması 1.2 puanlık bir artış gösterse de, iki ortalamanın da yarı reflektif seviyede olduğu görülmektedir. King ve Kitchener'e (1994) göre bireylerin bir seviyeden diğerine geçmeleri dönemlik ya da senelik uygulamalar sonucunda çok sık rastlanan bir durum değildir.

Soru 2: Öğretmen adaylarının sosyobilimsel konulara ve sorgulayıcı öğretime dayalı laboratuvar dersinde reflektif muhakeme kullanımı ile ortaya çıkan argümantasyon becerileri nedir?

Öğretmen adaylarının sınıf içi tartışmaları Toulmin (1958) argümantasyon modelinin Walker ve Zeidler (2007) tarafından geliştirilmesi ile elde edilen rubrik kullanılarak analiz edilmiştir. Rubrikteki dört basamak aşağıdaki şekilde tanımlanmıştır.

*Level 0, kanıt yok, konu alanı bilgisi kullanılmamış

*Level 1, yanlış kanıt ya da yanlış bilgi

*Level 2, konuya özgü olmayan kanıt ya da konu alanı bilgisi kullanılmış

*Level 3, doğru kanıt ve doğru konu alanı bilgisi kullanılmış

Tablo-6 öğretmen adayların herbir sosyobilimsel konu hakkında ortaya koydukları argüman örüntülerinden en az ve en çok tekrar edenleri göstermektedir. Bu bölümün devamında her bir argümantasyon örüntüsünün hangi konuda nasıl değişiklik gösterdiği açıklanmıştır.

Tablo-6 Sosyobilimsel konulara göre argümantasyon frekansları

	En az (frekans)	En çok (frekans)
Gıda Katkı maddeleri	L-0: (15)	L-3: (99)
Alternatif enerji	L-1: (38)	L-3: (97)
İklim değişimi	L-0: (14)	L-3: (61)
Endüstri devrimi	L-0: (13)	L-3: (77)

L-0 düzeyinde argümantasyon örüntüleri (Kanıt kullanmama)

L-0 düzeyindeki argümantasyon örüntülerine bakıldığında bu düzeyin frekans değerinin dört deneyin üçünde en az olduğu görülmektedir. Yalnızca alternatif enerji kaynakları haftasında daha sıklıkla kanıt kullanmadan iddia ürettikleri görülmektedir. Bunun sebebi, son yıllarda gündemden düşmeyen nükleer enerji politikası, çernobil felaketinden dolayı medyada göz önünde bulunan Kazım Koyuncu gibi ünlü isimlerin kanserden ölmesi konu hakkındaki bilgi kirliliğini artırması olabilir. Öğretmen adaylarının enerji konusu hakkında fikirlerinin olduğu ama bilgilerinin çok olmadığı görülmektedir.

L-1 düzeyinde argümantasyon örüntüleri (Yanlış kanıt kullanımı)

Yanlış kanıt kullanımına bakıldığında da yine alternatif enerji kaynakları haftasında yoğunluk olduğu gözlemlenmektedir. Ek olarak, öğretmen adaylarının endüstri devriminin çevreye etkilerini tartışırken de yanlış kanıt kullandıkları görülmektedir. Bunun sebebi endüstri devrimi ile ilgili genelde pozitif bir algıya sahip olmaları, endüstri devriminin çevreye olan negatif etkileri tartışılırken sahip oldukları pozitif algı sebebiyle yanlış iddialarda bulunmaları ve bu iddialarını yanlış delillerle savunmaya çalışmaları olabilir.

L2 düzeyinde argümantasyon örüntüleri (Yetersiz kanıt kullanma)

Yetersiz kanıt kullanımı 1, 2 ve 4. deneylerde benzer yüzdelik dilimdeyken % 22, 28 ve 25 iklim değişimi söz konusu olduğunda % 38 e çıktığı görülmektedir. Bunun sebebi iklim değişikliğinin öğretmen adaylarının günlük hayatta fazlasıyla tecrübe ettikleri ve hemen hemen her türlü medya aracında karşılarına çıkan bir konu olmasıdır. Konunun sosyal medyada sıklıkla yer alması adayların bu alandaki bilgilerinin çok olduğu dolayısıyla fazlaca iddia geliştirebildikleri fakat iddialarını yeterli kanıtla sunamamalarına sebep olduğu düşünülmektedir.

L3 düzeyinde argümantasyon örüntüleri (doğru kanıt kullanımı)

Adayları argümantasyon örüntüleri içerisinde en üst düzey olan L-3 seviyesindeki argümanların frekansına bakıldığında 2, 3, ve 4. deneylerde % 39, 37 ve 44 gibi benzer yüzdelik dilimlerde seyrederken, şaşırtıcıdır ki gıda katkı maddeleri deneyinde % 56 olduğu gözlenmektedir. Bunun sebebi, gıda katkı maddelerinin okul öncesi eğitiminde özel okul, kreş vb. yerlerde veli duyarlılıkları, çocuklar üzerindeki negatif etkilerinin sıklıkla tartışılması olarak yorumlanabilir. Bu sonucun katılımcıların çoğunluğunun okul öncesi öğretmen adaylarının olduğu bu grup için normal olduğu düşünülmektedir.

