EXAMINATION OF PRE-SERVICE CHEMISTRY TEACHERS' COMPETENCY IN THE FIELD OF ENVIRONMENTAL EDUCATION AND SUSTAINABLE DEVELOPMENT

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ABSTRACT

EXAMINATION OF PRE-SERVICE CHEMISTRY TEACHERS' COMPETENCY IN THE FIELD OF ENVIRONMENTAL EDUCATION AND SUSTAINABLE DEVELOPMENT

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The purpose of this study was to explore pre-service chemistry teachers' competency related to Environmental Education and Sustainable Development. In doing so, the frame was set to focus on three fields of competency: (i) content knowledge, (ii) pedagogical content knowledge, (iii) chemistry literacy.

The data gathered from 24 pre-service chemistry teachers at the end of the spring semester of 2016-2017. Essay type questions was used as the source of data. The instrument was created by using the current competences of chemistry teachers constituted by Turkish Ministry of Education in 2011. According to answers of pre-service chemistry teachers coding scheme was created. Results of the study revealed that pre-service chemistry teachers have limited level of competency in the basis of Environmental Education and Sustainable Development.

Keywords: Pre-service Chemistry Teachers, Environmental Education, Education for Sustainable Development

ÖZ

KİMYA ÖĞRETMEN ADAYLARININ ÇEVRE EĞİTİMİ VE SÜRDÜRÜLEBİLİR KALKINMA ALANINDAKİ YETERLİLİKLERİNİN İNCELENMESİ

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Bu çalışmanın amacı, kimya öğretmenlerinin çevre eğitimi ve sürdürülebilir kalkınma ile ilgili yeterliklerini incelemektir. Bunu yaparken, üç yetkinlik alanına odaklanılmıştı, Bu üç alan: (i) içerik bilgisi, (ii) pedagojik içerik bilgisi, (iii) kimya okur yazarlığıdır.

Çalışmanın verileri 2016-2017 bahar yarıyılı sonunda 24 kimya öğretmeni adayından elde edilmiştir. Veriler, açık uçlu sorular aracılığı ile toplanmıştır. Kullanılan ölçme aracı, 2011 yılında TC Milli Eğitim Bakanlığı tarafından kimya öğretmenleri için hazırlanan özel alan yeterlikleri kullanarak tasarlanmıştır. Kimya öğretmeni adaylarının cevaplarına kodlama şemaları geliştirilmiş ve çalışmanın sonuçları kodlamalara göre değerlendirilmiştir. Çalışmanın sonucu, kimya öğretmen adaylarının Çevre Eğitimi ve Sürdürülebilir Kalkınma alanlarındaki yetkinlik düzeyinin sınırlı olduğunu ortaya koymuştur.

Anahtar Kelimeler: Kimya Öğretmen Adayları, Çevre Eğitimi, Sürdürülebilir Kalkınma İçin Eğitim

To my beloved family

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LIST OF ABBREVIATIONS

C: Competence

EE: Environmental Education

ESD: Education for Sustainable Development

MEB: Ministry of Education

N: Number of Participants

PCT: Pre-service Chemistry Teacher

UN: United Nations

UNCED: The United Nations Conference on Environment and Development

UNEP: The United Nations Environment Programme

UNESCO: United Nations Educational, Scientific and Cultural Organization

WCED: World Commission on Environment and Development

CHAPTER 1

INTRODUCTION

It's a fact that in todays' world the issues such as climate change, water pollution, loss of biological diversity is considered as global environmental problems (Jegsted & Sinnes, 2015). These problems are the results of human relationship with nature. Increase in population, excessive use of natural sources, the desire of economic growth that is closely related with natural resource depletion are the major examples for unsustainable use of natural resources; thus, they are the major implications of the results of human-environment relationship. The vitality of nature, thus the sustainability of the planet is threatened growingly by the above-mentioned problems. Correspondingly, as stated in United Nations Environment Programme (UNEP, 2012) environmental problems will continue to grow as long as unsustainable relation of human being continues with the nature of the planet.

When the source of environmental problems is scrutinized, it is obvious that human being is located in the center. While this is the case, the solution involves people; realizing threats on nature and sustainability of the planet and taking individual responsibilities for today and tomorrow. Since the problem cannot be specialized for just some of the societies or just for some of the governments, it is crucial to take action both in national and international areas.

Helping the people living in this planet realize the threats due to unsustainable lives, acting responsibly, and constructing a sustainable future are a few of the major solutions to the threats we are facing today. Such solutions related to helping individuals become aware of the threats and act accordingly, however, are contained in the goals of Environmental Education (EE) and Education for Sustainable Development (ESD).

Environmental education has first come into agenda in 1972 during Stockholm Conference. In the Declaration of the Conference in 1972 in Stockholm, the main actions that asked by both individuals of societies and governments to take were about changing behaviors and attitudes to the environment and nature. Principles stating that mankind must safeguard all kind of natural sources for both present and future generations, or that the necessity of decrease in pollution and insufficient life standards in developing countries could be avowed as just some critical points which reach to environmental education. Later on, again with an international conference, in Tblisi (1977), the concept of EE became a current issue in order to take its place on education by the cooperation of United Nations Education, Scientific, and Cultural Organization (UNESCO) and United Nations Environment Programme (UNEP). As one can see for more over than 40 years, concept of EE has been the subject of important global conferences and the importance of it increasingly continues.

On the other hand, in Rio de Janerio (1992), ESD became the main topic of the United Nations Conference on Environment and Development. Correspondingly, after the decisions taken in Rio (1992), the main structure of ESD subject came to the fore in International Conference on Environment and Society: Education and Public Awareness for Sustainability (1997). According to Declaration of the Conference in Rio (UNCED, 1992), sustainable development can only be achieved by the participation of all citizens and the right of development should be used intending with meeting the needs of environment for both present and future generations in an equal way. Since today's children are the ones who are going to shape the world of future, making them participate and be aware of sustainable development action in order to be achieved seems crucial, education is essential. In accordance with the United Nations (2002), in order to include all citizens especially children for achieving sustainable development education is recognized.

When the all problems related with environment and vitality of world are reconsidered, it can be seen that the way of solutions pass through the process of education. Therefore, EE and ESD are the ways for permanent solutions to these

problems that the world is facing today and might be facing tomorrow. EE and ESD subjects are determined to be given in programs of instruction both in an interdisciplinary and multi-disciplinary way (Ünal & Dımışkı, 1998). In other words, EE and ESD subjects could be included in education programs as a separate lesson or could be included implicitly in the related subjects of lessons such as biology, geography, chemistry etc. Thus, education programs at every level of grade regardless of the kind of lesson, can be prepeared in a way which will enable students to have the knowledge and the awareness related with the environmental problems and the solutions.

With respect to International Environmental Education Program (IEEP, 1994) secondary education is the most effective level for students to take environmental education. When the circumstances are considered in secondary education level, it can be said that there are many types of lessons which can EE and ESD objectives be integrated. One of them is chemistry which is a widely partaking field of science not only in classes but also in our daily lives. Therefore, it is surely beyond doubt that chemistry is one of the most convenient program among secondary education lessons in order to integrate EE and ESD objectives. By including topics of water pollution, recycling, hazardous chemicals etc. chemistry is a proper subject in order to give EE objectives. Moreover, according to Burnmeister & Eilks (2012) chemistry subject has an important role in ESD, when the importance of the chemical industry and chemical knowledge on the problems that threating vitality and sustainability of the world is considered (Jegstad & Sinnes, 2015).

Chemistry program in secondary schools is an important tool to realize the targets for EE and ESD. However integrating EE&ESD objectives in curricula might be a controversial issue, especially when chemistry teachers are not included in the whole picture. Because, teachers are the key elements as they have an important role in shaping future citizens' knowledge, awareness and behaviors. As reported by

UNESCO-UNEP (1987) role of the teachers are crucial in developing education process on environmental issues. Moreover, to be able to accomplish effective application of EE and ESD in schools, teacher education also should be in a convenient way which supplies the knowledge of appropriate teaching methods, materials etc. for EE and ESD (UNESCO-UNEP, 1987). Owing to the fact that future teachers are the ones who will be playing an active role in education of tomorrows, it is important to have suitably-trained teachers as far as EE and ESD are considered.

As a result of all, tackling sustainability problems comprises education programs in different levels as well as teacher education and training programs. The international experience of more than 40 years however (???) related to EE and ESD (UNESCO-UNEP, 1977; UNCED, 1992) states that EE ad ESD shall be integrated in all education programs.

Environment as a global issue has started to take more place in Turkish education program in the last ten years, beginning from 2008 curriculum developments (Kürkçüoğlu, 2012). With respect to Secondary Education Chemistry Program (2013), the place of EE and ESD now can be seen more in the program of chemistry just like other disciplines. Consequently, the teacher education program for chemistry teachers also include EE and ESD related competency criteria in order to have suitably-trained chemistry teacher with existing program. The current chemistry teacher competences divided in three categories as content knowledge, pedagogical content knowledge and chemistry literacy, and competences related with EE and ESD are found to be included in all of the categories.

1.1 Purpose of the Study

The purpose of this study is to explore pre-service chemistry teachers' competences related to Environmental Education and Education for Sustainable Development.

The context of the study is set as to explore pre-service chemistry teachers' competences related to Environmental Education and Education for Sustainable Development based on:

i. Content knowledge
ii. Pedagogical content knowledge
iii. Chemistry literacy

While exploring the competencies, however, the frame was set as to comprise of chemistry teacher competences related to EE and ESD. Accordingly, the questions leading the research are:

1. What is the competency level of pre-service chemistry teachers' according to content knowledge related to EE and ESD?

2. What is the competency level of pre-service chemistry teachers' according to pedagogical content knowledge related to EE and ESD?

3. What is the competency level of pre-service chemistry teachers' according to chemistry literacy related to EE and ESD?

1.2 Significance of the Study

Examination of pre-service chemistry teachers' competency in the field of EE and ESD is very significant since the current chemistry education programs includes many EE and ESD integrated topics. Today's pre-service chemistry teachers, are the ones who will teach the chemistry to future generation. It is important to examine pre-service teachers' competence level in EE and ESD field in order to raise a generation who are environmentally literate and responsible for the nature.

Moreover, the instrument used in the study could provide further information to examine chemistry teacher competences in the field of EE and ESD. Studies including environmental education, sustainable development and chemistry education was limited in literature. Literature containing these three concepts is generally limited with the studies on curriculum designs, environmental attitudes and chemistry literacy levels of pre-service and in-service teachers. Considering all these, current study could bring a new glance to the chemistry education and teacher training literature by contributing to field of EE and ESD.

CHAPTER 2

LITERATURE REVIEW

In this chapter, theoretical background of Environmental Education, Education for Sustainable Development, examination of chemistry subject in terms of EE and ESD and teacher education with respect to EE and ESD topics are studied.

2.1 Environmental Education & Education for Sustainable Development

It is an undeniable fact that environment is a part of human beings as well as human beings are part of environment. Correspondingly, the interactive relation between human beings and nature have lasted inevitably for centuries. Misusing of developing technology, increasing demand of consuming more and more and population growth are some reasons that put human-environment relationship in danger in terms of nature and environment. As a result of the changes in scientific discoveries, technology and social perceptions, present issues related with nature and environment have gained a new extend in last decades (UNESCO-UNEP, 1977). Expanding problems with nature and environment first started to become an issue in 1970s. Consequences of these problems were started to be realized by the national and international areas until then. As a result, solutions to problems of nature and environment have become an issue, which is worth to work on since then.

The effort on environmental issues have started with the United Nations Conference on the Human Environment (Stockholm, 1972). In order to promote the behavior of conserving and fostering the human environment, common principles for all nations were discussed in the conference (United Nations, 1972). It is proclaimed that human beings have the responsibility of protecting and enhancing the environment, for well-being of not only present generation but also for future

generations (United Nations, 1972). The conference report included education as a crucial factor in order to conduct environmental responsibility for individuals. The need of education related to environmental issues is expressed with principle 19 with the statement of:

> *"Education in environmental matters, for the younger generation as well as adults, giving due consideration to the unprivileged, is essential in order to broaden the basis for an enlightened opinion and responsible conduct by individuals, enterprises and communities in protecting and improving the environment in its full human-dimension."*

Based upon the emphasis on the education process in the UN report, researching about environmental education in the worldwide, United Nations Educational, Scientific, and Cultural Organization (UNESCO) found out that the present education programs are inadequate with respect to environmental education. The lack of proper education programs with respect to environment was a problematic issue that need to be improved (UNESCO, 1975). For this reason, to give more and effective place to environmental issues in education process, with the co-operation of UNESCO and UNEP, Intergovernmental Conference on Environmental Education was held in Tbilisi (1977). In the presence of 265 delegates and 65 other representatives, the main topics of the conference were the existing environmental problems, the place of education on the solutions of environmental problems, recent work done related with environmental education both national and international state, and further needs for the development of environmental education globally (UNESCO-UNEP, 1977). The aims, principles and goals of environmental education were aimed to emerge and recommendations were indicated in the Final Report of the Conference. According to final report, environmental education was stated to aim composing a consciousness to environmental issues, well-being and survival of the humanity both for present and future generations. In accordance with this purpose, it was stated that regardless of the grade level, environmental education should have part in programs of education

both as a different subject and as an integrated topic in different sort of learning subjects and the key process for proper environmental education awareness, knowledge, attitude, skills and participation were set as objectives (UNESCO-UNEP, 1977).

One step further, the attempt of "sustainable development" came to the fore with the Brundtland Report (UN, 1987). The term of sustainable development stated in the report as a development;

> *"Which meets the needs of the present without compromising the ability of future generations to meet their own needs".*

According to the definition, it can be said that sustainable development concerns not only environment but also development of the nations. Making emphasis on the need of development of nations, environmental problems, equity, economy and the linking of all these factors each other, a new perception was brought out by World Commission on Environment and Development (WCED) with Brundtland Report (UN, 1987). The idea that economic development and the degeneracy on environment are associated was first made in 1972 in United Nations Conference on the Human Environment indeed. Later than, under the light of attempts and decisions of former conferences, United Nations Conference on Environment and Development (UNCED) was held in Brazil in 1992 with the principle themes of environment and sustainable development. The main goal of the conference was to consider a way of development that would exclude the degeneracy of the environment while promoting socio economic development with considering the needs of countries in order to provide a healthy future for the world. The main message of the conference was to indicate the attitude and behavior change towards the environment for a better future (UNCED, 1992). There are 5 important documents acquired at the end of the conference; Agenda 21, the Rio Declaration on Environment and Development, the Statement of Forest Principles, the United Nations Framework Convention on Climate Change and the United Nations Convention on Biological Diversity (UNCED, 1992). The declaration of the

conference creates the infrastructure of the documents. The Rio Declaration proclaims that people from all social groups including children, women, adults etc. should have parts to take on sustainable development issue. Agenda 21, addresses education as a crucial factor in order to support sustainable development process and increase the awareness of people.

In the light of conferences and the decisions, it can be said that the necessity to go for a renewal with respect to EE and ESD on the education programs were emphasized. It is surely beyond doubt that the revision is needed in both curricula of formal education and teacher education programs. In order to reach the goals of EE and ESD the revision in education programs plays a big role when the whole picture is considered.

Eventually, the current situation initiated the idea of revision on education programs with respect to EE and ESD in many countries including Turkey.

2.2 Integration of Environmental Education and Education for Sustainable Development in Education Programs

It is recommended that in both formal and non-formal education in every level, education related to environment should be given to all human being regardless of their ages (UNESCO-UNEP Tbilisi, 1977). Because of the fact that environmental problems are increasing day by day, integrating environmental and development issues to education has become more critical. The environmental attempt in education which was started with Tbilisi, brought the necessity of renewal on education programs. Since then, many countries have environmental and development subjects integrated in their curriculum (Ünal & Dımışkı, 1998; Thathong, 2010; Esa, 2010; Shaari & Osman, 2011).

According to the studies, in order to include EE and ESD in education, there are two models of integration recommended by UNESCO-UNEP IEEP prepared by

Hungerford et. al. (1994). The first model implies that environmental issues could be given as an interdisciplinary (single subject) subject which includes the related parts of other subjects such as mathematics, life sciences and social studies, physical sciences etc. as one option. The second one claims that environmental issues could have place in education programs as integrated in the related parts of current subjects of science, mathematics, social studies, arts/humanities, communications etc. , which is called as multi-disciplinary (infusion) model. It can be said that both models have advantages and disadvantages with respect to implementation, teacher competencies, curriculum development, age level appropriateness etc.

It is expressed that implementation of interdisciplinary model could be easier than multidisciplinary because of the fact that multidisciplinary model would need more teachers to be trained. However, in the interdisciplinary model, the teacher should have in-depth training in terms of environmental education, in multidisciplinary model, on the other hand, not much depth training of teachers would not be needed. If the appropriateness level of models is considered, owing to the fact that environmental goals in education could be given with many different subjects in different levels, multidisciplinary model can be more suitable than interdisciplinary model (Hungerford et. al., 1994).

On behalf of an efficient education with respect to environment, both models are recommended to be involved in curriculums (Hungerford et al., 1994). Thus, while both models are preferred to be used in curriculums by some authorities, only interdisciplinary or multi-disciplinary model is integrated in curriculums of some education programs. According to the research, infusion model is very effective on applying environmental issues and problem-solving skills with many different subjects of topics (Hungerford et. al., 1994). It can be said that by this way, learners may have the chance to use and integrate environmental concepts in variety of situations in their daily life.

When the role of education programs in implementing EE and ESD in various subjects considered, it is inevitable to encounter many studies on this subject

from many different countries. The education programs have been subject to researchers both for curriculum studies and teacher education studies in the point of EE and ESD. Many different studies focusing on different parts of EE and ESD, revealed the current situations of education programs and teacher education, various problems, results and inferences related with EE and ESD.

In the year of 2007, Uzun & Sağlam stated that the secondary school curriculum of Turkey did not have any must courses related with environmental education. Moreover, it was revealed that teachers did not find the curriculum effective enough in order to make students gain knowledge attitude and responsibility about environmental issues. Moreover, despite of changing curriculum over the years, even though more place was given to EE and ESD than before (Kürkçüoğlu, 2012), the current curriculum was found to have environmental issues integrated in only a few subjects (Içöz, 2015).

Adedayo and Olawepo (1997) stated in their studies that the curriculum in Nigeria EE have not been adequately integrated to the programs of science and social science education. Moreover, it is stated that more efforts on teacher education and curriculum developments related with environmental issues should be made. According to Norris, (2016) EE was integrated in the current subjects such as mathematics, religious studies, English language, science subjects etc. of the Nigeria Education Program in both primary and secondary levels. Moreover, the curriculum was designed to focus around the four goals of EE that are ecological foundation, human environment and development, environmental change and impact, sustainable development (Norris, 2016).

About the integration of EE and ESD subjects in education programs, Gwekwerere (2014) revealed that environmental issues are not covered deeply in the education programs of primary and middle school. As a result, pre-service teachers in Ontario are found to have limited environmental knowledge. Negre at al. (2014) stated that, teacher training program at primary level in Spain contains only a few

environmental sustainability including competences. Moreover, the limited context of clarifications exists for the practice of these competences (Negre at al., 2014).

2.3 Place of EE & ESD in Chemistry Education

It is a fact that chemistry is one of the most available subjects in order to use interdisciplinary model of EE according to its nature. Pharmaceutics, construction industry, energy sources, food industry, house cleaning are only some of the fields that includes chemistry. The use of chemistry in that wide area increases the importance of the content of chemistry lessons when considered from the side of students. The nature of the chemistry enables to discuss not only the theoretical knowledge of chemistry but also the socio-scientific issues related with daily life problems (Juntunen & Aksela, 2014). When the goals of EE and ESD are considered (chapter 2.1), there are many points that EE, ESD and chemistry subjects are interacted. Moreover, previous research revealed that there are many different ways to include environmental issues in chemistry education, like implementing the concepts in lab works or adding sustainability strategies in chemistry education context (Burnmeister & Rauch & Eilks, 2012).

According to Burnmeiser & Eilks (2012), the science of chemistry is told to have an important place for ESD. According to a study which was done by Juntunen and Aksela (2014), including sustainable development issues in chemistry classes was stated as a big step of development. Integration of topics like pollution, effects of chemicals in the nature and human health, enables to connect chemistry subject to the daily life events of students (Juntunen & Aksela, 2014).

Including environmental issues in chemistry lessons would both make chemistry classes more integrated with daily life examples and available environment in order to raise students who have environmental awareness. Achieving EE and ESD objectives in chemistry classes would create a better understanding environment in terms of daily life and chemistry connection (İçöz, 2015). Thus, it can be said that including more environmental issues in chemistry

would be one bigger step in order to have a better and sustainable environment in the future. Correspondingly, when the literature is examined, it is seen that chemistry, EE and ESD relationship have been subject to many research topics.

2.4 Chemistry Education Program in Turkey with Respect to EE and ESD

2.4.1. General Objectives of Chemistry According To Secondary Education Chemistry Program

It is important to educate students in a way where they are able to keep pace with the changing and increasingly globalizing world. The developments in science and technology and having different problems and different questions than yesterday's world result in working up with the education programs since the education is the crucial way to keep up with the changing world. For this very reason, the curricula of education programs are being revised in years according to needs. Like in other countries, there have been changes in curriculum in Turkish Education Program in different past years. In Secondary Education Program the last change was made in 2013. According to Ministry of National Education, the programs were revised by Board of Education and Discipline. According to goal of the secondary education chemistry program, students are aimed to be literate in science and aimed to be literate in chemistry (MEB, 2012). As secondary education subjects like physics, biology, mathematics etc., chemistry subject also has objectives that are divided in some categories of scientific literacy themes. It is possible to see goals and objectives that reflect these goals, which are related with Environmental Education and Education for Sustainable Development for secondary education chemistry program. With reference to Secondary Education Chemistry Program (2013), the general aim of fundamental level chemistry education program contains four items. Examining the general aims, two in four were found to be related with EE and ESD. The two aims are:

Acquires the basic concepts, principles, models, theories, laws and skills of chemistry and uses these knowledge and skills to explain events related to everyday life, human health, industry and environmental problems.

Develops an attitude that can distinguish the positive and negative aspects of chemical technologies reflected in human life; evaluates them in terms of human health, society, environment and quality of life.

The objectives of chemistry subject seem to be divided into 6 sub-topics which are under scientific literacy themes. There is no objective found related with EE and EDS in the topics of nature of science, understanding scientific knowledge and psychomotor skills in secondary education chemistry program's general objectives. On the other hand, in the topics of skills-life skills, science & technology & society & environment and economy and lastly attitudes & values, there are some objectives which contain EE and ESD aims. The objectives are implicitly given part in the program. Since there are objectives in chemistry education program which are also the concern of EE and ESD, it can be expected that there are EE and ESD subjects integrated in chemistry units which can be given implicitly or explicitly. Objectives:

1. Gains awareness against environmental problems.

2. Describes the positive/negative effects of science and technology improvements on human and nature analytically.

3. Is enthusiastic about finding solutions to environmental problems.

2.4.2 Competency for Turkish Chemistry Teachers

It is a fact that teachers have one of the most important role in the process of education during the school life of the students. When it is considered that education

has a dynamic structure with its whole dimensions, it seems essential to make teachers develop continuously and question the competency of teachers in their fields of teaching (MEB, 2012). It is possible to have more qualified teachers as long as they are aware of the general and specific competencies that they should have according to their teaching field of profession. For the very reason The Ministry of Education in Turkey, continuously works on the teacher competencies' in cooperation with universities which have an important role in the education of teacher candidates (MEB, 2012). In 2011, Ministry of Education prepared a special field competency criteria named "General Competencies of Teaching Profession" for the teachers of elementary education. Based on the fact that secondary education level has many branches, taking into account of Secondary Education Project, specialized field based competency criteria for Turkish Language, History, Geography, Philosophy, Mathematics, Biology, Physics and Chemistry were designed (MEB, 2011). Competences organized in different subtopics for chemistry subject just like other seven subjects. Chemistry teachers' competences were categorized in three sub-topics which are content knowledge, pedagogical content knowledge and chemistry literacy. Category of content knowledge includes the competence of a chemistry teacher's ability of evaluation for a theory, law, principle, hypothesis and concepts of chemistry and relating them with other subjects or disciplines. The items consist of the chemical knowledge which are specified in chemistry topics such as electrochemistry, organic chemistry, acids and bases etc. Also, there are items that express that chemistry teachers should be able to associate chemistry with the other disciplines of subjects such as physics, science and technology and mathematics. In the pedagogical knowledge part, the competencies include the following and evaluating the curriculum and planning the education process according to the curriculum with proper education strategies, assessment and evaluation techniques. In this part of competencies, chemistry teachers are expected to be able to explain the teaching methods, their advantages and disadvantages and improve measurement materials in order to measure the scientific process skills of students. The third category includes the competencies about the ability of understanding the nature of science, using the ability of scientific

knowledge and laboratory and making relations between chemistry, technology, society and environment by using informatics and communication skills. As it seems, there are many criteria of competencies in the chemistry teacher education comprising many different aspects of education. Examining the competencies of whole three categories, it was found that Environmental Education and Education for Sustainable Development is one of the areas that are included in the competencies for chemistry teachers to have. Compared to first two categories - content knowledge and pedagogical knowledge -, the third category which includes competency criteria related with chemistry literacy has more items integrated in about EE and ESD subjects. Therefore, it can be said that the competencies, which chemistry teachers are expected to have involve chemistry and environment related items. Moreover, chemistry teachers are expected to have competencies related with education for sustainable development. Items such as "teacher gives examples which show that chemistry, technology, society and environment are involved in an interaction" and "teacher examines the contribution of chemistry in preventing environmental pollution" shows that EE and ESD subjects are integrated in program for chemistry teacher education. Even though the EE and ESD related areas of competencies are not indicated in an explicit way, the part of EE and ESD in chemistry teacher education can be understood from the items taken from Competency Criteria for Chemistry Teacher listed in the table below.

Table 1: Competences Related with EE and ESD for Chemistry Teachers

Competence Categories for Chemistry Teachers	**Competences Related with EE and ESD**
Content Knowledge Competences	C1. Judges the changes that occur in the atomic nucleus in terms of energy and the effects on environment. C2. Explains the organic and inorganic compounds of chemicals which are used in daily life such as cleaning materials, dyes, fertilizer, explosives, fuels, plastics, superconductors and alloys.
Pedagogical Content Knowledge Competences	C3. Explains the technology, society, environment and nature of science dimensions of curriculum. C4. Gives examples that emphasizes the relationship between chemistry, technology, society and environment during the teaching process. C5. Organizes extracurricular activities which will help students to understand the relationship between chemistry, technology, society and environment by taking sociocultural conditions into consideration.
Chemistry Literacy Competences	C6. Organizes seminars and panels in school in order to draw attention to the national and international problems such as environmental pollution, global warming. C7. Gives examples to chemicals and chemistry technologies which destroy the environment. C8. Examines the contribution of chemistry to the prevention of environmental pollution. C9. Gives examples that shows chemistry, technology, society and environment are interaction.

CHAPTER 3

METHOD

The study is aimed to explore pre-service chemistry teachers' competences related to Environmental Education and Education for Sustainable Development. The data collected from pre-service chemistry teachers who are at the end of the 4th grade and 5th grade at the semester. Participants were given a test consist of essay-type questions in a class environment. This chapter includes the process followed in the presented study. Study design, participant selection, content of the instrument and procedure that is employed in data collection in the study is described in this chapter.

Participants of the study are pre-service chemistry teacher who were enrolled in 4th or 5th grade in the second semester of the 2016-2017 academic year, in a university in Turkey. The selection of the participants was made due to their grades at the current semester. Pre-service chemistry teachers are taking their training courses in the 5th grade of their education process. Participants who were selected for the study thus, were the ones who will take their teacher training courses in the next semester or who were taking the teacher training course in the current semester. Eleven 4th and thirteen 5th grade pre-service chemistry teachers were enrolled in study. Total number of twenty-four pre-service chemistry teachers participated the study. The gender profile of the participants consists of eight males and sixteen female pre-service chemistry teachers.

Data was collected with an instrument that is created by using the current competences of chemistry teachers constituted by Turkish Ministry of Education in 2011. In the competences prepared for Turkish chemistry teachers by Turkish Ministry of Education, competences were divided in three parts as; Content Knowledge, Pedagogical Content Knowledge and Chemistry Literacy. All three

parts of the competences were examined by two researchers and the ones related with EE and ESD subjects were taken in order to be used in the instrument creation. Total number of 9 competences in 113, were found to be related with EE and ESD field. Two of content knowledge competences, three of pedagogical content knowledge competences and four of chemistry literacy competences were found to be related with EE and ESD and chosen in order to be examined in the study.

Table 2: Competences Related with EE and ESD for Chemistry Teachers

Competence Categories for Chemistry Teachers	**Competences Related with EE and ESD**
Content Knowledge Competences	C1. Judges the changes that occur in the atomic nucleus in terms of energy and the effects on environment. C2. Explains the organic and inorganic compounds of chemicals which are used in daily life such as cleaning materials, dyes, fertilizer, explosives, fuels, plastics, superconductors and alloys.
Pedagogical Content Knowledge Competences	C3. Explains the technology, society, environment and nature of science dimensions of curriculum. C4. Gives examples that emphasizes the relationship between chemistry, technology, society and environment during the teaching process. C5. Organizes extracurricular activities which will help students to understand the relationship between chemistry, technology, society and environment by taking sociocultural conditions into consideration.
Chemistry Literacy Competences	C6. Organizes seminars and panels in school in order to draw attention to the national and international problems such as environmental pollution, global warming. C7. Gives examples to chemicals and chemistry technologies which destroy the environment. C8. Examines the contribution of chemistry to the prevention of environmental pollution. C9. Gives examples that shows chemistry, technology, society and environment are interaction.

Eight essay type questions including sub-questions was designed by using the competences related with EE and ESD. The questions in the instrument regulated with respect to remarks of two expert in the field.

After the creation of the instrument was completed, pilot study was made with two pre-service chemistry teachers. There were not any adding or removal done in the questions of the instrument after the application of the pilot study. The data collection was made in class environment in order to provide more effective responding process of participants. Data collected at the end of the semester of 2016-2017.

Results evaluated in three parts according to three research questions. In the first part, results of the questions related with content knowledge competences were coded. The next three questions related with pedagogical content knowledge competences were evaluated in the second part of the results. In the chemistry literacy part of the results four questions were coded in order to examine the competence of pre-service chemistry teachers. Two researches evaluated the results by coding the data in order to provide reliability of the results. In all three parts of the result evaluation, data which was gained from pre-service chemistry teachers were tried to be categorized by coding. The main categories were decided according to the frequency of the answers.

CHAPTER 4

FINDINGS

In this chapter, the results related to the research questions of the thesis are presented. Therefore, the content of each section is related to one of the research questions. As research questions implied, competences considered as the basic concept of the study. Accordingly, the sections of this chapter comprise of content knowledge, pedagogical content knowledge and chemistry literacy of pre-service chemistry teachers related to EE and ESD.

4.1 Content Knowledge of Pre-service Chemistry Teachers Related to EE and ESD

In this part, EE and ESD related competences of pre-service chemistry teachers were evaluated according to the answers they have given to the questions they were asked in the context of this thesis. The competence related to EE and ESD content knowledge is the ability of a chemistry teacher to evaluate a theory, law, principle hypothesis and concepts related with chemistry (MEB, 2011).

4.1.1 Energy and Environment

The competence that is evaluated through the answers given to the first question in Environmental Education and Sustainable Development Competence Evaluation Questions for Chemistry Teachers is related to the pre-service teachers' content knowledge on the changes that occur in the atomic nucleus in terms of energy and the effects on environment (A1.26th competence in the table, appendix B).

According to Secondary School Teachers Special Field Competences; Chemistry (MEB, 2011), chemistry teachers are expected to be able to judge the changes in the nucleus regarding energy and environmental effects. In order to explain the effects, PCTs have to have proper information about the changes that occur in the nucleus of atoms. Therefore, the answers given for this question are evaluated into 2 parts: At first the part of the question evaluated was: *"What could be the changes occur that in the atomic nucleus*?" As a result of evaluation of the pre-service teachers' answers, three main categories were emerged:

1. Right Answer
2. Partially Right Answer
3. Wrong Answer

Right answer: Radioactive decays, fission and fusion reactions

Eight PCTs out of twenty-four gave the expected answer for this question: *Radioactive decays, fission and fusion reactions* (Çoruh, 2015, p. 152).

> *"Fission and fusion reactions, radioactive decays (such as* α*,* β*,* γ*)." (PCT 5)*
> *"Fission, fusion* α*,* β*,* γ *radioactive decays." (PCT 4)*

Partially right answer: (Only fission or only fusion reaction accepted as partially right answer)

The answers given by twelve of the pre-service chemistry teachers (out of 24) however were not exactly the expected answers but were close.

> *"The nucleus of an atom can be split (fission)." (PCT 7)*
> *"Fission; for the radioactive reactions." (PCT 14)*

Wrong/no answer

Four of the PCTs' answers, on the other hand, were either irrelevant (N=2) or empty (N=2) as far as the first knowledge question is considered.

> *"When we consider the atom theories; at the first times, there were no concept of nucleus. After, the concept of nucleus was discovered and it was discovered that there were proton and neutron particles in the nucleus. Scientific knowledge had changed and became as it is expected today." (PCT 18)*

Therefore, considering the answers given for the first question, it can be said that 20 PCTs out of 24 have an idea about what changes can occur in the nucleus of an atom.

Table 3: Categories related to EE and ESD content knowledge - question 1

"What could be the changes that occur in the atomic nucleus?"	
Categories	**Number of PCTs**
Right answer: ***radioactive decays, fission and fusion reactions****	8
Partially right answer: ***only fission or only fusion reaction***	12
Wrong answer	4

Answer for the question taken from 12th grade Physics textbook based upon the changed curriculum (MEB, 2013)

At the second part of the content knowledge, the answers evaluated for the following question: *"How can you judge the changes that occur in the atomic nucleus in terms of energy and the effects on environment*?"

In the question 1/a, pre-service chemistry teachers were asked about the changes that occur in the atomic nucleus in terms of energy and the effects on environment. Answers given by the pre-service chemistry teachers were evaluated under three main categories in terms of energy of the atomic nucleus changes:

1. Atomic nucleus changes release a large amount of energy
2. Atomic nucleus changes releases an energy which causes radiation
3. No/irrelevant answer

Atomic nucleus changes release a large amount of energy

The first category consists of the answers given by 10 pre-service chemistry teachers who all wrote that the atomic nucleus changes release a large amount of energy. 2 pre-service chemistry teachers in 10, also indicated that this energy is formed as heat.

> *"These changes on the nucleus can be used to make bombs. When they are used in order to make bombs, very high amount of energy occurs." (PCT 14)*

> *"Because of giving a great amount energy to environment and transferring this energy in the form of heat…" (PCT 2)*

Atomic nucleus changes release an energy which causes radiation

With judging energy of the atomic nucleus changes is a kind of energy that causes radiation, six of the pre-service chemistry teachers merged under the second

category. Two pre-service chemistry teachers who said that the energy causes radiation also indicated the energy type as heat.

> *"Reactions on the nucleus causes radiation. These changes are exothermic type, while the environment gains heat, system loses heat." (PCT 21)*

No/irrelevant answer

Eight of the pre-service chemistry teachers did not made any judgement or made an irrelevant judgment about the question. Six of the pre-service chemistry teachers in that eight, were the ones that gave the right answer (3 PCTs) or gave and partially right answer (3 PCTs) for the question *"What could be the changes that occur in the atomic nucleus?*" Therefore, even though pre-service chemistry teachers have the knowledge of the changes occur in atomic nucleus are radioactive decays (fission and fusion reactions) some pre-service chemistry teachers were not able to make judgement about the decays in terms of energy.

Table 4 : Categories related to EE and ESD content knowledge - question 1a

"How can you judge the changes that occur in the atomic <u>nucleus</u> <u>in terms of energy</u> and the effects on environment?"	
Categories	Number of PCTs
atomic nucleus changes release a large amount of energy	10
atomic nucleus changes release an energy which causes radiation	6
no/irrelevant answer	8

Following results were evaluated from the second part of question 1/a which is related with the environmental effects of atomic nucleus changes. Answers given by the pre-service chemistry teachers were evaluated under three main categories in terms of effects of the atomic nucleus changes on environment:

1. Atomic nucleus changes have negative effects on environment
2. Atomic nucleus changes have negative effects on environment and human-being
3. No/irrelevant answer

Atomic nucleus changes have negative effects on environment

Most of the pre-service chemistry teachers judged the changes on atomic nucleus as to have a negative effect on environment. The frequency of pre-service chemistry teachers who indicated a negative effect on environment is 19 in 24. Moreover, four of the pre-service chemistry teachers that stated negative effect on environment, also stated that if these changes on atomic nucleus can be keep under control the effects could be lowered on environment.

> *"As an example, nuclear reactors and atomic bombs can be thought. If the reactions can be kept under control that large amount of energy may be beneficial but failing this may cause huge destructions." (PCT 19)*

Atomic nucleus changes have negative effects on environment and human-being

Eight of pre-service chemistry teachers that judged the changes on nucleus as to have negative effect on environment also indicated the negative effect of these changes on human-being.

"Released radioactive decays in these reactions are harmful for environment and human-being. These works should be kept under control." (PCT 3)

"... the effect on environment could be at a fearful rate. Atomic bomb for example works with radioactive decay and even many years passes, the effects of the bomb will still last due to the half-life of radioactive materials, just like the example of Chernobyl disaster. The disaster of Chernobyl still effecting many people today." (PCT 17)

No/irrelevant answer

Besides, four pre-service chemistry teachers did not give any answers on the effects of atomic nucleus changes on environment and one pre-service chemistry teacher gave an irrelevant answer with the question.

Table 5: Categories related to EE and ESD content knowledge - question 1a

"How can you judge the changes that occur in the atomic nucleus in terms of energy and the effects on environment?"	
Categories	**Number of PCTs**
Atomic nucleus changes have negative effects on environment	11
Atomic nucleus changes have negative effects on environment and human-being	8
No/irrelevant answer	5

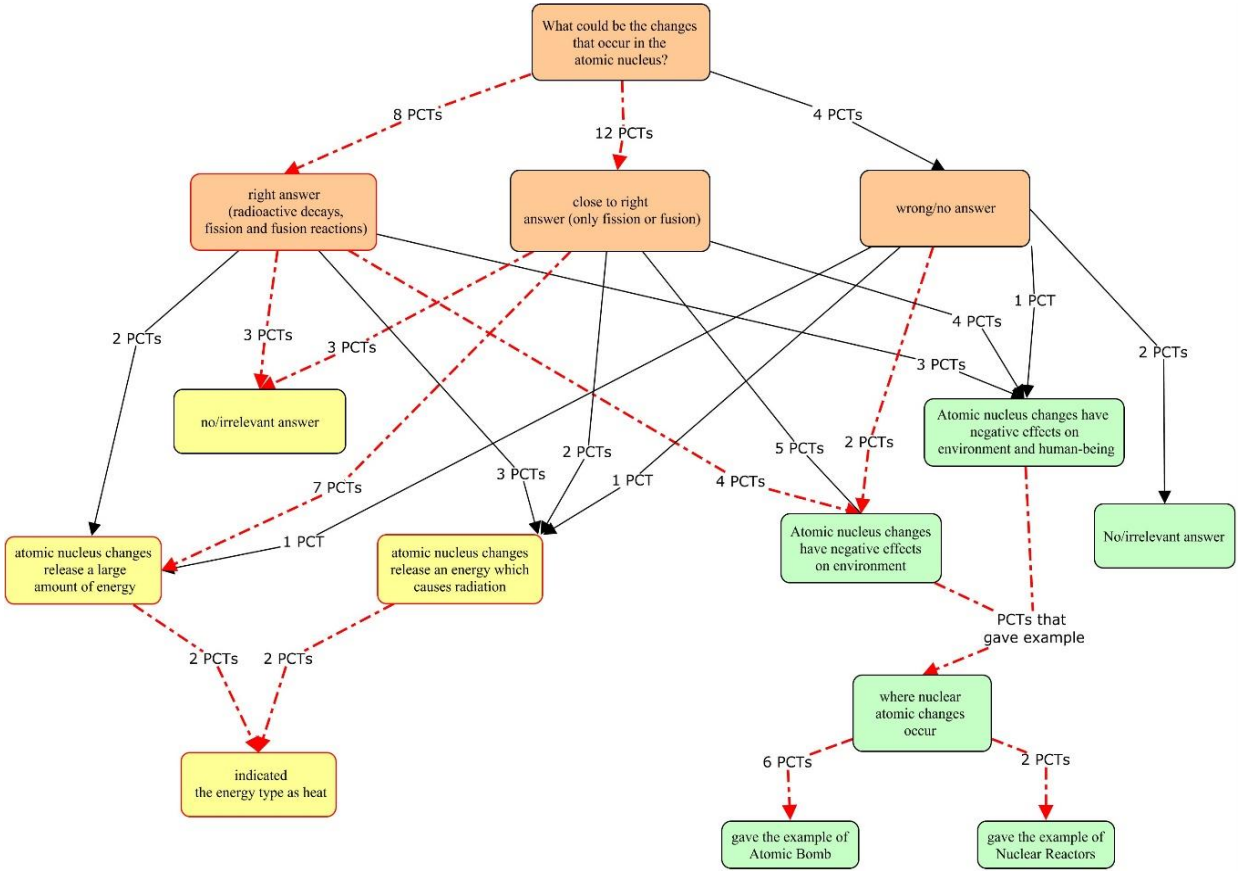

Figure 1 Answer pathways of PCTs for the first question

4.1.2 Organic and Inorganic Compounds of Chemicals

The competence that is evaluated through the answers given to the second question in Environmental Education and Sustainable Development Competence Evaluation Questions for Chemistry Teachers is related to the pre-service teachers' content knowledge about the explanations of the organic and inorganic compounds of chemicals which are used in daily life.

According to Secondary School Teachers Special Field Competences; Chemistry (MEB, 2011) chemistry teachers are expected to be able to explain the organic and inorganic compounds of chemicals which are used in daily life such as cleaning materials, dyes, fertilizer, explosives, fuels, plastics, superconductors and alloys (A1.27th competence in the table, appendix B).

The answers given for this question are evaluated into two parts: At first the part of the question evaluated was: *What do come to your mind when you think of the chemicals that are used in daily life*?" As a result of evaluation of the pre-service teachers' answers, examples from different types of chemicals were merged under eight categories. One of the pre-service teachers leave the question unanswered.

1. Cleaning Materials
2. Cosmetics
3. Pharmaceuticals
4. Industrial Materials
5. Food Industry
6. Construction Materials
7. Stationary Equipment
8. Fuel
9. No answer

Cleaning Materials

Nearly all of the pre-service chemistry teachers with a number of twenty-three in twenty-four indicated cleaning materials such as soap, detergent, bleach etc. as chemicals used in daily life.

> *"Cleaning materials are the first chemicals that come to my mind. Bleach, sprit of salt, drain opener etc." (PCT 23)*

Cosmetics

Fifteen pre-service teachers from twenty-four mentioned cosmetic products such as creams, perfumes and deodorants.

Pharmaceuticals

Pharmaceutical products were given as example by eight pre-service chemistry teachers.

Industrial Materials

Eight pre-service chemistry teachers gave examples of industrial materials to chemicals which are used in daily life.

> *"Chemicals that used in daily life reminds me the chemistry present in cleaning materials. Also, plastics are the chemicals that come to my mind." (PCT 24)*

Food Industry

Five pre-service chemistry teachers gave example from food industry.

> *"Everything actually. Cleaning materials, cosmetics, the preservatives and sweetening agent in food products, pharmaceuticals, and vitamins are obtained with using chemicals." (PCT 15)*

Construction Materials

Four pre-service chemistry teachers in twenty-four mentioned construction materials as chemicals that have place in daily life such as dyes and lime.

Stationary Equipment

Three of pre-service chemistry teachers gave examples of stationary equipment.

> *"Soap, detergent as cleaning materials; paper, pen, ink as stationary equipment; perfume, deodorant, cream as cosmetics; polymers and pharmaceuticals." (PCT 21)*

Fuel

Two pre-service teachers gave the example of fuels.

No answer

Only one pre-service chemistry teacher leaved the question unanswered.

Table 6: Categories related to EE and ESD content knowledge - question 2

"What do come to your mind when you think of the chemicals that are used in daily life?"	
Categories	Number of PCTs
Cleaning Materials	23
Cosmetics	15
Pharmaceuticals	8
Industrial Materials	8
Food Industry	5
Construction Materials	4
Stationary Equipment	3
Fuel	2
No answer	1

Second part of question was "*Can you explain organic and inorganic compounds of these that are used in daily life materials (cleaning materials, dyes, fertilizers, explosives, fuels, plastics, superconductors and alloys)?"* There were two categories of pre-service chemistry teacher according to answers to this question.

1. No explanation
2. At least one chemical's compound explained

No explanation

Nine of pre-service chemistry teacher could not give any organic or inorganic compounds of any materials. They indicated either that they have no idea or just leave the question unanswered.

At least one chemical's compound explained

15 pre-service chemistry teachers were able to give at least one example of the compounds of a chemical, which is used in daily life. Pre-service chemistry teachers could explain compounds of maximum four different daily life chemicals. Five pre-service chemistry teachers explained four different chemicals, also other five pre-service chemistry teachers were able to indicate two different chemicals' compounds correctly, four pre-service chemistry teachers gave just one example and one pre-service chemistry teacher were able to give three different chemicals compounds correctly. The highest frequency of chemicals whose compounds explained correctly belongs to plastics, explosives and soap. Pre-service chemistry teachers also indicated the compounds of materials as fertilizers, detergent, bleach, dye, lime, food preservative, and drain opener, sprit of salt, stomach syrup and aspirin.

> *"Plastics comprise of polymers (for example vinyl is a polymer)." (PCT 13)*

"I know that there is hydrogen peroxide in dye. In cleaning materials for example in soap, there are base and oil products which creates the hydrophobic and hydrophilic structures of "micelles". Plastics are consisting of polymers." (PCT 17)

"Sprit of salt : HCl, Bleach : NaOCl, Drain opener : NaOH, also I know that in fertilizers, there are compounds of potassium like KNO_3" (PCT 23)

Table 7 : Categories related to EE and ESD content knowledge - question 2a

"*Can you explain organic and inorganic compounds of these that are used in daily life materials (cleaning materials, dyes, fertilizers, explosives, fuels, plastics, superconductors and alloys)?*"		
Categories		Total Number of PCTs
PCTs who explained at least one chemical's compound correctly	4 correct chemicals' compounds : 5 PCTs	15
	3 correct chemicals' compounds : 1 PCT	
	2 correct chemicals' compounds : 5 PCTs	
	1 correct chemical's compounds : 3 PCTs	
PCTs who did not explain any compounds of chemicals		9

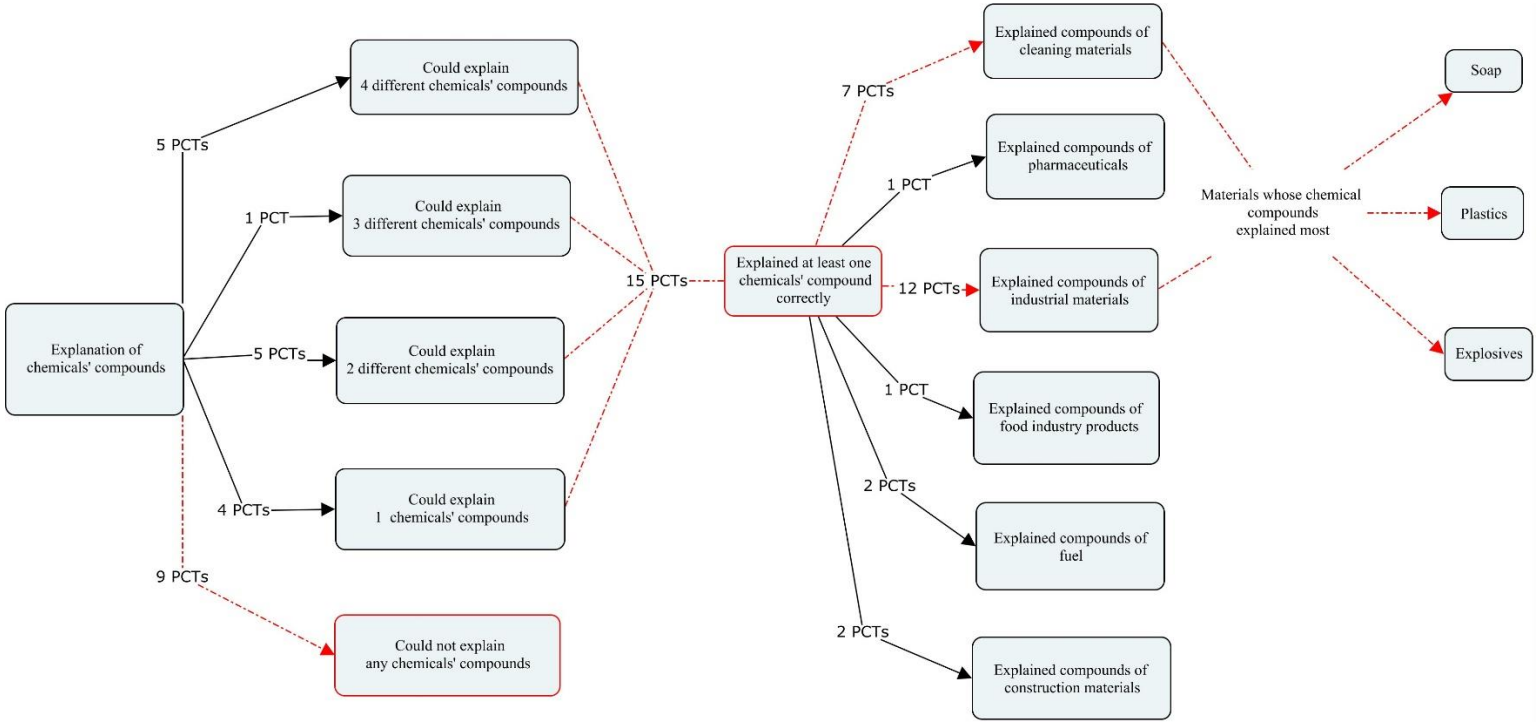

Figure 2 Answer pathways of PCTs according to second question

4.2 Pedagogical Content Knowledge of Pre-service Chemistry Teachers Related to EE and ESD

In this part, competences that includes EE and ESD based context taken from pedagogical content knowledge part of Chemistry Teacher Competences (MEB, 2011) were evaluated. Competences in these part belongs to the section of is related with the ability of a chemistry teacher to follow and evaluate the curriculum and the ability of a chemistry teacher to plan and perform the teaching process with respect to curriculum (MEB, 2011).

4.2.1 Environment dimension of the curriculum

The competence that is evaluated through the answers given to the third question in Environmental Education and Sustainable Development Competence Evaluation Questions for Chemistry Teachers is related to the pre-service teachers' pedagogical content knowledge on explaining the technology, society, environment and nature of science dimensions of chemistry curriculum (B1.5th competence in the table, appendix B).

In this part, PCTs answers to question of *"Can you explain the technology, society, environment and nature of science dimensions of chemistry curriculum? Can you explain what kind of topics chemistry curriculum includes related with these dimensions?"* were evaluated with respect to EE and ESD. Only results related with environment dimension of curriculum was revealed below. According to evaluation, the answers of the PCTs were collected in three categories.

1. No explanation
2. Noting related with environment dimension
3. At least one topic explained

No explanation

8 of PCTs did not explain any part of environment dimension of chemistry curriculum or stated that they have no idea about environment dimension of the current chemistry curriculum.

> *"I do not have any information about any of this content located within the current chemistry curriculum." (PCT 23)*

Noting related with environment dimension

4 of PCTs indicated that there is nothing related with environment dimension is included in chemistry curriculum. In other words, half of the PCTs whether have no idea about the environment related concepts in the chemistry curriculum or think that there is not any environment related concept in the curriculum.

> *"I know that there is not comprehensive information related with environment in the chemistry curriculum. However, the concept can be integrated into a topic with proper examples and make students learn about the relationship between chemistry and environment." (PCT 8)*

At least one topic explained

The other half of the PCTs on the other hand, explained at least one existing topic of current chemistry curriculum, which includes environmental dimensions. 12 PCTs, who explained at least one existing topic, specified their explanations with the topics of;

10^{th} grade 4^{th} unit Chemistry Everywhere (6 PCTs),
10^{th} grade 3^{rd} unit Energy in Industry and the Living (4 PCTs),
12^{th} grade 4^{th} unit Chemistry in Our Lives (4 PCTs),
11^{th} grade 6^{th} unit Reaction Rate and Equilibrium (1 PCT),
9^{th} grade 1^{st} unit Science of Chemistry (1 PCT).

Moreover, two PCTs stated that there are many environment-integrated sub-topics in the various units in chemistry curriculum.

> *"With giving examples from daily life, the curriculum emphasizes the usage of chemistry in industry. In this topic, curriculum also includes the explanation of harmful or harmless chemicals, which are used in many different areas of industry." (PCT 12)*

> *"I think that chemistry is very capable of including environment concept because of its nature. I know that in chemistry books that are used in high schools at the present time, there are reading text related with environment. Specifically, as an example, I can mention a reading text related with Haber Process in the unit of chemical equilibrium. This text for example, speaks of a method of fertilization and its effects on environment." (PCT 24)*

Table 8: Categories related to EE and ESD pedagogical content knowledge – question 3

"Can you explain the technology, society, environment and nature of science dimensions of chemistry curriculum? Can you explain what kind of topics chemistry curriculum includes related with these dimensions?"	
Categories	Number of PCTs
No explanation	8
Noting related with environment dimension	4
At least one topic explained	12

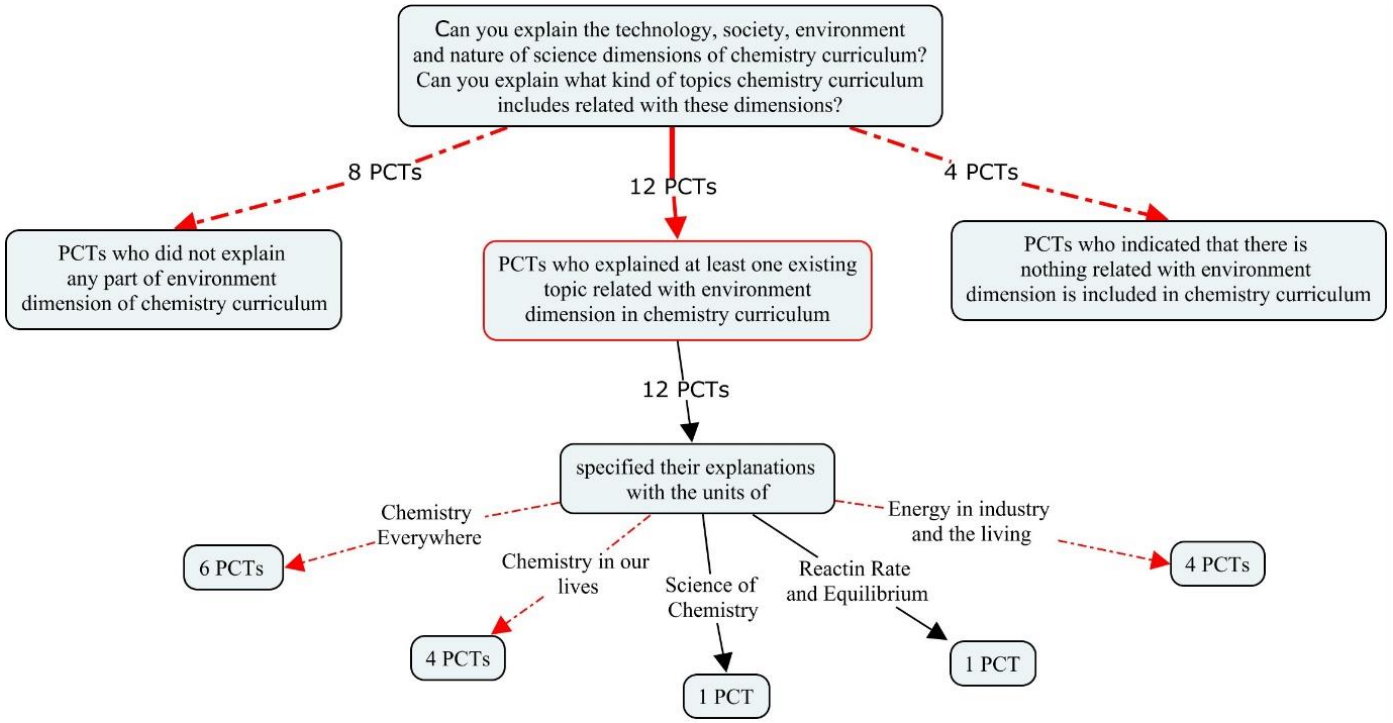

Figure 3 Answer pathways of PCTs according to third question

4.2.2 The relationship between chemistry, technology, society and environment

The competence that is evaluated through the answers given to the fourth question in Environmental Education and Sustainable Development Competence Evaluation Questions for Chemistry Teachers is related to the pre-service teachers' pedagogical content knowledge on giving examples that emphasizes the relationship between chemistry, technology, society and environment during the teaching process (B4.8th competence in the table, appendix B).

According to Secondary School Teachers Special Field Competences; Chemistry (MEB, 2011) chemistry teachers are expected to be able to give examples that emphasizes the relationship between chemistry, technology, society and environment during the teaching process. The answers given for this question evaluated with *"Would you give examples that emphasize the relationship between chemistry, technology, society and environment in your class when you become a teacher? Why?"* As a result of evaluation of the pre-service teachers' answers, three main categories were emerged:

1. Yes, I would give examples
2. Only if the topic is related
3. No I would not give examples

Yes, I would give examples

21 of the PCTs were collected under a category by stating that they would give examples in order to emphasize the relationship between chemistry, technology, society and environment in their teaching process. Reasoning's of PCTs who stated that they would give examples and would give examples if only the current topic is related, are collected under five main categories. 14 PCTs stated that they would give such examples in order to provide environmental awareness to students. 11 of PCTs gave their reasoning as to emphasize place of chemistry in daily life. 8 of PCTs indicated that they would use examples to emphasize the

relationship between chemistry, technology, society and environment in order to provide better learning for students. 4 PCTs indicated that they would use such examples because chemistry, technology, society and environment cannot be separated from each other. Lastly, 2 of PCTs indicated that they would use such examples to show students how chemistry could be used in order to solve environmental problems.

> *"Yes. I would include these examples in my lesson in order to show that chemistry have much place in our daily lives. By using these examples, I would also draw attention how chemistry can help us to get rid of the environmental problems which effects our lives." (PCT 23)*

> *"I would give these examples in order to make learning permanent for students. Connecting chemistry with daily life examples would make the lesson more interesting and lasting." (PCT 5)*

> *"Yes. I would give these examples to make students contribute to the society and environment we are living. I would try to create awareness and responsibility about environment by using the examples." (PCT 4)*

Only if the topic is related

The second category consists of 2 PCTs who indicated that they would give examples which emphasize the relationship between chemistry, technology, society and environment only if the current topic is related with these concepts

No, I would not give examples

1 PCT on the other hand, stated that she would not give examples which emphasize chemistry, technology, and society and environment relationship.

> *"I would not give examples to emphasize the relationship between chemistry, technology, society and environment because of not having the proper content of knowledge."*

Table 9: Categories related to EE and ESD content knowledge - question 4

"Would you give examples that emphasize the relationship between chemistry, technology, society and environment in your class when you become a teacher? Why?"	
Categories	Number of PCTs
Yes, I would give examples	21
Only if the topic is related	2
No, I would not give examples	1

4.2.3 Organizing extracurricular activities

The competence that is evaluated through the answers given to the fifth question Environmental Education and Sustainable Development Competence Evaluation Questions for Chemistry Teachers is related to the pre-service teachers' pedagogical content knowledge on organizing extracurricular activities which will help students to understand the relationship between chemistry, technology, society and environment by taking sociocultural conditions into consideration. (B4.10th competence in the table, appendix B)

According to Secondary School Teachers Special Field Competences; Chemistry (MEB, 2011) chemistry teachers are expected to be able organize extracurricular activities which will help students to understand the relationship between chemistry, technology, society and environment by taking sociocultural conditions into consideration. In this part of the study question of *"What kind of extracurricular activities would you organize which will help students to understand the relationship between chemistry, technology, society and environment when you become a teacher?"* were evaluated. As a result of evaluation of the pre-service teachers' answers, five categories were emerged:

1. Field trip
2. Projects
3. Conferences
4. Show a documentary
5. No answer/activities

Field trip

According to the results 14 PCTs would organize a field trip to factories to help students to understand the relationship between chemistry, technology, society and environment.

Projects

9 PCTs indicated that they would give students projects which includes concepts of chemistry, technology, society and environment.

> *"I would give students research projects in groups related with environment chemistry and society, then make them present the ideas they gathered in the class." (PCT 21)*

Conferences

7 PCTs stated that they would organize conferences about related concepts with speakers who are specialists in their field.

> *"In order to help students to build chemistry and environment relationship I would take students to recycling factories." (PCT 1*

Show a documentary

4 PCTs thought it would help students to understand the relation between chemistry, technology, society and environment if they were watched a documentary consisting of the related concepts.

> *"I would not skip that kind of informative topics related with environment in my class like most of the teachers do. I would bring detailed documentaries in class, and invite various speakers in order to give conferences." (PCT 5)*

No answer/activities

2 PCTs leave the question unanswered while 1 PCT stated that he would not organize any activities.

> *"I do not think I would organize extracurricular activities. Concepts of technology and society are out of my professionalism. I could explain the effect of chemistry in my lessons already." (PCT 9)*

Table 10: Categories related to EE and ESD pedagogical content knowledge-question 5

"What kind of extracurricular activities would you organize which will help students to understand the relationship between chemistry, technology, society and environment when you become a teacher?"	
Categories	Number of PCTs
field trip	14
give projects to students	9
organize conferences	7
show a documentary	4
no answer/activities	3

4.3 Chemistry Literacy of Pre-service Chemistry Teachers related to EE and ESD

In this part, EE and ESD related competences of pre-service chemistry teachers were evaluated according to the answers they have given to the questions they were asked in the context of this thesis. The competence related to EE and ESD chemistry literacy, is the ability of chemistry teachers to build relationship between chemistry, technology, society and environment and their attitudes towards these concepts.

4.3.1 Organizing seminars and panels in school

The competence that is evaluated through the answers given to the sixth question Environmental Education and Sustainable Development Competence Evaluation Questions for Chemistry Teachers is related to the pre-service teachers' chemistry literacy on organizing seminars and panels in school in order to draw attention to the

national and international problems such as environmental pollution, global warming. (C3.7th competence in the table, appendix B).

According to Secondary School Teachers Special Field Competences; Chemistry (MEB, 2011) chemistry teachers are expected to organize seminars and panels in school in order to draw attention to the national and international problems such as environmental pollution, global warming. The answers given for this question are evaluated into 2 parts: At first the part of the question evaluated was: *"What kind of national and international environmental problems exist at the present time?"* As a result of evaluation of the pre-service teachers' answers, two main categories were emerged:

1. Named at least one environmental problem
2.No idea

Named at least one environmental problem

According to answers of PCTs, it was explored that most of the PCTs (20 PCTs) were able to state environmental problems that exist at the present time 11 PCTs indicated that pollution is a kind of environmental problem both national and international levels. 9 of the PCTs stated that they see global warming as an international environmental problem. 7 of the PCTs also indicated that decreasing amount of natural sources is an environmental problem again both national and international levels. 4 of PCTs mentioned release of harmful wasted as an environmental problem. The other selections of PCTs as environmental problems existing at the present time were carbon emission, ozone depletion, and existence of nuclear power plants, usage of chemical fertilizers, and usage of fossil fuels.

No idea

Only 4 PCTs stated that they have no idea about the existing problems of environment in national and international level.

Table 11: Categories related to EE and ESD chemistry literacy– question 6

"What kind of national and international environmental problems exist at the present time?"	
Categories	Number of PCTs
Named at least one environmental problem	20
No idea	4

The following question was *"What kind of activities would you organize in order to draw attention to these problems at school?"*. As a result of evaluation of the pre-service teachers' answers, five main categories were emerged:

1. Projects
2. No activities
3. Seminars
4. Show documentary
5. Organize environment days

Projects

Answers of PCTs revealed that 8 of PCTs would give projects to students in order to draw attention to environmental problems.

"I would give them a project which they can work on groups and present the project to other students. For example a research about Chernobyl can be a good topic in order to emphasize environmental problem of nuclear power plants." (PCT 12)

No activities

7 of PCTs stated that they would just talk about the concepts in their class and would not do other activities out of the class.

"I would not to activities in school. But I would mention the environmental problems when the related chemistry topic is instructed in class." (PCT 9)

Seminars

5 PCTs stated that they would organize seminars at schools in order to take the students attention to environmental problems.

Show documentary

Other 5 PCTs indicated that they would show a documentary which is related with current environmental problems.

Organize environment days

2 of PCTs stated that they would organize environment days and do activities like cleaning the environment around schoolyard.

"I think prevention of environmental problems first starts with individual attempts. In this manner I would make cleaning on the school yard with students by collecting garbage or collecting battery

and plastic wastes etc. By this activities I would take a step on raising environmental consciousness." (PCT 17)

4.3.2 Chemicals and chemistry technologies which destroy the environment

The competence that is evaluated through the answers given to the seventh question in Environmental Education and Sustainable Development Competence Evaluation Questions for Chemistry Teachers is related to the pre-service teachers' chemistry literacy on giving examples to chemicals and chemistry technologies which destroy the environment (C4.6th competence in the table, appendix B).

According to Secondary School Teachers Special Field Competences; Chemistry (MEB, 2011) chemistry teachers are expected to give examples to chemicals and chemistry technologies which destroy the environment**.** The answers given for this question are evaluated due to the question of *"As a chemistry teacher candidate, can you give examples to chemicals and chemistry technologies which destroy the environment?"* The results collected under two main categories.

1. At least one example of chemicals or chemistry technologies
2. No examples

At least one example of chemicals or chemistry technologies

21 PCTs gave examples to chemicals and chemistry technologies which destroy the environment. PCTs gave many different examples to chemicals and chemistry technologies. The most common category of examples was wastes released from factories (11 PCTs), fuels (9 PCTs), deodorants (5 PCTs) and nuclear power plants (5 PCTs). The other examples of chemicals and chemistry technologies which destroy the environment were chemicals used as cleaning materials, pesticides, gases released from exhaust resources.

"Fuels, deodorants and exhaust gases these are chemicals that effects the ozone layer. Especially, usage of nuclear plants is very dangerous for humanity." (PCT 5)

"The wastes of factories are released to environment both to the air as gas and to city water as liquids. Increase in CO_2 gas level substantially damages ozone layer and causes global warming." (PCT 17)

"Usage of fuels which causes air pollution, pesticide usage such as DDT and generally not controlling the chemical wastes and their recycling process can be given as examples to chemicals and chemistry technologies." (PCT 23)

No examples

3 PCTs did not give any examples.

Table 12: Categories related to EE and ESD chemistry literacy– question 7

"As a chemistry teacher candidate, can you give examples to chemicals and chemistry technologies which destroy the environment?"	
Categories	Number of PCTs
At least one example of chemicals or chemistry technologies	21
No examples	3

4.3.3 Contribution of Chemistry to the Prevention of Environmental Pollution

The competence that is evaluated through the answers given to the eighth question in Environmental Education and Sustainable Development Competence Evaluation Questions for Chemistry Teachers is related to the pre-service teachers' chemistry literacy on examining the contribution of chemistry to the prevention of environmental pollution (C4.7th competence in the table, appendix B).

According to Secondary School Teachers Special Field Competences; Chemistry (MEB, 2011) chemistry teachers are expected examine the contribution of chemistry to the prevention of environmental pollution. The answers given for this question *"What is the contribution of chemistry to prevention of environmental pollution? Can you explain it with giving examples?"* Are evaluated: Result related with this question were collected under two categories.

1. Explanation with at least one example
2. No explanations/examples

Explanation with at least one example

12 PCTs explained the contribution of chemistry to prevention of environmental pollution by giving at least one example.

> *"For example, about the pollution caused by CO_2 emission, chemical filters can be used in order to decrease the emission." (PCT 13)*

> *"The concept of green chemistry, can provide producing materials which are less harmful to environment, this would contribute both to preservation of environment and human health." (PCT 15)*

"The disadvantage of CO_2 emission can be associated with chemistry. However, the process of filtration is a chemical method and it is used for decreasing the CO_2 emission." (PCT 9)

"I worked in chemistry laboratory with the subject of pesticides. In order to clean or quantify the pesticides we used carbon nanotubes by using GC analysis." (PCT 22)

No explanations/examples

The other 12 PCTs did not give an example that explains the contribution of chemistry to prevention of environmental pollution.

"I am not sure about whether chemistry has a contribution about prevention of environmental pollution. Moreover, I can say that the chemicals we are using are one of the main reasons that causes pollution on environment." (PCT 18)

Table 13: Categories related to EE and ESD chemistry literacy– question 8

"What is the contribution of chemistry to prevention of environmental pollution? Can you explain it with giving examples?"	
Categories	Number of PCTs
PCTs who explained the contribution of chemistry to prevention of environmental pollution	12
PCTs who did not explain the contribution of chemistry to prevention of environmental pollution	12

4.3.4 Examples which shows chemistry, technology, society and environment are interacted.

The competence that is evaluated through the answers given to the fourth/b question in Environmental Education and Sustainable Development Competence Evaluation Questions for Chemistry Teachers is related to the pre-service teachers' chemistry literacy on giving examples which shows chemistry, technology, society and environment are interacted (C4.8th competence in the table, appendix B).

According to Secondary School Teachers Special Field Competences; Chemistry (MEB, 2011) chemistry teachers are expected to give examples which shows chemistry, technology, society and environment are interacted. The answers given are evaluated due to the question of *"Can you explain that chemistry, technology, society and environment are interacted by giving an example?*" The results collected under two main categories:

1. At least one example
2. No example

At least one example

10 PCTs were able to show that chemistry, technology, society and environment are interacted by giving an example.

> **"***People who lives in a seaside where a nuclear power plant exists are faced with effects of both chemistry and technology. Moreover, people are faced with the effects of that nuclear power plant on environment. Thus, people and environment are being affected from technology and chemistry at the same time." (PCT 12)*

*"In fact, in pharmaceutical industry chemistry, technology, society and environment are interbedded. The technology is used to produce drugs which includes chemicals. These drugs are presented to society and consumed by people. However when producing the drugs, at the same time factories should think about the chemical wastes which may cause environmental pollution."(PCT 16***)**

No examples

According to answers of PCTs it is revealed that most of the PCTs (14 PCTs) did not explain that chemistry, technology, society and environment are interacted.

Table 14: Categories related to EE and ESD chemistry literacy– question 4/b

"Can you explain that chemistry, technology, society and environment are interacted by giving an example?"	
Categories	Number of PCTs
At least one example	10
No examples	14

CHAPTER 5

DISCUSSION

This chapter provides a brief summary of the study. Conclusions and discussions were presented with respect to results of the study. Afterwards, recommendations and implications were provided for further studies.

5.1 Summary of the Study

This study was conducted in order to explore the competences of pre-service chemistry teachers related to Environmental Education and Education for Sustainable Development. The competences were investigated under three categories which are content knowledge, pedagogical content knowledge and chemistry literacy with respect to Chemistry Teachers Competences (MEB, 2011). Participants of the study were all 4 and 5 grade pre-service chemistry teachers in the spring term of 2016-2017 semester. Eight essay type questions having also sub questions, which were conducted with respect to Chemistry Teachers Competences (MEB, 2011) were used as data source.

5.2 Discussion

5.2.1 Content Knowledge of Pre-service Chemistry Teachers related to EE and ESD

Energy and environment

The current findings of the study indicated that most of the pre-service chemistry teachers at least have an idea about the changes that occur in nucleus of an atom. However, only minority of pre-service chemistry teachers give the correct

answer thus, only minority of them can be accepted as knowledgeable about radioactive decay types.

Most of pre-service chemistry teachers were able to give at least one example to atomic nucleus changes, however some of them did not bring any idea about the energy of these changes. The situation reveals that having the knowledge about radioactive decays may not be enough in order to comment on the energy of these decays. Moreover, only some of the pre-service chemistry teachers connected the radioactivity concept with atomic nucleus changes. This number seems to suggest that pre-service chemistry teachers are not fully informed about the nature of radioactive decays. Correspondingly, according to a study which was held in 2011, some of pre-service science teachers including chemists, have limited content knowledge related with radioactivity subject (Colclough & Lock & Soares, 2011).

Indicating the results related with environmental effects of atomic nucleus changes, it can be said that most of the pre-service chemistry teachers (N=19) are aware about the negative effects that are caused by radioactive decays. Even though most of the pre-service chemistry teachers did not connected radioactivity with atomic nucleus changes, they are mostly aware of the negative effects that can be caused by radioactivity of nucleus changes occur in atoms. While talking about the negative effects on environment and human-being, pre-service chemistry teachers used connections with atomic bomb and nuclear reactors. The possible effects of daily life and current events on media may have brought these examples out.

Organic and Inorganic Compounds of Chemicals

Explaining the compounds of chemicals which are used in daily life, seem to as a coercive field for pre-service chemistry teachers. The content of chemicals is important when some effects of daily life chemicals on environment taken into consideration. It is important that whether pre-service chemistry teachers are aware of the effects of everyday chemicals on environment or not, since the chemical industry is so much integrated in our lives. Although nearly all pre-service chemistry

teachers were able to list different types of chemicals used in daily life, only some of them explained the compounds of everyday life chemicals Results represent that nearly half of the pre-service chemistry teachers are lacking of subject knowledge on explaining the compounds of daily life chemicals.

5.2.2 Pedagogical Content Knowledge of Pre-service Chemistry Teachers Related to EE and ESD

Environment dimension of the curriculum

According to results for curriculum related part of the study, it can be claimed that half of the pre-service chemistry teachers are not aware of the EE and ESD related objectives and topics integrated in current chemistry curriculum. Considering the grade level of the pre-service chemistry teachers who were enrolled with the study, it is expected from them to have comprehensive knowledge of curriculum since they have been receiving or will be receiving the teacher training courses at high schools during the year. However, the lack of knowledge about the environment dimension of the curriculum shows the opposite. The reason may be the limited context of chemistry teacher training programs of universities in terms of EE and ESD. Moreover, pre-service chemistry teachers may not have witnessed the teaching of EE and ESD related topics when they were teacher trainees in high schools. According to a study which was done with in-service chemistry teachers, the subjects related with environmental education in chemistry lessons are not even being instructed in high schools (Içöz, 2015). When that's the case, pre-service chemistry teachers may have been facing the lack of EE and ESD related subjects in chemistry since from their high school years. If chemistry teacher education programs do not include EE and ESD integrated lectures, it is inevitable that pre-service teachers are being graduated without the knowledge of EE and ESD related objectives in the curriculum. As one of the previous study done in 2007, the teacher training programs in Turkey have limited content of courses with respect to environmental issues (Kürkçüoğlu, 2007).

On the other hand, the results reveal that pre-service chemistry teachers who were able to explain the environment dimension of current chemistry curriculum are mostly familiar with “chemistry everywhere”, “energy of industry and the living” and “chemistry in life” units included in curriculum. One of the previous study also indicated that in-service chemistry teachers also stated the “chemistry in life” unit as an EE related subject in the chemistry curriculum.

The relationship between chemistry, technology, society and environment

Nearly all of the pre-service chemistry teachers were found to be enthusiastic about emphasizing the chemistry, society, and technology and environment relationship in their classes. It is revealed that they are willing to use examples in order to emphasize that relationship, so that they would be able to provide environmental awareness to students. More than half of the pre-service teachers gave their reasoning to include that examples in their classes as to increase environmental awareness. Moreover, the results show that, pre-service chemistry teachers are not only willing to include environmental issues in their classes, but also willing to organize extracurricular activities in order to make students understand the relationship between chemistry, society, technology and environment. Considering the situation with respect to EE and ESD pre-service chemistry teachers seems to have positive attitude and concerned about environmental issues. The previous studies conducted in Turkey also reveals that pre-service chemistry teachers in Turkey are enthusiastic about environmental issues including chemistry subjects (Içöz, 2015; Tuncer et al. 2010).

5.2.3 Chemistry Literacy of Pre-service Chemistry Teachers related to EE and ESD

Organizing seminars and panels in school

According to results, many of pre-service chemistry teachers came up with the idea of organizing activities out of the class in order to draw attention to

environmental problems. Pre-service chemistry teachers seem to be enthusiastic about organizing activities such as projects, seminars, environment days and documentary watching hours at school. Claiming that they would willing to do such activities in order to draw attention to environmental problems, shows pre-service chemistry teachers' concern about the environment. The result for this part of the study is parallel with the findings of the previous section (5.2.2.). Moreover, it can be said that nearly most of the pre-service chemistry teachers are aware of some of the current environmental problems such as pollution (air, soil, and water), global warming, scarcity of natural resources etc.

Chemicals and chemistry technologies which destroy the environment

The results showed that nearly all of the pre-service chemistry teachers were able to give examples to chemicals and chemistry technologies that destroy the environment. Wastes released from factories, fuels, deodorants were the categories which most commonly were given as example to hazardous chemicals. Even though all of the pre-service science teachers could not give the names of exact chemicals which are hazardous to environment, some of them were at least able to talk about how these chemicals or chemistry technologies destroy the environment.

Contribution of chemistry to the prevention of environmental pollution

Considering the aims of EE and ESD, the contribution of chemistry on environmental problems is a topic worth to teach in chemistry classes. However, it is a fact that teachers would not be able to discuss the relation of contribution of chemistry on environment unless they have not the content knowledge for connecting two concepts. The findings of the study revealed the truth that half of the pre-service chemistry teachers are not able to explain how chemistry can contribute to prevention of environmental pollution.

Examples which shows chemistry, technology, society and environment are interacted

The findings of the study of section 5.2.2 revealed the fact that pre-service chemistry teachers are enthusiastic about to discuss the relationship between chemistry, technology, society and environment in their classes. However, only less than half of the pre-service teachers seem to have the knowledge to explain that chemistry, technology, society and environment are interacted.

5.3 Conclusion

One conclusion of this study is that pre-service chemistry teachers' competence in content knowledge related with EE and ESD is limited with specific subjects. Having the content knowledge of chemistry do not always provide pre-service chemistry teachers comment about causes, results or effects of the chemistry on environment. The limited chemistry content knowledge related with EE and ESD may be caused lack of courses which includes environmental issues in the faculties of education and chemistry departments.

Another conclusion is that pre-service chemistry teachers' competence in pedagogical content knowledge are inadequate in terms of EE and ESD since most of them lack of the chemistry curriculum knowledge related with environmental dimension. Even though they indicated a great willing of teaching the subjects related with EE and ESD, both lacking of content knowledge and pedagogical content knowledge may cause pre-service chemistry teachers to start their teaching profession without knowing how to include EE and ESD based topics in chemistry.

The chemistry literacy competence of pre-service chemistry teachers seems limited in terms of EE and ESD. According to results, pre-service teachers are aware of the chemicals destroying the environment. It can be said that they have the required chemistry literacy about the hazardous chemicals. Although pre-service chemistry teachers have the required chemistry knowledge, they seem to have

difficulty using the chemistry knowledge on explaining the relationship between chemistry, environment and daily life. Pre-service chemistry teachers are insufficient about emphasizing the role of chemistry on environmental problems and its solutions.

Finally it can be inferred that chemistry teacher candidates ensure the competences related with EE and ESD only in a limited level. It can be revealed that pre-service chemistry teachers are going to graduate without providing some of the competences that is determined by the ministry of education.

5.4 Limitations of the Study

The result of the study is limited with participants of twenty-four pre-service chemistry teachers who are studying in a university in Ankara. The results may change if the study is done with other groups of pre-service chemistry teachers from different universities.

Another limitation of the study may be the collection method of responds of pre-service chemistry teachers. Expressions of pre-service chemistry teachers could be less than they know, because they may have get bored of writing long answers to questions.

5.5 Recommendations for Further Researches

Taking into account the results of the study several suggestions can be made in order to flourish the field of chemistry with respect to environmental education and education for sustainable development.

On the basis of the results of the study, it is clear that pre-service chemistry teachers are being graduated without having the competences related with EE and ESD. The courses in universities teacher education programs could be designed as including much subjects related with EE and ESD. Since pre-service chemistry

teachers seems enthusiastic about integrating environmental issues in their future classes, an effective teaching of environmental issues can be provided for students by training pre-service teachers with EE and ESD integrated education programs. The current situation with respect to EE and ESD of chemistry teacher education programs is a subject worth to study in this manner.

Another recommendation can be made for further studies may be the examination of competences of current in-service chemistry teachers. For an effective instruction of current EE and ESD related objectives of chemistry subjects, teachers should have the proper content and pedagogical content knowledge of EE and ESD. Since pre-service chemistry teachers' competence were found to be inadequate in terms of EE and ESD, it is possible that in-service chemistry teachers to show the exact features. Even it can be considered to give an in-service training for chemistry teachers in order to emphasize the place and role of EE and ESD related subjects in chemistry curriculum.

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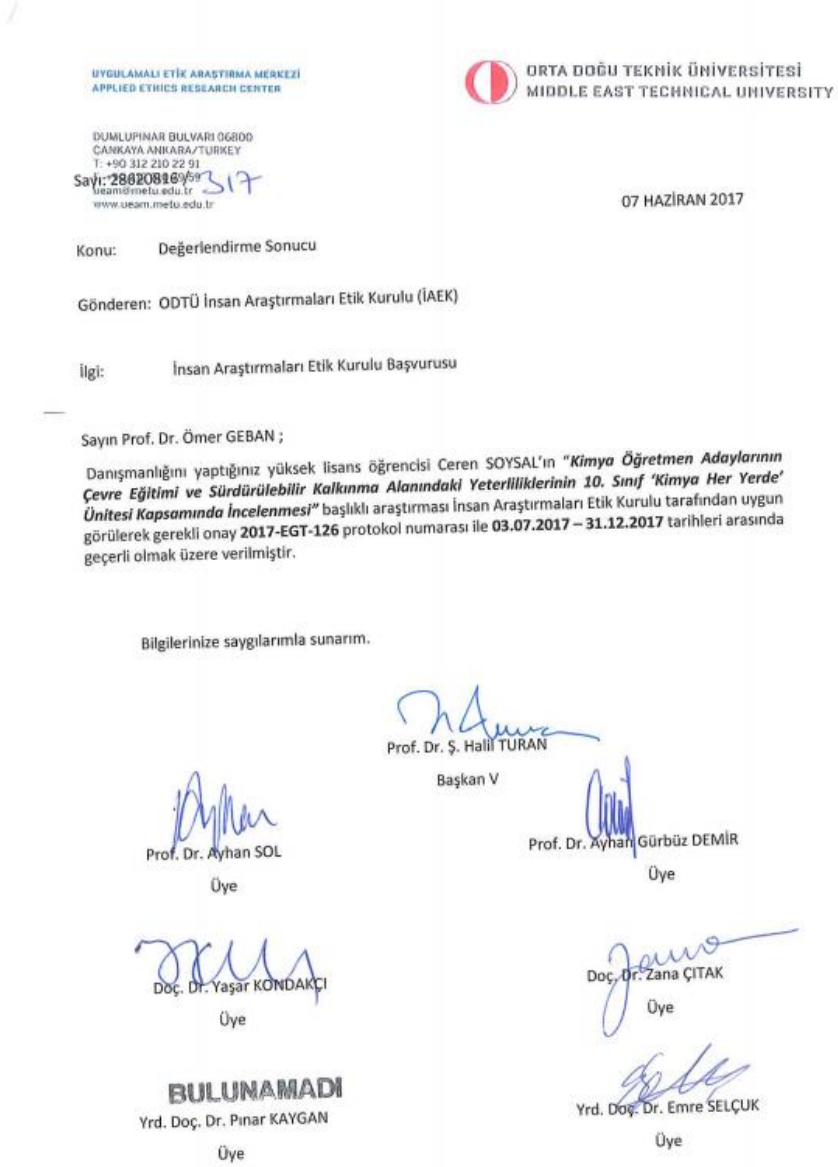
APPENDIX – A

PERMISSION OF ETHICAL COMMITTEE

Figure A1. Permission of Ethical Committee



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07 HAZİRAN 2017

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof. Dr. Ömer GEBAN ;

Danışmanlığını yaptığınız yüksek lisans öğrencisi Ceren SOYSAL'ın ***"Kimya Öğretmen Adaylarının Çevre Eğitimi ve Sürdürülebilir Kalkınma Alanındaki Yeterliliklerinin 10. Sınıf 'Kimya Her Yerde' Ünitesi Kapsamında İncelenmesi"*** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülerek gerekli onay **2017-EGT-126** protokol numarası ile **03.07.2017 – 31.12.2017** tarihleri arasında geçerli olmak üzere verilmiştir.

Bilgilerinize saygılarımla sunarım.

Prof. Dr. Ş. Halil TURAN
Başkan V

Prof. Dr. Ayhan SOL
Üye

Prof. Dr. Ayhan Gürbüz DEMİR
Üye

Doç. Dr. Yaşar KONDAKÇI
Üye

Doç. Dr. Zana ÇITAK
Üye

BULUNAMADI
Yrd. Doç. Dr. Pınar KAYGAN
Üye

Yrd. Doç. Dr. Emre SELÇUK
Üye

APPENDIX – B

TURKISH CHEMISTRY TEACHER COMPETENCES

Figure B1. Chemistry Teachers' Special Field Competences

KİMYA ÖĞRETMENİ ÖZEL ALAN YETERLİKLERİ

Yeterlik Alanı	**A. KİMYA BİLGİSİ**
Kapsam	Bu yeterlik alanı, kimya ile ilgili kuram, kanun, prensip, hipotez ve kavramları değerlendirebilmeyi, diğer ders ve disiplinlerle ilişkisini kurabilmeyi ve prensip, hipotez ve kavramların öğrenilmesi için gerekli olan matematik bilgilerini ve becerilerini kullanabilmeyi kapsar.

YETERLİKLER	**PERFORMANS GÖSTERGELERİ**
A.1. Kimya ile ilgili kuram, kanun, prensip, hipotez ve kavramları değerlendirebilme	**A.1.1.** Maddeleri IUPAC kurallarına göre adlandırarak bazılarını geleneksel isimleriyle eşleştirir. **A.1.2.** Maddeleri farklı özelliklerine göre sınıflandırır. **A.1.3** Maddenin dört halinin özelliklerini karşılaştırarak açıklar. **A.1.4.** Günlük yaşamda karşılaştığı bazı olay ve olguları maddenin taneciklı doğasıyla ilişkilendirerek açıklar. **A.1.5.** Madde ve maddenin değişimini makroskopik, mikroskopik ve sembolik boyutlarda karşılaştırarak açıklar. **A.1.6.** Mol, stokiyometri ve kimyanın temel kanunları ile ilgili hesaplamaları yapar. **A.1.7.** Elektromanyetik ışın-madde etkileşimini irdeler. **A.1.8.** Tarih içinde atom kuramlarının nasıl geliştiğini açıklar. **A.1.9.** Başlıca element ve bileşikleri, elde edilişleri, fiziksel ve kimyasal özellikleri açısından sorgular. **A.1.10.** Periyodik sistemde periyodik özelliklerin değişimini inceler. **A.1.11.** Maddeleri oluşturan tanecikleri bir arada tutan etkileşimleri karşılaştırır. **A.1.12.** Kimyasal bağlar ile ilgili kuramların varsayım ve sınırlıklarını karşılaştırır. **A.1.13.** Kinetik teorilerinin varsayım ve sınırlıklarını göz önünde bulundurarak maddelerin özelliklerini açıklar. **A.1.14.** Gaz kanunlarının varsayım ve sınırlıklarını karşılaştırır. **A.1.15.** Bir kimyasal değişimdeki reaksiyon türünü irdeler. **A.1.16.** Çözeltilerin özelliklerini çözücü çözünen etkileşimleri açısından irdeler. **A.1.17.** Asit-baz kuramlarının varsayım ve sınırlıklarını karşılaştırır. **A.1.18.** Reaksiyon kinetiği ile ilgili problemleri çözer. **A.1.19.** Kimyasal dengenin dinamiklerini irdeleyerek ilgili problemleri çözer. **A.1.20.** Maddelerde meydana gelen değişimleri enerji ve entropi değişimleriyle ilişkilendirir.

KİMYA ÖĞRETMENİ ÖZEL ALAN YETERLİKLERİ

Yeterlik Alanı	**A. KİMYA BİLGİSİ**
Kapsam	Bu yeterlik alanı, kimya ile ilgili kuram, kanun, prensip, hipotez ve kavramları değerlendirebilmeyi, diğer ders ve disiplinlerle ilişkisini kurabilmeyi ve prensip, hipotez ve kavramların öğrenilmesi için gerekli olan matematik bilgilerini ve becerilerini kullanabilmeyi kapsar.

YETERLİKLER	**PERFORMANS GÖSTERGELERİ**
A.1. Kimya ile ilgili kuram, kanun, prensip, hipotez ve kavramları değerlendirebilme	**A.1.21.** Kimyasal enerji-elektrik enerjisi dönüşümlerini irdeleyerek ilgili problemleri çözer. **A.1.22.** Belli bir amaca uygun olarak maddelerin hangi yöntemle analiz edilebileceğini belirler. **A.1.23.** Karbon esaslı maddelerin elde edilişlerini irdeleyerek sınıflandırır. **A.1.24.** Fonksiyonel grup içeren ve içermeyen karbon esaslı maddelerin reaksiyonlarını irdeler. **A.1.25.** Biyolojik süreçlerde meydana gelen kimyasal reaksiyonları irdeler. **A.1.26.** Atom çekirdeğinde meydana gelen değişimleri enerji ve çevreye olan etkileri açısından muhakeme eder. **A.1.27.** Temizlik maddeleri, boyalar, gübre, patlayıcılar, yakıtlar gibi günlük yaşamda kullanılan maddelerin bileşenlerini açıklar.
A.2. Kimya ile diğer ders ve disiplinler arasında ilişki kurabilme	**A.2.1.** İlköğretim Fen ve Teknoloji dersi kapsamındaki kimya konularını kimya dersi içeriği ile karşılaştırır. **A.2.2.** Elektrik, manyetizma, atom kuramları, kuantum fiziği, kuvvet ve hareket gibi fizik konularıyla kimya konuları arasında farklılıkları ve /veya benzerlikleri açıklar. **A.2.3.** Solunum, sindirim, boşaltım gibi biyolojik süreçler ve hücrenin yapısı, DNA, RNA, ATP gibi biyolojinin konularıyla kimyanın konuları arasında farklılıkları ve /veya benzerlikleri açıklar. **A.2.4.** Kimya alanındaki bilgilerin tarih, coğrafya, arkeoloji, jeoloji, ilâçbilimi gibi ders ve disiplinlerdeki uygulamalarına örnekler verir.

KİMYA ÖĞRETMENİ ÖZEL ALAN YETERLİKLERİ

Yeterlik Alanı	**A. KİMYA BİLGİSİ**
Kapsam	Bu yeterlik alanı, kimya ile ilgili kuram, kanun, prensip, hipotez ve kavramları değerlendirebilmeyi, diğer ders ve disiplinlerle ilişkisini kurabilmeyi ve prensip, hipotez ve kavramların öğrenilmesi için gerekli olan matematik bilgilerini ve becerilerini kullanabilmeyi kapsar.

YETERLİKLER	**PERFORMANS GÖSTERGELERİ**
A.3. Kimya ile ilgili kuram, kanun, prensip, hipotez ve kavramların öğrenilmesi için gerekli olan matematik bilgilerini ve becerilerini kullanabilme.	**A.3.1.** Farklı sayı kümelerinde dört işleme dayalı hesaplamaları yapar. **A.3.2.** Birinci ve ikinci dereceden bir ve iki bilinmeyenli denklemler ile ilgili problemleri çözer. **A.3.3.** Üslü sayılarla ilgili hesaplamaları yapar. **A.3.4.** Logaritmik fonksiyonlar ile ilgili hesaplamaları yapar. **A.3.5.** Koordinat sistemlerini açıklar. **A.3.6.** Ekstrapolasyon ve interpolasyon yöntemlerini kullanarak yeni veri noktaları oluşturur. **A.3.7.** Üç boyutlu geometrik şekiller çizer.

Yeterlik Alanı	**B- KİMYA EĞİTİMİ BİLGİSİ**
Kapsam	Bu yeterlik alanı, öğretim programının izleme ve değerlendirme, öğrencilerin ön bilgi ve öğrenme zorluklarını analiz edebilmeyi, konuya uygun öğretim yaklaşım, strateji, yöntem, teknik ve modelleri analiz edebilmeyi, öğretim sürecini öğretim programına göre planlamayı ve uygulayabilmeyi, ölçme-değerlendirme tekniklerine karar verebilmeyi kapsar.

YETERLİKLER	**PERFORMANS GÖSTERGELERİ**
B.1. Öğretim programını izleme ve değerlendirebilme	**B.1.1.** Öğretim programının kuramsal dayanaklarını açıklar. **B.1.2.** Öğretim programının vizyon ve felsefesini açıklar. **B.1.3.** Öğretim programındaki konu içeriklerinin dağılım ve sıralamasını irdeler **B.1.4.** Öğretim programında yer alan kazanımlar arasında ilişki kurar. **B.1.5.** Öğretim programının teknoloji, toplum, çevre ve bilimin doğası boyutlarını açıklar. **B.1.6.** Öğretim programını amaç, içerik, öğrenme-öğretme süreci ve değerlendirme öğelerinin uyumluluğu açısından sorgular. **B.1.7.** Öğretim programının uygulanması sırasında karşılaşılan sorunları tespit eder. **B.1.8.** Öğretim programının uygulanması sırasında karşılaşılan sorunlara getirdiği çözüm önerilerini zümre öğretmenleri ile paylaşır.
B.2. Öğrencilerin ön bilgi ve öğrenme zorluklarını analiz edebilme	**B.2.1.** Öğrencilerin kimya konuları ile ilgili önbilgi ve tecrübelerini belirler. **B.2.2.** Öğrencilerin kimya ile ilgili sahip olabileceği yanılgı ve öğrenme zorluklarının sebeplerini araştırır. **B.2.3.** Öğrencilerin kimya ile ilgili sahip olabileceği yanılgı ve öğrenme zorlukları hakkındaki araştırmaları inceler. **B.2.4.** Öğrencilerin kimya ile ilgili sahip olabileceği yanılgı ve öğrenme zorlukları hakkında gerektiğinde zümre öğretmenleri ve uzmanlarla tartışır.

Yeterlik Alanı	**B- KİMYA EĞİTİMİ BİLGİSİ**
Kapsam	Bu yeterlik alanı, öğretim programının vizyon, felsefe ve kuramsal dayanakları ile içeriğini izleme ve değerlendirebilmeyi, öğrencilerin ön bilgi ve öğrenme zorluklarını analiz edebilmeyi, konuya uygun öğretim yaklaşım, strateji, yöntem, teknik ve modellere karar verebilmeyi, öğretim sürecini öğretim programına göre planlamayı ve uygulayabilmeyi, ölçme-değerlendirme tekniklerine karar verebilmeyi kapsar.

YETERLİKLER	**PERFORMANS GÖSTERGELERİ**
B.3. Konuya uygun öğretim yaklaşım, strateji, yöntem, teknik ve modelleri analiz edebilme	**B.3.1.** Öğrenme-öğretme sürecinde kullanılabilecek yaklaşım, strateji ve yöntemleri açıklar. **B.3.2.** Öğrenme döngüsü, probleme dayalı öğrenme, işbirlikli öğrenme, proje tabanlı öğrenme, araştırma-sorgulama, rol oynama, tahmin et-gözle-açıkla, buluş yoluyla öğrenme gibi kimya öğretiminde kullanılabilecek strateji, yöntem ve teknikleri avantaj ve dezavantajları açısından karşılaştırır. **B.3.3.** Kimya ile ilgili kavram yanılgılarını, bilim insanlarınca kabul gören görüşlerle değiştirilmesine yardımcı olacak öğretim yöntem ve tekniklerini açıklar. **B.3.4.** Örnek olay incelemesi, kelime çağrışımı, kavram haritası, zihin haritası, beyin fırtınası, soru-cevap gibi öğretim tekniklerinin kavram öğretimindeki önemini açıklar. **B.3.5.** Kimya öğretiminde analoji, metafor, simülasyon, animasyon gibi modelleri kullanmanın önemini açıklar. **B.3.6.** Laboratuvarda kullanılabilecek öğretim yöntem ve tekniklerini avantaj ve dezavantajları açısından karşılaştırır.

Yeterlik Alanı	**B- KİMYA EĞİTİMİ BİLGİSİ**
Kapsam	Bu yeterlik alanı, öğretim programının vizyon, felsefe ve kuramsal dayanakları ile içeriğini izleme ve değerlendirebilmeyi, öğrencilerin ön bilgi ve öğrenme zorluklarını analiz edebilmeyi, konuya uygun öğretim yaklaşım, strateji, yöntem, teknik ve modellere karar verebilmeyi, öğretim sürecini öğretim programına göre planlamayı ve uygulayabilmeyi, ölçme-değerlendirme tekniklerine karar verebilmeyi kapsar.

YETERLİKLER	**PERFORMANS GÖSTERGELERİ**
B.4. Öğretim sürecini öğretim programına göre planlama ve uygulayabilme	**B.4.1** Dersini öğretim programına göre planlarken kimya ve kimya eğitimiyle ilgili kitap, dergi, yazılım, internet gibi çeşitli kaynaklardan faydalanır. **B.4.2.** Dersini planlarken öğrencilerin olası kavram yanılgılarını dikkate alır. **B.4.3.** Dersini planlarken güvenlik önlemlerini dikkate alır. **B.4.4.** Öğretim koşullarını ve öğrenme zorluklarını dikkate alarak belirli bir kimya konusuyla ilgili farklı öğretim yaklaşım, strateji, yöntem ve teknikleri arasından uygun olanını kullanır. **B.4.5.** Öğretim sürecinde üst-düzey düşünme (yaratıcı düşünme, eleştirel düşünme, üstbilişsel düşünme, öz düzenleme gibi) problem çözme ve bilimsel süreç becerilerini kazandırmaya yönelik öğretim etkinliklerine yer verir. **B.4.6.** Kimya ile ilgili bilişsel, duyuşsal ve devinimsel kazanımları öğrencilere kazandırmak için laboratuvar etkinlikleri düzenler. **B.4.7.** Öğrencilerin bilimin doğasını anlamalarına yardımcı olacak öğretim etkinlikleri yapar. **B.4.8.** Öğretim sürecinde kimya, teknoloji, toplum ve çevre ilişkilerine vurgu yapan örneklere yer verir. **B.4.9.** Öğretim sürecinde konuyu günlük yaşam ile ilişkilendirecek örneklere yer verir. **B.4.10.** Sosyokültürel şartları dikkate alarak öğrencilerin kimya, teknoloji, toplum ve çevre ilişkilerini fark etmelerine yardımcı olacak ders dışı etkinlikler düzenler.

Yeterlik Alanı	**B- KİMYA EĞİTİMİ BİLGİSİ**
Kapsam	Bu yeterlik alanı, öğretim programının vizyon, felsefe ve kuramsal dayanakları ile içeriğini izleme ve değerlendirebilmeyi, öğrencilerin ön bilgi ve öğrenme zorluklarını analiz edebilmeyi, konuya uygun öğretim yaklaşım, strateji, yöntem, teknik ve modellere karar verebilmeyi, öğretim sürecini öğretim programına göre planlamayı ve uygulayabilmeyi, ölçme-değerlendirme tekniklerine karar verebilmeyi kapsar.

YETERLİKLER	**PERFORMANS GÖSTERGELERİ**
B.5. Ölçme-değerlendirme tekniklerine karar verebilme	**B.5.1.** Ulusal sınavlarda kimya konularıyla ilgili sorulan soruların içeriğini irdeler. **B.5.2.** Öğrencinin kimya başarısının değerlendirilmesinde bilişsel, duyuşsal ve devinimsel kazanımları bir bütün olarak ele alır. **B.5.3.** Kimya öğretim programının vizyon ve kazanımlarını dikkate alarak öğrenme-öğretim sürecinin her aşaması (ön, süreç ve son) için ölçüm aracı geliştirir. **B.5.4.** Öğrenme-öğretme sürecini değerlendirirken geleneksel ve alternatif değerlendirme tekniklerini kullanır. **B.5.5.** Öğrenme-öğretme sürecinde üst düzey ve bilimsel süreç becerilerini ölçmeye yönelik ölçüm araçlarını kullanır. **B.5.6.** Laboratuvar kullanma becerilerini ölçmeye yönelik ölçüm aracı geliştirir.

Yeterlik Alanı	**C- KİMYA OKURYAZARLIĞI**
Kapsam	Bu yeterlik alanı, bilimin doğasını anlayabilmeyi, üst düzey, bilimsel süreç ve laboratuvar becerilerini kullanabilmeyi, tutum ve değerlere sahip olabilmeyi, kimya, teknoloji, toplum ve çevre arasında ilişki kurabilmeyi, bilişim ve iletişim becerilerini kullanabilmeyi kapsar.

YETERLİKLER	**PERFORMANS GÖSTERGELERİ**
C.1. Bilimin doğasını anlayabilme	**C.1.1.** Bilgi türleri arasında bilimsel bilginin önemini açıklar. **C.1.2.** Bilimsel bilginin gelişebilir ve değişebilir olduğunu bilim tarihinden örnekler vererek açıklar. **C.1.3.** Bilimsel bilginin gözlem yapma, deney tasarlama, veri toplama gibi olgusal ve sonuç çıkarma, model oluşturma gibi kurgusal süreçlerini betimler. **C.1.4.** Bilimsel bilgiye ulaşmada kullanılan farklı akıl yürütme yollarına (tümevarım, tümdengelim v.b.) kimya konularından örnekler verir. **C.1.5.** Bilimsel bilgi için varsayım ve sınırlılıkların önemine örnekler verir. **C.1.6.** Hipotez, kuram ve kanun arasındaki farkları örneklerle açıklar. **C.1.7.** Biliminin belli bir ırk ve cinsiyetin tekelinde olmadığını bilim tarihinden örnekler vererek açıklar. **C.1.8.**Biliminin gelişmesinde dikkatli deney yapmanın ve verileri toplarken objektif olmanın önemini açıklar. **C.1.9.** Bilimin bütünsel (holistik) bir yapıda olduğunu örneklerle açıklar. **C.1.10.** Bir insan uğraşı olan bilimin bireyin ve toplumun bakış açısı ve değerlerinden nasıl etkilendiğini açıklar.

Yeterlik Alanı	C- KİMYA OKURYAZARLIĞI
Kapsam	Bu yeterlik alanı, bilimin doğasını anlayabilmeyi, üst düzey, bilimsel süreç ve laboratuvar becerilerini kullanabilmeyi, tutum ve değerlere sahip olabilmeyi, kimya, teknoloji, toplum ve çevre arasında ilişki kurabilmeyi, bilişim ve iletişim becerilerini kullanabilmeyi kapsar.

YETERLİKLER	PERFORMANS GÖSTERGELERİ
C.2. Üst düzey, bilimsel süreç ve laboratuvar becerilerini kullanma	**C.2.1.** Bilimsel bir çalışmayı, gözlem yapma, ölçme, sonuç çıkarma, sınıflandırma, tahmin etme ve iletişim boyutlarından oluşan temel bilimsel süreç becerileri açısından gözden geçirir. **C.2.2.** Bilimsel bir çalışmayı, hipotez kurma, değişkenleri ve aralarındaki ilişkiyi belirleme, araştırmalar tasarlama, deney yapma, veri toplama, verileri çizelge ve grafiklerle gösterme, sebep ve sonuç ilişkilerini anlama, modeller oluşturma boyutlarından oluşan ileri düzeydeki bilimsel süreç becerileri açısından gözden geçirir. **C.2.3.** Hipotezler arasında denenebilir olanını seçer. **C.2.4.** Ölçüm sonuçlarını uygun sayı ve birimlerle ifade eder. **C.2.5.** Ölçüm sonuçlarını modellerle sunar. **C.2.6.** Bilimsel bir araştırma yaparken bireysel ve işbirliği içinde çalışmanın önemini açıklar. **C.2.7.** Analitik düşünme becerisini olay ve olguları açıklamada kullanır. **C.2.8.** Yaratıcı ve eleştirel düşünme becerisinin kimya bilimindeki önemini açıklar. **C.2.9.** Güvenlik sembollerini tanır. **C.2.10.** Laboratuarda kullanılan araç ve gereci tanır. **C.2.11.** Kimyasal maddeleri etiketleyerek düzenler. **C.2.12.** Gerekli önlemleri alarak kimyasal maddeleri, araç ve gereçleri güvenli ve doğru bir şekilde kullanır. **C.2.13.** Laboratuarda eksik olan araç ve gerece alternatifler sunar. **C.2.14.** Laboratuarda kullanılan alet ve araçların arızalarını belirleyerek tamiri için çözüm yolu önerir. **C.2.15.** Güvenlik konusunda kimya araştırmalarında ve kimya endüstrisinde tanımlanan riskleri ve geliştirilen kuralları açıklar. **C.2.16.** Laboratuvar atıklarını uygun koşullarda saklar ve gerektiğinde bertaraf eder.

Yeterlik Alanı	C- KİMYA OKURYAZARLIĞI
Kapsam	Bu yeterlik alanı, bilimin doğasını anlayabilmeyi, üst düzey, bilimsel süreç ve laboratuvar becerilerini kullanabilmeyi, tutum ve değerlere sahip olabilmeyi, kimya, teknoloji, toplum ve çevre arasında ilişki kurabilmeyi, bilişim ve iletişim becerilerini kullanabilmeyi kapsar.

YETERLİKLER	PERFORMANS GÖSTERGELERİ
C.3. Tutum ve değerlere sahip olabilme	**C.3.1.** Yaşam boyu öğrenmeyi hayat felsefesi haline getirir. **C.3.2.** Kimya ve kimya eğitimindeki bazı kavram, konu ve bunların geçtiği durumları daha iyi anlayabilmek için güncel ve değişik kaynakları (kitap, makale, vb.) isteyerek okur. **C.3.3.** Bazı güncel, ekonomik ve toplumsal problemlerin çözümünde kimya biliminin rolünü açıklar. **C.3.4.** Kimya ve kimya eğitimiyle ilgili sorunların tartışıldığı seminer, çalıştay, sempozyum vb. toplantılara gönüllü olarak katılır. **C.3.5.** Kimya ile ilişkili meslekler hakkında çevresindeki insanlara bilgi verir. **C.3.6.** Bilim insanlarına ve bilimsel araştırmalara neden saygı duyulması gerektiğini açıklar. **C.3.7.** Çevre kirliliği, küresel ısınma gibi ulusal ve uluslararası sorunlara dikkat çekmek için okulunda panel ve seminerler düzenler.
C.4. Kimya, teknoloji, toplum ve çevre arasında ilişki kurabilme	**C.4.1.** Kimyanın başlıca amacının doğal dünya ile ilgili betimleme, açıklama, yordama yapmak ve/veya elde edilen bilgileri teknolojiye dönüştürerek toplumun yararına sunmak olduğunu ifade eder. **C.4.2.** Kimyanın sosyal, ekonomik ve teknolojik etkilerine örnekler verir. **C.4.3.** Kimya, uygulamalı kimya ve teknoloji arasındaki farklılıkları ve ilişkiyi açıklar. **C.4.4.** Teknolojik gelişmelerin kimya bilimine nasıl ve ne şekilde katkıda bulunduğunu örneklerle açıklar. **C.4.5.** Dünyanın farklı kültürlerindeki halklar ve bireyler tarafından keşfedilen ve geliştirilen bilimsel bilgi ve teknolojik araçların toplumların değişmesine nasıl katkıda bulunduğunu tahlil eder. **C.4.6.** Çevreyi tahrip eden kimyasallara ve kimya teknolojilerine örnekler verir. **C.4.7.** Çevre kirliliğinin önlenmesinde kimya biliminin katkısını irdeler. **C.4.8.** Kimya, teknoloji, toplum ve çevrenin karşılıklı etkileşim içinde olduğunu gösteren örnekler verir.

Yeterlik Alanı	**C- KİMYA OKURYAZARLIĞI**
Kapsam	Bu yeterlik alanı, bilimin doğasını anlayabilmeyi, üst düzey, bilimsel süreç ve laboratuvar becerilerini kullanabilmeyi, tutum ve değerlere sahip olabilmeyi, kimya, teknoloji, toplum ve çevre arasında ilişki kurabilmeyi, bilişim ve iletişim becerilerini kullanabilmeyi kapsar.

YETERLİKLER	**PERFORMANS GÖSTERGELERİ**
C.5. Bilişim ve iletişim becerilerini kullanabilme	**C.5.1.** Kimya ve kimya eğitimiyle ilgili bilimsel dil ve terminolojiyi kullanarak düşüncelerini yazılı ve sözlü olarak ifade eder. **C.5.2.** Kimya ve kimya eğitimiyle ilgili sorunları tartışırken farklı bakış açılarını dikkate alır. **C.5.3.**Kimya ile ilgili yazılımların etkin bir şekilde kullanımı için donanım ve işletim sistemi becerilerini geliştirir. **C.5.4.** Kimya ile ilgili verileri işlemek için uygun yazılım uygulamalarını kullanır. **C.5.5.** Kimyanın öğrenilmesi ve öğretilmesi amacıyla geliştirilmiş paket programları kullanır. **C.5.6.** Kimya alanında bilgiye ulaşmada, geliştirmede ve paylaşmada gerekli internet kullanma becerilerini geliştirir.

APPENDIX – C

ENVIRONMENTAL EDUCATION AND SUSTAINABLE DEVELOPMENT COMPETENCE EVALUATION QUESTIONS FOR CHEMISTRY TEACHERS

Cinsiyet: Yaş:

Sınıf:

Daha önce çevre/çevre eğitimi/sürdürülebilir kalkınma için eğitim konularından birini içeren bir ders/eğitim/etkinlikte bulundunuz mu? Etkinliği çok kısa bir şekilde açıklayınız.

Aşağıdaki açık uçlu soruları lütfen ilgili alana cevaplayınız.

1) Kimyasal açıdan düşünüldüğünde atom çekirdeğinde meydana gelen değişimler nelerdir?

    a) Bu değişimleri enerji ve çevreye olan etkileri açısından nasıl değerlendirirsiniz?

2) Günlük hayatta kullanılan kimyasal maddeler deyince aklınıza neler geliyor?

    a) Günlük hayatta kullanılan bu maddelerden bazılarının (temizlik maddeleri, boyalar, gübre, patlayıcılar, yakıtlar, plastikler, süper-iletkenler ve alaşımlar vb) organik ve inorganik bileşenlerini açıklayabilir misiniz?

    b) Günlük hayatta kullanılan bu madelerin çevreye etkileri hakkında bilgi verebilir misiniz?

    c) Günlük hayatta kullanılan bu maddelerin içerdiği hangi bileşenlerin çevrede nasıl bir etki bıraktığını açıklayabilir misiniz?

3) Kimya öğretim programının teknoloji, toplum ve çevre boyutlarında nelere yer verdiğini, programın bu konularla bağlantılı olarak neler içerdiğini açıklayabilir misiniz?

4) Öğretmen olduğunuzda dersinizde kimya, teknoloji, toplum ve çevre ilişkilerine vurgu yapan örneklere yer verir misiniz? Neden?

   a) Dersinizde bu örnekleri nasıl ve hangi amaç ile kullanırsınız?

   b) Kimya, teknoloji, toplum ve çevrenin karşılıklı etkileşim içinde olduğunu bir örnek ile açıklayabilir misiniz?

5) Öğretmen olduğunuzda öğrencilerin kimya, teknoloji, toplum ve çevre ilişkilerini fark etmelerine yardımcı olacak ne gibi ders dışı etkinlikler düzenlersiniz?

6) Sizce günümüzde çevre ile ilgili ne gibi ulusal ve uluslararası sorunlar bulunmaktadır?

   a) Bu çevre sorunları ve kimya alanı arasında nasıl bir bağlantı vardır?

   b) Öğretmen olduğunuzda bu sorunlara dikkat çekmek için okullarda ne gibi aktiviteler düzenlersiniz?

7) Bir kimya öğretmeni adayı olarak çevreyi tahrip eden çeşitli kimyasallara ve kimya teknolojilerine örnekler verebilir misiniz?

8) Çevre kirliliğinin önlenmesinde kimya biliminin katkısı nedir? Örnekler ile açıklayabilir misiniz?