3.soru Öğretmen adaylarının sosyobilimsel konulara ve sorgulayıcı öğretime dayalı laboratuvar dersinde ortaya çıkan reflektif muhakeme ve argümantasyon yetenekleri arasında bir ilişki var mıdır?

Araştırmanın iki değişkeni, argümantasyon ve reflektif muhakeme becerileri arasında ilişkiye bakmak için ki-kare testi uygulanmıştır. Dört sosyobilimsel konunun üç tanesinde (gıda katkı maddeleri, iklim değişimi ve endüstri devrimi) bu değişkenler arasında anlamlı bir sonuç bulunmuştur. Gıda katkı maddeleri için X^2 (4, n = 20) = 21.49, p = .000) olarak hesaplanmıştır. Aradaki ilişkinin gücü ise Cramer's V değeri ile hesaplanmıştır ve bu değer gıda katkı maddeleri için 0.73 olarak hesaplanmıştır. Pallant'a (2007) göre bu değer üç kategorili değişkenler için büyük etki aralığında kabul edilmektedir. Diğer SBK olan, alternatif enerji kaynakları haftasının ki-kare sonucu ise X^2 (4, n = 20) = 4.8, p = .332) olarak bulunmuştur. Ve iki değişken arasında anlamlı bir ilişki olmadığı tespit edilmiştir. İklim değişikliğinin çevreye etkileri X^2 (6, n = 19) = 16.07, p = .023) ve endüstri devrimi sonuçları X^2 (4, n = 20) = 10.80, p = .016) incelendiğinde ise adayların reflektif muhakeme ve argümantasyon yetenekleri arasında anlamlı bir ilişki olduğu görülmüştür.

Profesyonel öğretmen yetiştirme programları yeni teorilerin kullanımı, bilginin yapılandırılması, geliştirilmesi ve değerlendirilmesi alanlarını içerir. Bu çalışma öğretmen adaylarına hazır bilgi kalıplarını kullanmak yerine kendi inşa ettikleri temeller üzerine bilgiyi yapılandırmaları olanağı tanımaktadır. Çalışma sonuçları göstermiştir ki, SBK temelli sorgulayıcı öğretime dayalı laboratuvar dersi öğretmen adaylarının reflektif muhakeme yeteneklerine olumlu etki etmiştir. Öğretmen adaylarının günlük hayatta karşılaştıkları sorunları fen dersleri ile ilişkilendirebilme, reflektif düşünebilme, kanıtlara dayalı argüman geliştirebilme becerilerini artırabilmek için bu konularda deneyim kazanmalarının gerekliliği ortaya çıkmıştır. Bu tür uygulamaların artırılmasıyla eğitim ve öğretimimizde daha sorgulayıcı, kritik-eleştirel ve tartışmacı yöntemlerin geliştirilmesine olanak verilmiş olacaktır. Sonuç olarak, ilköğretim programlarından üniversite programlarına varıncaya değin geleneksel yöntemden ziyade daha çok kritik-eleştirel ve tartışmaya yönelik dersler ve aktivitelere ağırlık verilmesi öğrencilerin olaylara daha kritik yaklaşmasını ve çok boyutlu bir bakış açısı kazanmalarını sağlayacaktır.

Appendix M: Curriculum Vitae

PERSONAL INFORMATION

Surname, Name: Karışan, Dilek
Nationality: Turkish (TC)
Date and Place of Birth: 20 January 1986, Denizli
Marital Status: Single
Phone: +90 312 210 7516
Fax: +90 312 210 7984
email: dilekkarisan@gmail.com

EDUCATION

Degree	**Institution**	**Year of Graduation**
PhD	METU, Science Education	2014
MS	YYU, Science Education	2011
BS	METU, Science Education	2008
High School	Denizli Anatolian High School	2003

WORK EXPERIENCE

Year	Place	Enrollment
2011- Present	METU, Faculty of Education	Research Assistant
2009-2011	Yuzuncu Yil University,	Research Assistant

FOREIGN LANGUAGES

Advanced English

SCHOLARLY WORKS & REFEREED PUBLICATIONS

Karisan, D., Yilmaz-Tuzun, O. (2013). An Exploration Of Undergraduate Engineering, Education, Art's and Sciences Students' Chemistry Laboratory Anxiety Levels. *International Journal on New Trends in Education and Their Implications, 4* (4). 75-86.

Karisan, D., Senay, A., Ubuz, B. (2013). A Science Teacher's PCK In Classes With Different Academic Success Levels. *Journal of Educational and Instructional Studies in the World, 3* (1). 22-31.

PAPERS PRESENTED AT INTERNATIONAL CONFERENCES

Karisan, D., Yılmaz-Tuzun, Ö. (2013) Anxiety and Education. *European Conference On Educational Research (ECER),* İstanbul, Turkey, 9-13 September 2013.

Karisan, D., Yılmaz-Tuzun, Ö. (2013) An Exploration Of Preservice Science Teachers' Argumentation Skills and Their Reflective Judgment Stages through Socioscientific Issues . *European Conference on Educational Research (ECER),* İstanbul, Turkey, 9-13 September 2013.

Karisan, D., Senay, A., Ubuz, B. (2013). A Science Teacher's Pck In Classes With Different Academic Success Levels. National Association for Research in Science Teaching, National Association for Research in Science Teaching , NARST, Puerto Rico, United States of America, April 6-9.

Karisan, D., Yılmaz-Tuzun, Ö. (2012). An Exploratıon of Undergraduate Engineering, Education, and Arts and Sciences Students' Chemistry Laboratory Anxiety Levels, *Applied Educational Congress (APPED),* Ankara, Türkiye, 13-15 September 2012.

Karisan, D. & Topcu, M. S. (2012). An Exploration Of Preservice Science Teachers' Written Argumentation in Science Laboratory Work. National Association for Research in Science Teaching, NARST, Indianapolis, United States of America, March 26-28.

Senay, A., **Karisan, D.,** Ubuz, B. (2012). A Science Teacher's Knowledge about Assessments Strategies on Liquid Pressure Topic, *European Conference On Educational Research (ECER),* Cadiz, İspanya, 18-23 Eylül 2012.

Topcu, M. S., & **Karisan, D.** (2012). Preservice Science Teachers' Epistemological Beliefs and the Quality of Science Teaching, *European Conference On Educational Research (ECER)*, Cadiz, İspanya, 18-23 Eylül 2012.

Karisan, D. & Topcu, M. S. (2011). An Exploration Of Preservice Science Teachers' Written Argumentation Skills Regarding The Effects Of Climate Change Issue On The Earth. National Association for Research in Science Teaching , NARST, Orlando, United States of America, April 3-6

Topcu, M. S. & **Karisan, D**. (2011). The Effects Of Argumentation Based Classroom And Traditional Science Classroom On PSTs' Knowledge And Attitude Regarding The Global Climate Change Issue. National Association for Research in Science Teaching, NARST, Orlando, United States of America, April 3-6

NATIONAL CONFERENCE PRESENTATIONS

Karisan, D., & Yılmaz-Tüzün, Ö. (2012). Fen Öğretmen Adaylarının Laboratuvar Uygulamaları Dersindeki Yazılı Argümanlarının İncelenmesi. *10. Ulusal Fen Bilimleri ve Matematik Egitimi Kongresi*, Niğde, TÜRKİYE, Haziran, 27-30.

Karisan, D., Ubuz, B., Şenay, A. (2012). Fen ve Teknoloji Öğretmeninin Sivilarda Basinç Ünitesi İçin Kullandiği Öğretim Yöntemlerinin İncelenmesi. *10. Ulusal Fen Bilimleri ve Matematik Egitimi Kongresi*, Niğde, TÜRKİYE, Haziran, 27-30.

Cetinkaya, G., & **Karisan, D.** (2012) Fen Bilgisi Öğretmen Adaylarinin Bilimin Doğasi Hakkindaki Görüşleri ve Bilimin Doğasina İlişkin Üstbilişsel Yetenekleri Arasindaki İlişkinin İncelenmesi. *10. Ulusal Fen Bilimleri ve Matematik Egitimi Kongresi*, Niğde, TÜRKİYE, Haziran, 27-30.

Karisan, D. & Topcu, M. S**.** (2010). Fen Ögretmen Adaylarının iklim Degisikligi ve Dunyamıza Etkileri Hakkındaki Yazili argumanlarinin incelenmesi. *9. Ulusal Fen Bilimleri ve Matematik Egitimi Kongresi*, İzmir, TURKIYE, Eylul, 23-25

WORKSHOPS, LECTURES AND SYMPOSIA PRESENTED TO PROFESSIONAL ORGANIZATIONS AND INSTITUTIONS

Karisan, D. (2013). Invited Lecture. Socioscientific Issues in the context of Inquiry based laboratory, Invited Lecture, College of Education, Department of Secondary Education, University of South Florida, FL

Memberships & Scholarships :

2013- YÖK- Reseaarch Abroad Scholorship for PhD Students
2013- TÜBİTAK Turkish Science & Technology Research Ass. International Conference Scholarship
2012- NARST United States of America- Conference Scholarship
2012- EERA - Conference Scholarship
2011- TÜBİTAK Turkish Science & Technology Research Ass. International Conference Scholarship
2010- Ongoing: NARST Membership

Appendix N: Tez Fotokopisi İzin Formu

ENSTİTÜ

Fen Bilimleri Enstitüsü ☐

Sosyal Bilimler Enstitüsü ☐

Uygulamalı Matematik Enstitüsü ☐

Enformatik Enstitüsü ☐

Deniz Bilimleri Enstitüsü ☐

YAZARIN

Soyadı : Karışan
Adı : Dilek
Bölümü : İlköğretim

TEZİN ADI : Exploration Of Preservice Teachers' Reflective Judgment And Argumentation Skills Revealed In a Socioscientific Issues-Based Inquiry Laboratory Course

TEZİN TÜRÜ : Yüksek Lisans ☐ Doktora ☐

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐
3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. ☐

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: