REPUBLIC OF TURKEY

YILDIZ TECHNICAL UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

MIDDLE SCHOOL STUDENTS' DEVELOPMENT OF MODEL-BASED EXPLANATIONS ABOUT ECOLOGICAL INTERACTIONS THROUGH SOCIO-SCIENTIFIC ISSUE BASED INSTRUCTION

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MASTER OF SCIENCE THESIS

Department of Mathematics and Science Education

Science Education Program

Advisor

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A thesis submitted by Benzegül DURAK in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE is approved by the committee on 13.05.2019 in Department of Mathematics and Science Education, Science Education Program.

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I hereby declare that I have obtained the required legal permissions during data collection and exploitation procedures, that I have made the in-text citations and cited the references properly, that I haven't falsified and/or fabricated research data and results of the study and that I have abided by the principles of the scientific research and ethics during my Thesis Study under the title of Middle School Students' Development of Model-Based Explanations About Ecological Interactions Through Socio-scientific Issue Based Instruction supervised by my supervisor, Prof. Dr. Mustafa Sami TOPÇU. In the case of a discovery of false statement, I am to acknowledge any legal consequence.

Benzegül DURAK

Dedicated to my family

and my love

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Benzegül DURAK

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LIST OF ABBREVIATIONS

CCC	Crosscutting Concepts
DBR	Design-based Research
DCI	Disciplinary Core Ideas
ICT	Information and Communication Technology
MbL	Model-based Learning
MOIB	Model-oriented Issue-based
MoNE	Ministry of National Education
NGSS	Next Generation Science Standards
NOS	Nature of Science
NRC	National Research Council
NSTA	National Science Teacher Assocition
OECD	Organization for Economic Cooperation and Development
PISA	Program for International Student Assessment
SP	Scientific Practices
SPSS	Statistical Package for Social Sciences
SSR	Socio-scientific Reasoning
SSI	Socio-scientific Issues
SSI-TL	Socio-scientific Teaching and Learning
STP	Science Teaching Program
STS	Science-Technology-Society
STSE	Science-Technology-Society-Environment

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ABSTRACT

Middle School Students' Development of Model-Based Explanations about Ecological Interactions through Socio-scientific Issue Based Instruction

Benzegül DURAK

Department of Mathematics and Science Education

Master of Science Thesis

Advisor: Prof. Dr. Mustafa Sami TOPÇU

Using socio-scientific issues (SSI) as the context of science learning to achieve scientific literacy has been accepted by the science education community. For this reason, SSI-based instruction is used in class but unfortunately, the actual implementation of SSI-based teaching has been limited. One of the main reasons for this limited use of SSI is that well designed SSI-oriented curriculum materials are insufficient. In this thesis, the model-based learning approach is used to support the development of SSI-based instruction curriculum unit and an SSI-based curriculum unit was developed according to the SSI-based instruction model by Sadler, Foulk, and Friedrichsen (2007). The "white butterfly" issue, which is a local pest, is assigned as the SSI of the unit. The unit was prepared according to the objectives of the "Human and Environmental Relations/ Living Things and Life" unit in Science Teaching Program (2013) followed by the 7th grade students in the implementation period. Therefore, the unit developed in this thesis was applied to twenty-one 7th grade students who study at a public middle school at Düzce. The unit consists of 8 lessons through 15 lesson hours so 4 weeks. At the end of the unit, models and their explanations generated by students were collected and analyzed. Moreover, in order to assess content knowledge of the students, a unit test was applied to students. Analysis of data was completed in four steps. Firstly, in order to analyze models and explanations two rubrics were generated as a) components rubric, and b) explanatory process rubric which was developed by taking Zangori et al. (2017) study as an example. The second step was scoring models and explanations, and checking inter-rater reliability. Two scorers analyzed models and explanations independently and, the Cohen's Kappa calculated as 0.83, $p<0.001$ that indicate "near perfect agreement" between scorers. The next step was the analysis of the scores with an SPSS (Statistical Package for the Social Sciences). Since it was a repeated process on one student group, the Friedman test was used to analyze whether there was a significant difference between the modeling scores or not. Then, the Wilcoxon test was applied to determine the difference between scores of model 1 and model 2; model 1 and model 3; model 2 and model 3. As a result of these analyses, students' model-based explanations developed significantly through the unit. The last step of data analysis was scoring of students' unit tests. According to the test results, 86% of the students reached satisfactory and higher levels. It means, most of the students gain enough content knowledge of ecosystem and biodiversity topics.

Key words: Socio-scientific issue (SSI), SSI-based instruction, modeling, model-based learning

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ÖZET

Sosyo-bilimsel Konu Temelli Öğrenme Bağlamında Ortaokul Öğrencilerinin Ekolojik İlişkiler Konusunda Model Tabanlı Açıklamalarının Gelişimi

Benzegül DURAK

Matematik ve Fen Bilimleri Eğitimi Programı

Yüksek Lisans Tezi

Danışman: Prof. Dr. Mustafa Sami TOPÇU

Fen öğretiminde sosyo-bilimsel konuların (SBK) fen okuryazarlığına ulaşmak için kullanılması fen eğitimi araştırmacıları tarafından kabul edilmiştir. Bu nedenle, SBK temelli öğretim sınıflarda kullanılmaktadır, ancak ne yazık ki SBK temelli öğretimin gerçek kullanımı sınırlıdır. SBK temelli öğretimin bu sınırlı kullanımının ana nedenlerinden biri, iyi tasarlanmış olan SBK odaklı müfredat materyallerinin yetersiz olmasıdır. Bu tezde, SBK temelli öğretim ünitesinin gelişimini desteklemek için model temelli öğrenme yaklaşımı kullanılmış ve Sadler, Foulk ve Friedrichsen (2007) tarafından geliştirilen SBK temelli öğretim çerçevesine göre bir SBK temelli ünite geliştirilmiştir. Yerel bir zararlı olan "beyaz kelebek" konusu, ünitenin SBK'sı olarak belirlenmiştir. Ünite, uygulama döneminde 7. sınıf öğrencilerinin devam ettiği 2013 Fen Bilgisi Öğretim Programındaki *"İnsan ve Çevre İlişkileri / Canlılar ve Yaşam"* ünitesinin kazanımlarına uygun olarak hazırlanmıştır. Bu nedenle, bu tezde geliştirilen ünite, Düzce'de bir devlet ortaokulunda okuyan yirmi bir 7. sınıf öğrencisine uygulanmıştır. Ünite haftada 4 ders olmak üzere 15 ders saatini

kapsayacak şekilde 8 ders planından oluşmaktadır. Ünite sonunda, öğrenciler tarafından üretilen modeller ve açıklamaları veri olarak toplanmış ve analiz edilmiştir. Ayrıca, öğrencilerin içerik bilgilerini değerlendirmek için öğrencilere bir ünite sonu testi uygulanmıştır.

Toplanan verilerin analizi dört adımda tamamlanmıştır. İlk olarak, modelleri ve açıklamaları analiz etmek için (a) bileşenler rubriği, ve b) açıklama süreci rubriği olmak üzere 2 rubrik hazırlanmıştır. Rubriklerin hazırlanmasında Zangori ve arkadaşlarının (2017) çalışması temel alınmıştır. İkinci adımda, modellerin ve açıklamaların puanlanması ve değerlendiriciler arası güvenilirliğin kontrolü sağlanmıştır. Öğrencilerin modelleri ve açıklamaları bağımsız olarak iki değerlendirmeci tarafından analiz edilmiş ve değerlendirmeleri ile yapılan analizde Cohen'in Kappa değeri 0.83, $p < 0.001$ olarak yani "mükemmele yakın" olarak hesaplanmıştır. Bir sonraki adımda, Sosyal Bilimler için İstatistik Paketi (SPSS) programı ile rubrik puanlarının analizi yapılmıştır. Bir öğrenci grubunda tekrarlanan bir süreç olduğu için, modelleme puanları arasında anlamlı bir fark olup olmadığını analiz etmek için Friedman testi kullanılmıştır. Daha sonra, model 1 ve model 2; model 1 ve model 3; model 2 ve model 3 puanları arasındaki farkı belirlemek için Wilcoxon testi uygulanmıştır. Bu analizler sonucunda, öğrencilerin model temelli açıklamalarının ünite boyunca anlamlı ölçüde geliştiği görülmüştür. Veri analizinin son adımında, öğrencilerin ünite sonu testleri puanlanmıştır. Test sonuçlarına göre öğrencilerin %86'sı tatmin edici ve daha yüksek seviyelere ulaşmıştır. Bu, öğrencilerin çoğunun ekosistem ve biyoçeşitlilik konularında yeterli içerik bilgisi edindiği anlamına gelmektedir.

Anahtar kelimeler: Sosyo-bilimsel konu (SBK), SBK temelli öğretim, modelleme, model tabanlı öğrenme

1
Introduction

1.1 Literature Review

1.1.1 Scientific Literacy

Scientific literacy has attracted attention throughout the years, but there is almost no consensus about its definition [1]. The term of scientific literacy often is used as "public understanding of science" [2], [3]. However, according to [1] saying "public understanding of science" causes different meaning and interpretations about what the public should know and who the public is. On the other hand, although there is no consensus on its definition, scientific literacy is one of the few issues that both United States and European Union leaders think that it is a good thing and should be aimed to prepare students to the rest of their lives as scientifically literate citizens [4].

In spite of this uncertainty in the definition of scientific literacy, people agree on the provision of scientific literacy [5]. It may be explained with the idea that the meaning of scientific literacy is changed continuously because science itself is evolving and developing constantly [6].

In that case, as science educators and science education researchers trying to understand (1) what does scientific literacy mean, (2) why is scientific literacy important and, (3) how to improve scientific literacy is required [5].

1.1.1.1 What does scientific literacy mean?

The term "scientific literacy" was used by Paul Hurd at the end of the 1950s and to describe the understanding of science and its applications to society [1]. There are many definitions in literature which are similar to each other [7]. Instead of citing all of the similar definitions, I prefer to give some of them presented by varying institutions. Firstly, the National Research Council (NRC) [8] defines scientific literacy with the following five components;

- Knowledge of important scientific facts, concepts, principles, and theories.
- To be able to apply related information in daily life;
- Ability to use scientific inquiry processes
- Understanding of main ideas about the features of science, and important interactions of science, technology and society;
- Having knowledge about the attitudes, and interests toward science

Similar to the NRC's [8] definition, the Program for International Student Assessment (PISA), which is an event created by the Organization for Economic Cooperation and Development (OECD), define scientific literacy with components [9]. PISA defines scientific literacy because PISA is an event aims to evaluate the literacy of 15-year-old students in science, mathematics and literacy in a worldwide range [9]. In PISA [9], scientific literacy is defined with for components, which are *personal, social, global contexts; scientific competencies; the domains of scientific knowledge,* and *attitudes toward science.*

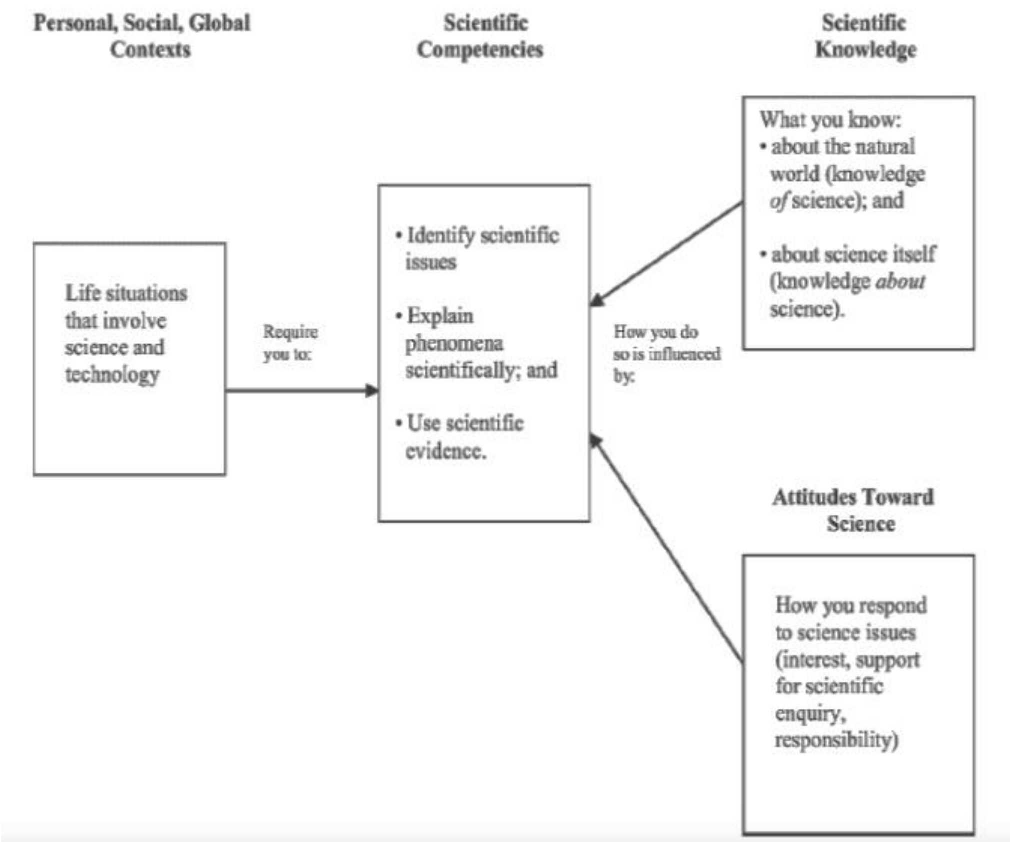


Figure 1.1 The components of scientific literacy (taken from [8])

The first component, as can be seen from Figure 1.1, is the personal, social, global contexts concerning the subjects that citizens are exposed in daily life. Health accidents, nutrition, disposal of waste, climate change issues are some examples of the personal, social, global contexts that students face as citizens in everyday life. The second component is scientific competencies required students to define scientific problems, explain phenomena scientifically, and use scientific evidence. The third component which is scientific knowledge consists of two parts. One of them is the *"knowledge of science"* means scientific content, the other is *"knowledge about science"* refers to how science works. The last component is attitudes towards science. It emphasizes that students' attitudes are important for scientific literacy. In other words, students' interests, beliefs, and motivations related to science affect scientific literacy levels.

1.1.1.2 Why is scientific literacy important?

There are many definitions of scientific literacy; and so there are various ideas about why scientific literacy is important. One of the common arguments on its importance is that scientific literacy is related to the well-being of a nation. It is claimed that national wealth depends on the successful competition in international markets. International competitiveness, in turn, is based on a strong national research and development program to protect or capture ground in the worldwide race for new high-tech products among others [1]. Second are again economical, scientifically literate individuals having more chance to be employed because the 21st century brings science and technology to many areas including sports, arts, etc. Therefore, the scientifically literate person is employable in these workplaces [7]. Moreover, if a high portion of the society would be scientifically literate, the support to the development of science will increase [1]. On the other hand, there are some direct benefits of scientific literacy to individuals. Simply, being the scientifically literate person is important to be able to both understand and to be skeptical about an article on a newspaper or a commentary on television (as cited in [7]). In addition, improved scientific literacy helps personal decisions like diet or vaccination in a positive way [7]. Lastly, scientific literacy is important for society. There are some public issues that require debate to deal with and therefore people all need to have some level of scientific literacy. For example, any citizen should have enough scientific background to discuss global warming, stem cells, nuclear power plants, and so on [7].

1.1.1.3 How to improve scientific literacy?

Again, there are many suggestions to science teachers to help them increase scientific literacy in classrooms. Four strategies are listed by Grant and Dianne [10] as;

- Identifying interesting science topics and integrating them into lessons
- Engaging students in reading research (to make familiar students how science is produced)
- Teaching students to read like scientists (by using science practices and connecting prior knowledge to new situations)
- Guiding students to evaluate data (to make familiar students using multiple sources) [10].

In addition, like many other countries (e.g. United States, France, Australia [11]), Turkey also states scientific literacy as the main aim of the science teaching program (STP) [12]. The STP [12] published by the Ministry of National Education (MoNE) of Turkey define scientific literacy as *"…a combination of science-related skills, attitudes, values, insights and knowledge necessary for individuals to develop their research-questioning, critical thinking, problem-solving and decision-making skills, to become lifelong learners, and to maintain their curiosity about their environment and the world"* and presents the main aim of the science education (between grades 3 to 8) as to raise scientifically literate students. For this aim, ten objectives are listed in the curriculum. These objectives are;

- ✓ To provide basic information about astronomy, biology, physics, chemistry, earth and environmental sciences, and science and engineering applications,
- ✓ To adopt scientific process skills and scientific research approach in the process of discovery of nature and understanding of the relationship

between human-environment and to find solutions to the problems encountered in these areas,

- ✓ To recognize the interaction between the individual, environment, and society; to develop an awareness of sustainable development on society, economy and natural resources,
- ✓ To take responsibility for daily life problems and to use knowledge of science, scientific process skills, and other life skills to solve these problems,
- ✓ To develop career awareness and entrepreneurship skills related to science,
- ✓ To help to understand how scientific knowledge is created, how this knowledge is developed by scientists and how it is used in new research,
- ✓ To raise interest and curiosity about events occurring in nature and near environment and to develop an attitude towards them
- ✓ To create awareness of the importance of safety in scientific studies,
- ✓ To develop reasoning skills, scientific thinking habits, and decision-making skills by using socio-scientific subjects,
- ✓ To ensure the adoption of universal values of ethics, national and cultural values and scientific ethics [12].

These objectives summarize the components of scientific literacy as scientific content knowledge, scientific practices, nature of science and socio-scientific issues both to understand the relation between science and society and to develop the skills such as reasoning, critical thinking, decision making.

1.1.2 Socio-scientific Issues (SSI)

There are many issues like stem cell, cloning, genetically modified foods, global warming, and nuclear power plants which we faced in daily lives. For at least some of these issues we have to make judgments and decisions about whether they should be, or not. For example, whether a nuclear power plant should be constructed, stem cells should be used to produce organs, or genetically modified foods should be banned or allowed. These issues usually result in debate because according to the perspective different options could be chosen. For example, for a person genetically modified foods should be used for effective use of agricultural land, or for another it should not be used because of reduction of biodiversity. Having different and opposing ideas makes these issues controversial, dilemmatic, and open to multiple solutions. Such issues are called as socio-scientific issues [13]. Sadler [13] defined socio-scientific issues (SSI) as "complex, open-ended, often contentious dilemmas, with no definitive answers and in response to socio-scientific dilemmas, valid, yet opposing, arguments can be constructed from multiple perspectives" (p. 514). Besides these characteristics, there are two criteria that one must have in order to become a socio-scientific issue. First, the issue must be related to science topics and second, it must have significance in social life [14]. Precisely, SSI are defined as social dilemmas related to science [15]. Although this definition of SSI is precise, SSI has multidimensional structure. Ratcliffe and Grace [16] explained the multidimensional structure of SSI:

SSI;

- is based on science
- develops within the limits of scientific knowledge
- requires to make decisions in the personal and social environment
- has moral dimension
- is found in media frequently
- is related with science and society at the same time
- is up to date topics
- has risk-cost analysis by looking at the interactive relations between risk and values,
- has social, economic and political dimensions [16]

At this point, it is important to note that SSI may be perceived similar to science, technology and society (STS) education. Although they look similar since both are related to science and society, the fact is that SSI originates from STS [16]. The main aim of the STS approach is to integrate science, technology and society in science education for meaningful science learning. Also, the National Teacher Association (NSTA) (1982) describe scientifically literate individual as who is knowledgeable about the relationship between science, technology and society. However, as Zeidler et al. pointed out, it was not enough for scientific literacy because the ethical dimension is not stated in STS [17]. Therefore, there is a shift to a new form of STS which is science, technology, society and environment (STSE) education. However, this change also was not satisfactory in terms of directing personal and individual moral and ethical development of students [17]. Then, Zeidler et al. [17] pointed out the idea of SSI instead of STS or STSE with the words;

"Whereas the overarching purpose of the STS approach is to increase student interest in science by placing science content learning in a societal context, SSI education aims to stimulate and promote individual intellectual development in morality and ethics as well as awareness of the interdependence between science and society. SSI therefore does not simply serve as a context for learning science, but rather as a pedagogical strategy with clearly defined goals (p. 360)." [17]

Also, Zeidler et al. [17] indicated that teachers should follow SSI in order to achieve scientific literacy because SSI provides teachers a coherent conceptual framework by considering students' morality and emotional development [17], [18]. Moreover, they presented a model which shows the socio-scientific elements of functional scientific literacy [17].

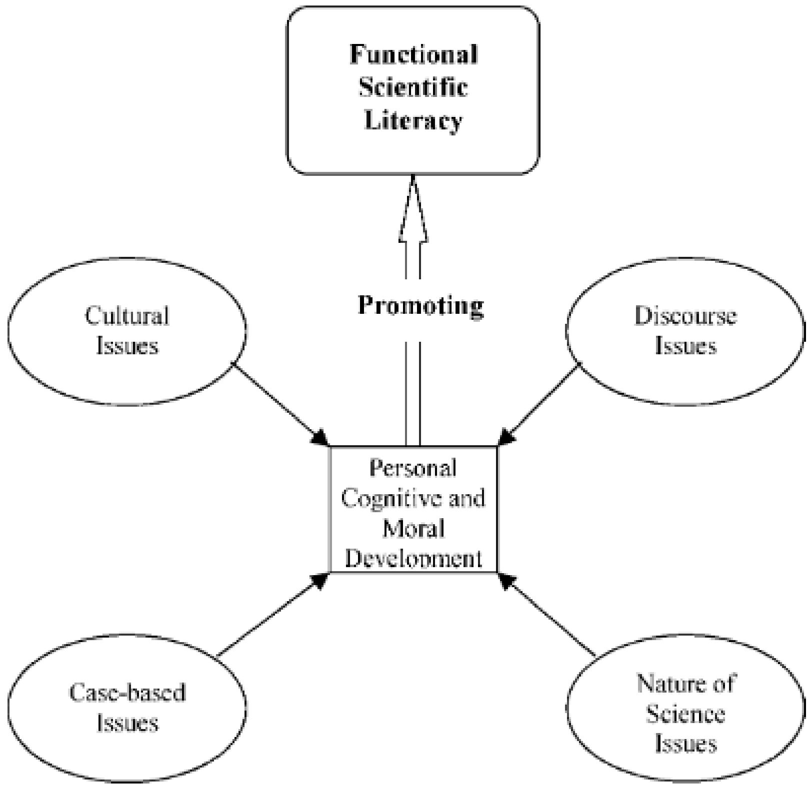


Figure 1.2 The socio-scientific elements of functional scientific literacy (taken from [17])

These elements of *discourse issues*, *cultural issues*, *case-based issues* and *nature of science issues* are similar to the features of STS but *personal cognitive and moral development* with relation to all other elements is completely different from the STS. Discourse issues mean how students create arguments and use reasoning and how students' previous opinions and beliefs frame their commitments or stances on moral issues. Cultural issues refer that students' decisions are influenced by cultural beliefs related to the natural world as moral factors. Case-based topics allow teachers to go beyond the STS curriculum and to develop students' mental habits to promote the resolution of ethical issues. Lastly, all of these components should relate to *personal cognitive and moral development* to achieve scientific literacy.

Consequently, the development of SSI could be represented with Figure 1.3 below.

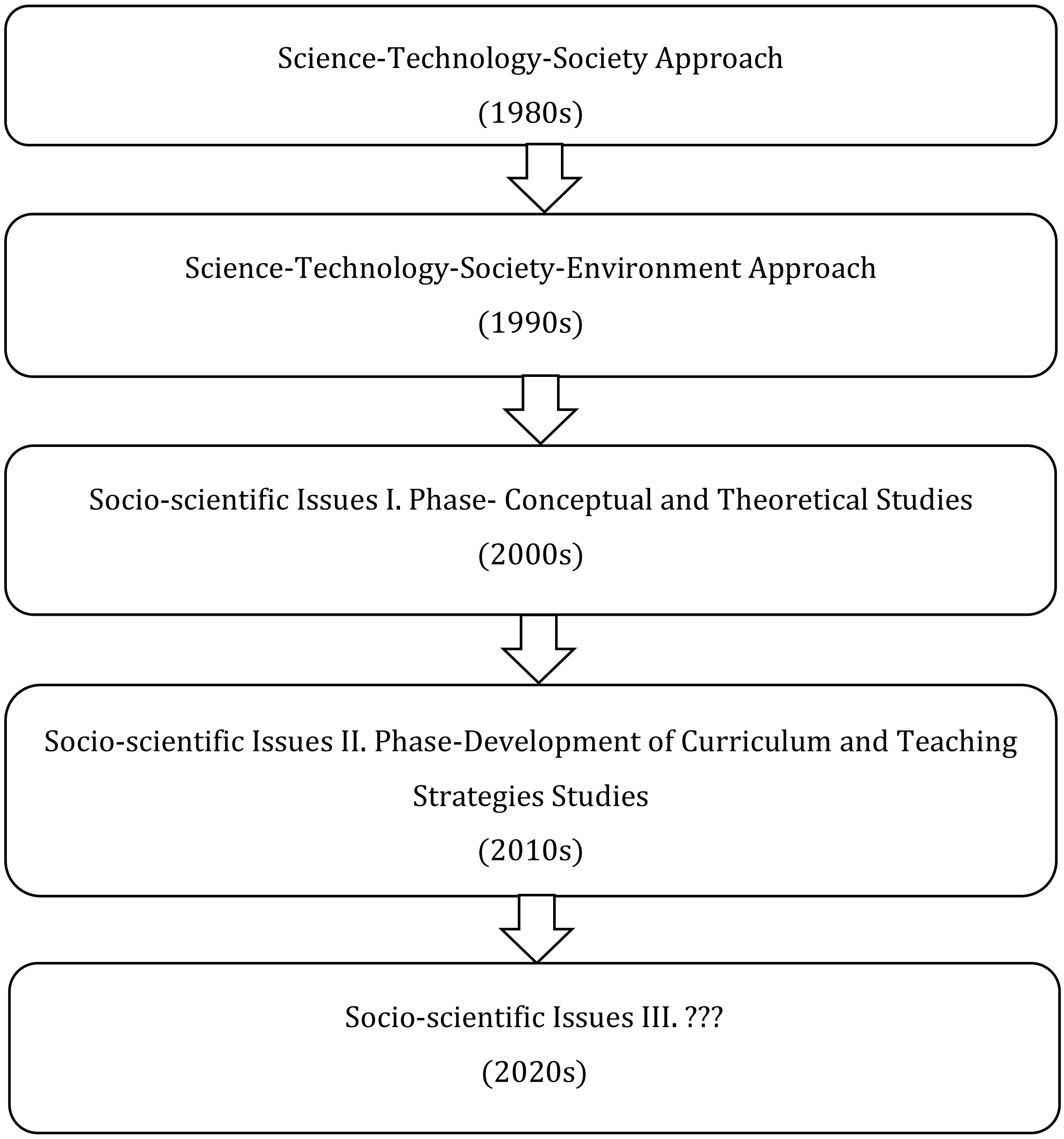


Figure 1.3 The development of socio-scientific issues (translated from [16])

After the transformation of the STSE approach into a new SSI approach at the beginning of 2000, it is seen that the SSI continues to develop within itself. This development can be examined at different stages. In Phase-1, mostly conceptual and theoretical studies related to SSI were made by the researchers. Then, in Phase-2, by considering previous studies on SSI in Phase-1 researchers began to develop curriculum studies and teaching models to cope with SSI in classroom settings. In this respect, it is possible to conclude that in the 2020s, new study trends related to SSI can be done by researchers [16].

1.1.3 Scientific Practices

Scientific practices or in the full phrase *"scientific and engineering practices"* are the practices that helps students to understand how scientific knowledge develops; and shows students a wide variety of approaches used to explore, model and explain the world. In addition, being involved in engineering practices also helps students understand the links between engineering and science, as well as how engineers work [19]. In that case, there is a reminder that NRC [19] prefers to use the term *"practice"* instead of *"skills"* to emphasize that participating in scientific research requires not only skills, but also specific knowledge of each practice. Here is the list of scientific and engineering practices;

- Asking questions (for science) and defining problems (for engineering)
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations (for science) and designing solutions (for engineering)
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

Generally, the practices are similar for both science and engineering. However, some (1 and 6) practices mean different. In order to understand the meaning of each practice, one should understand why these practices emerged. The roots of scientific practices depend on scientific inquiry. Scientific inquiry is also the third component of the scientific literacy [7], means a list of skills to learn science that involves conducting activities that address the procedural and epistemological aspects of science. However, teaching science through inquiry faced with critics and shifted to scientific practices [20].

Table 1.1 A comparison of the abilities to do scientific inquiry [21] with the set of scientific practices found in the Framework for K-12 Science Education [20] (taken from [20])

Fundamental abilities necessary to do scientific inquiry (Grades 5–8)	**Scientific Practices**
Identify questions that can be answered through scientific investigations	Asking questions and defining problems
Design and conduct a scientific investigation	Developing and using models
Use appropriate tools and techniques to gather, analyze and interpret scientific data	Planning and carrying out investigations
Develop descriptions, explanations, predictions and models using evidence	Analyzing and interpreting data
Think critically and logically to make the relationship between evidence and explanations	Using mathematical and computational thinking
Recognize and analyze alternative explanations and predictions	Constructing explanations and designing solutions
Communicate scientific procedures and explanations Use mathematics in all aspects of scientific enquiry	Engaging in argument from evidence obtaining, evaluating and communicating information

The table shows the comparison of the abilities to do scientific inquiry [21] with the set of scientific practices found in the Framework for K-12 Science Education [19] the shifts from scientific inquiry to scientific practices. Basically, the difference between scientific inquiry and scientific practices is what students should experience, what students should learn, and an advanced professional language to convey meaning [19], [20], [21]. Moreover, scientific inquiry follows such activities which students use these abilities whereas scientific practices are not focusing steps to follow. In other words, there is no need to engage in each scientific practice in teaching, rather engaging in practice only has value if; (a) it helps students develop a deeper and broader understanding of what we know, how we know, and the epistemic and procedural structures that guide the practice of science; (b) it is a more effective way to improve knowledge; (c) it presents a more authentic image of the science [20].

- *Asking questions (for science) and defining problems (for engineering)*

This practice refers to the starting point of science and engineering. Science starts with asking a question about a phenomenon required to develop theories to explain it, whereas engineering starts with a problem, need, or request to be solved [19], [20].

- *Developing and using models*

Scientists use models to develop explanations about phenomena whereas engineers use them to analyze existing systems and test solutions of a problem. In addition, in science, models make possible to see more than observable ones and also imagine which has not yet been seen [19], [20].

- *Planning and carrying out investigations*

Planning and carrying out investigations is a major practice of scientists and engineers. Identifying dependent and independent variables and deciding how data is collected are main steps for both scientists and engineers [19], [20].

- *Analyzing and interpreting data*

After data collection, it should be analyzed in a proper way and also interpreted to derive meaning. In that practice, checking sources of error and supporting data with a secondary source are included [19], [20].

- *Using mathematics and computational thinking*

In science and engineering, using mathematics and computation is essential to make sense about the relationships between variables. This practice makes scientists enable to predict behavior of systems and make engineers enable to make simulations of designs and test their development [19], [20].

- *Constructing explanations (for science) and designing solutions (for engineering)*

The aim of science is the construction of theories that provide an explanation of the world and for students should be engaged in this practice by constructing logical explanations based on evidence. On the other hand, engineering design, a systematic process for solving problems depends on scientific knowledge and models [19], [20].

- *Engaging in argument from evidence*

Reasoning and argumentation are essential both for science to find the best explanation of phenomenon and for engineering to find the best solution to problem [19], [20].

- *Obtaining, evaluating, and communicating information*

Without communication both science and engineering are not developed. It is because science and engineering improve by deriving meaning from other science products (papers, symposiums, etc.) [19], [20].

Although, the main aspects of science and engineering practices are given it is not known how to incorporate these practices in science education [20].The answer of the question is related with the creativity of a teacher, science educator or science education researcher. For effective use of scientific practices in lessons, teachers and students need support [22]. For instance, there is a learning approach that depends on modeling.

Model-based learning comes with the idea that modeling is a core practice to achieve scientific literacy [23]. Although models are used in science education for different purposes like representing a hypothesis, showing equations, explaining a phenomenon, etc. [24], model based-learning depends mental models produced by students [25]. The main aim of model-based learning is making students' thinking visible and making-sense about science content [25].

Zangori et al. [26], developed and implemented a modeling-centered SSI unit to teach carbon cycling and climate change with respect to the interrelationship between carbon cycling and climate change. In the study, they expected students to develop, use, evaluate and revise their models and lastly each student develops three hierarchical models through the lessons. Participants of the study were 50 students who were 10th graders and attended the biology course. They both developed models and wrote prompts to explain what they think about how carbon cycle works. As a result of the study, students' model scores were increased and reached a satisfactory level. Moreover, students' explanations of carbon cycling, climate change and their interrelationships showed increase although many of the students did not achieve to identify the mechanism of the interrelationship. Zangori et al. theorized that the inclusion of model-based learning in an SSI unit supports students in developing and using models to express model-based explanations of carbon cycling, climate change and the relationship between them [26].

Another study which also uses model-based learning and SSI together is the study by Peel et al. [25]. They studied on natural selection in the context of antibiotic resistance issue. Again, modeling and SSI based unit was developed and implemented to 10th grade students who attended biology class. Students made pre and post models about the bacteria level at the population and individual level. Consequently, students' model-based explanations increased in natural selection content. Moreover, students' misconceptions about natural selection and antibiotic resistance significantly decreased after the study [25].

Both of the studies ([25], [26]) and some other studies ([27], [28] and [29])) show that modeling is a successful supporter of SSI-based instruction. In the present study, modeling and model-based learning was used to support SSI-based instruction. As an SSI, white butterfly issue, which is a local pest, was integrated to the unit to teach the ecosystem and biodiversity unit.

1.1.4 Ecosystem and Biodiversity

In the aim of the scientifically literate students, some concepts are essential to teach. “Ecosystem and biodiversity” issue is one of these concepts. Students should have enough knowledge and understanding of the relationships in between ecosystems in order to be able to make informed decisions about their ecosystems and environment [7], [30].

Understanding ecosystems’ processes are difficult for students because as stated in Honwad et al. study; “they are complex systems that transcend spatial, temporal and cognitive boundaries” [30]. Moreover, ecosystems include visible (animals, trees, etc.) and invisible (air, temperature, etc.) components which are linked to each other. It means, change in one pattern in an ecosystem results in change in overall functioning of the system [30], [31].

Studies on ecosystem and biodiversity show that when students asked to draw or name a component in an ecosystem, they state often visible components of the ecosystem [32]. Moreover, they have difficulties to explain causality in ecosystem relations [31]. In order to improve students’ understanding of multidimensional structure of ecosystems, studies suggest context-based learning of ecosystems not only for student understanding of science, but also for strong decision-making in a society [31], [33].

Moreover, studies suggest that to promote deep understanding of ecosystem and biodiversity requires students to understand how they organize ideas. Specifically, identifying students’ pre-concepts can be useful in enhancing students' knowledge development [31]. From this perspective model-based learning can be integrated to the teaching of ecosystem and biodiversity concepts like Jordan et al. [31] did in their study. They asked students after many simulations and also real observation of an aquarium; “*1) what is an ecosystem? 2) systems have interactions, draw how things interact in an aquarium and 3) is the nitrification process a system? Why or why not?”*. They collected and analyzed data to determine how middle school students understand ecosystems. Although, the study was conducted before students were taught about ecosystem, students’ responses to the questions were satisfying. It means students could answered questions about ecosystem by observing an aquarium and watching simulations about ecosystems without any direct instruction in class. However, they could not explain the interactions or cycles (nitrification cycle). Therefore, having a sample system like aquarium in a class is not enough to develop understanding of complexity of ecosystems [31].

In this study, ecosystem and biodiversity unit is addressed by modeling oriented SSI-based instruction. A local issue related with the ecosystem which is white butterfly issue, is adopted to the instruction. In this way, students have a chance to understand both the complex relations in ecosystems and the science behind them and, social dimensions of the changes in ecosystems.

1.2 Objective of the Thesis

The aim of this thesis is to investigate 7th grade students' development of model-based explanations when they study on modeling-oriented SSI-based curriculum unit. The investigation is guided by the question which is;

"How do 7th grade students' model-based explanations about white butterfly issue change through SSI based instruction?"

For this purpose, an SSI-based curriculum unit was developed according to the SSI-based instruction model by Sadler, Foulk and Friedrichsen [34]. Model-based learning approach ([26]) is used to support the unit. The "white butterfly" issue, which is a local pest, is assigned as the SSI focus of the unit. The unit was prepared according to the objectives of the *"Human and Environmental Relations/ Living Things and Life"* unit in Science Teaching Program (STP) ([35]) followed by the 7th grade students in the implementation period. Therefore, the unit developed in this thesis was applied to twenty-one 7th grade students who study at a public middle school at Düzce. The unit consists of 8 lessons through 15 lesson hours so 4 weeks. At the end of the unit, models generated by students and models' written explanations about the main question of the unit were collected and analyzed. Moreover, in order to assess content knowledge of the students, a unit test (developed by MoNE, [36]) was applied.

The framework of the unit and information about the "white butterfly" issue are mentioned in following chapter in detail.

1.3 Rationale of the Study

In the previous parts it is deeply discussed that using SSI as the context of science learning to achieve scientific literacy has been accepted by science education community [37]. Also, it is unfortunately stated that the actual implementation of SSI-based teaching has been limited [38]. One of the main reasons for this limited use of SSI is that well designed SSI-oriented curriculum materials are insufficient [39]. This thesis includes the design of the modeling-oriented SSI-based instruction curriculum unit and many other related materials. These are collected and open sources for others. It means this thesis supplies teachers a well-designed SSI-based unit plan and also a guide to develop an SSI-based unit.

Moreover, the present study carries another importance and fills some gaps in the literature. Firstly, there are few studies in the literature about SSI and they are mostly conducted with prospective teachers [40]. Secondly, few studies focusing on students, rather than teachers or prospective teachers, study on students' argumentation skills, reasoning skills or critical thinking skills [41], [42], [43], [44], [45]. Also, these studies on students rarely use SSI-based instruction framework to develop the unit (e.g. [41], [42], [45]). Lastly, the issues in these studies are global issues like gene editing [41] or bee hives [42].

Moreover, there is limited study with SSI-based instruction framework and modeling used together to develop a unit (e.g. [25], [26], [27], [28] and [29]). SSI-based instruction studies generally use argumentation as a scientific practice (e. g. [41], [42], [46]). Therefore, this thesis study contributes to the limited literature by addressing an SSI with a modeling-oriented SSI-based curriculum unit.

This study has a novelty in literature. In this study, implementation of the unit was completed by a science teacher via collaboration with researcher. As a researcher, I developed the modeling-oriented SSI-based curriculum unit, and the science teacher of the participants applied the unit. Moreover, he contributed to the unit development process by giving tips about the learning styles of students. On the other hand, other studies depend on SSI-based instruction implemented by the researcher by self in class [41], [42], [45]). It could be in two different ways. First, the teacher may make a research and use his/her students as participations (e. g.

[45]), or second, the researcher may design a unit and take permissions from schools and teachers to teach participant students in class (e.g. [41] and [42]). Therefore, this study shows that collaboration of a researcher and science teacher ends up with success.

2
Framework

2.1 Framework for Socio-scientific Issue (SSI) Based Instruction

Socio-scientific issues (SSI) are complex and controversial societal issues with notional, procedural or theoretical relations with science [13], [47]. Common examples of SSI include climate change, genetically modified foods, energy sources like nuclear power plants. Those issues are frequently on the focus of media and so give chance people to interact with science whether or not they have a basis on science [38]. Therefore, science educators tend to use of SSI to engage students in learning by connecting the science concepts with real life. In another word, science educators use SSI in lessons to help students to learn science with social context (e.g. [25], [26], [27]). However, the actual implementation of SSI-based instruction has been limited. There are many research aims to find out the reason behind it [11]. According to the Hofstein et al. [39] there are two main reasons for this limited use of SSI. Firstly, the well-designed SSI-oriented curriculum material is limited [39]. Secondly, the support for teachers who are trying to implement SSI teaching is limited [39]. For this reason, Sadler, Foulk and Friedrichsen [34] designed a framework as a guide for developing the SSI unit. This framework [34] has been formed by evolving various models and frameworks is the result of long studies. The older frameworks that guide the current framework of SSI teaching and learning [39] are listed in the following subtitles.

2.1.1 "An Emergent Framework for SSI-Based Education" (by [48])

The first model which "an emergent framework for SSI-based education (Figure 2.1)" was presented by Sadler at the end of his book [48]. This framework was a final study of the book. In order to construct the framework, Sadler said that he examined Eilk's model deeply and reflect the chapters on the book [48]. Eilk's model which gave Sadler a starting point was not a model for each SSI class; it was a guide for Eilk's study in chemistry class [48]. Therefore, Sadler wanted to create an inclusive model and named it as “framework” to be less specific and others could build a model on this framework. This framework consists of four primary aspects: design elements, learner experiences, classroom environment, and teacher attributes [48].

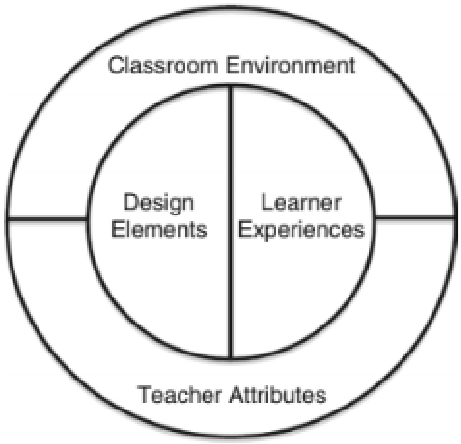
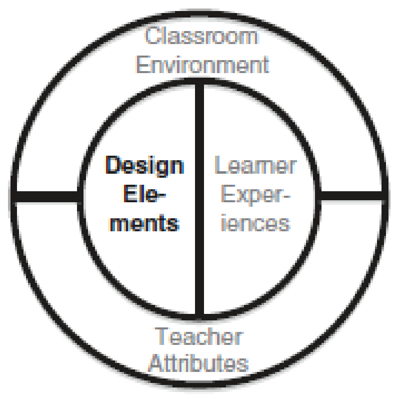


Figure 2.1 “An emergent framework for SSI-based education” (taken from [48])

Basically, *design elements* refer to the important points for the design of well-done SSI-based instruction [48]. *Learner experiences* point out opportunities for students to access during SSI-based instruction [48]. *Classroom environment* represents the contextual properties of the learning environments required for successful design and experience [48]. *Teacher attributes* refer to characteristics and practices that teachers should take for the successful implementation of SSI-based instruction [48]. Design elements and learner experiences are located at the center of graphic representation to indicate that these as core elements of SSI instruction [48]. Classroom environment and teacher attributes are situated peripherally to demonstrate the role both of these elements play in shaping implementation of design elements and learner experiences [48]. All of these aspects of the framework elements are described in more detail in the following sections.

- *Design Elements*

One of the core aspects of an emergent framework for SSI-based education are design elements [48]. Design elements are divided into two categories inside which are essential design elements and recommended design elements [48]. The first of essential design elements is that the SSI-based instruction will relate to a compelling social issue which related to science [48]. Secondly, the issue should be presented at the beginning of the instruction. It is important to construct learning experiences truly around the issue [48]. Next one, the instruction should engage students to higher-order practices like argumentation, reasoning and decision making [48]. Lastly, a culminating activity should be presented to collect ideas about the issue [48]. This activity can change according to the context but an activity like policy-making includes role play and debate helps to create formalized suggestions [48].



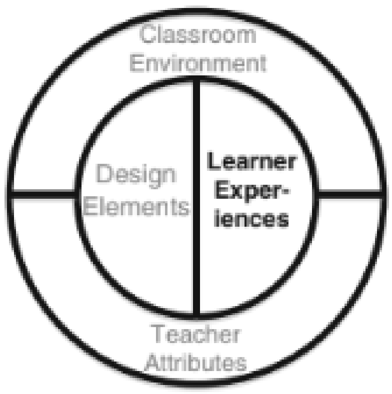
Essential *Design Elements*
1. Build instruction around a compelling issue. 2. Present the issue first. 3. Provide scaffolding for higher-order practices (e.g. argumentation, reasoning and decision-making). 4. Provide a culminating experience.
Recommended*Design Elements*
5. Use media to connect classroom activities to the "real world." 6. Use technology to facilitate student learning experiences.

Figure 2.2 Essential and recommended *design elements* for SSI-based education (taken from [48])

Besides essential design elements, there are two other design elements recommended. Those are useful elements when designing a SSI-based instruction but not necessary [48]. The first one is that using media in classroom activities [48]. It helps to make connection between the learning activities in classroom and ‘real world’. Also, this connection assists to increase students’ interest [48]. The other recommended design element is using technology in class [48]. It could be in different ways but using technology to facilitate students learning experiences fits the nature of the SSI-based instruction [48]. It is because SSI are current and inconstant issues, and so following them is possible with the help of using technology [48].

- *Learner Experiences*

The other core aspect of an emergent framework for SSI-based education is learner experiences. Similarly, to the design elements, it also divides into two categories as essential learning experiences and recommended learning experiences. Learning experiences refer to that students should experience through SSI-based education [48]. The first essential learning experiences are students' engaging in higher-order practices like argumentation, reasoning or decision making [48]. Experiencing these practices is important for students because learning in SSI-based education is possible by negotiating the SSI deeply [48]. Moreover, students should be confronted with the scientific ideas and theories related to the compelling issue they study [48]. Confronting students with the science content may not be enough for learning, so students should collect and/or analyze scientific data related to the issue [48]. In order to reach the data students can use technology. The last essential learner experiences elements is negotiating the social dimensions of the issue [48]. Since SSI are societal and controversial issues, students should have opportunities to explore the social dimensions of the issue like economics and politics [48].



Essential *Learning Experiences*
1. Engage in reasoning, argumentation, decision-making and or position taking. 2. Confront the scientific ideas and theories related to the issue being considered. 3. Collect and/or analyze scientific data related to the issue being considered. 4. Negotiate the social dimensions of the issue being considered.
Recommended *Learning Experiences*
5. Confront the ethical dimensions of the issue being considered. 6. Consider nature of science themes associated with the issue.

Figure 2.3 Essential and recommended *learning experiences* for SSI-based education (taken from [48])

Furthermore, there are two recommended learning experiences which the emergent framework for SSI-based education presents [48]. The first recommended learning experience is related with the last essential learning experience. Negotiating the ethical dimensions of the issue is recommended [48]. Although some authors of the book thought that ethical dimensions should be added to the essential learning experiences, Sadler expressed that exploring some of the social dimensions of SSI is essential for SSI-based education, but explicitly focusing on ethical dimension of the issue may not be necessary [48]. The other recommended learner experience is providing students the opportunity to consider the nature of science (NOS) in the SSI context. It is recommended to increase the quality of SSI-based instruction [48].

- *Classroom Environment*

Classroom environment is one of the two peripheral aspects of an emergent framework for SSI-based education. It represents the features required for successful implementation of the core aspects [48]. Classroom environment and also the other peripheral aspect teacher attributes are required to implement the core aspects effectively [48]. The first expectation from classroom environment is that it should be inviting for student participation. Also, it should set a collaborative and interactive ambiance in which students and teachers feel free to negotiate ideas about the SSI [48]. It is possible with the other classroom environment feature which students and teachers should be respectful to each other [48]. The last feature is that students and teachers feel safe within the environment it is because SSI are controversial in nature and open to opposing ideas [48]. Therefore, negotiating about the issue feeling safely would be more productive [48].

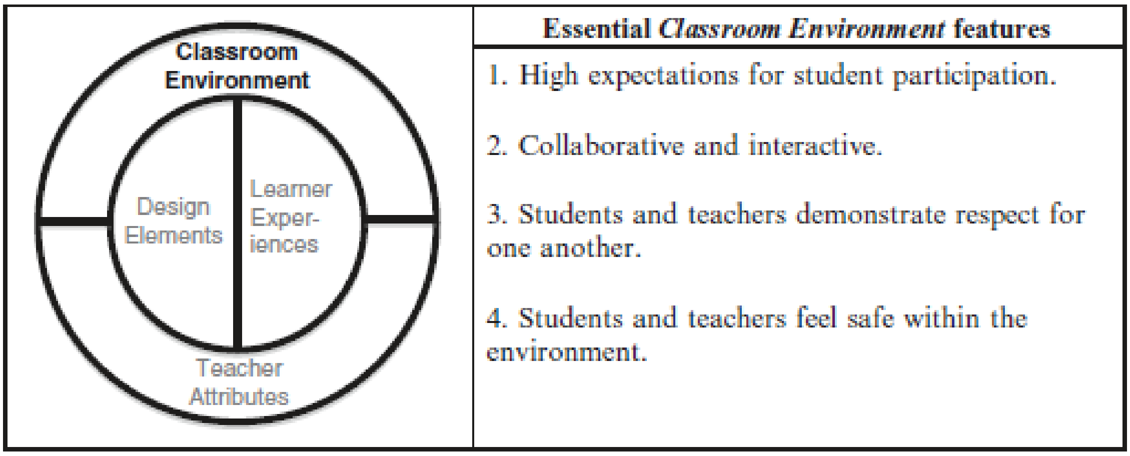
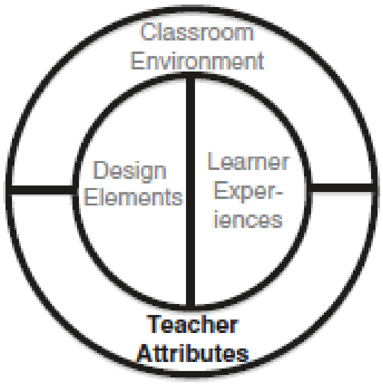


Figure 2.4 Essential *classroom environment* features for supporting SSI-based education (taken from [48])

- *Teacher Attributes*

The final aspect of an emergent framework for SSI-based education is about teachers who implement the SSI-based education. The first and most important characteristic of teachers is that teachers should be knowledgeable about the issue in terms of both science behind the issue and itself of the issue with social considerations [48]. Although it is expected that teacher have enough information about the issue, it is understandable that the teacher could not have all responses about the issue [48]. Therefore, the teacher should be honest about his/her limitations and open to other experts' contributions [48]. In addition, the teacher should be aware of that the SSI-based education requires a class very different to the traditional education [48]. Negotiating about the issue in class can create some uncertainties and the teacher should be willing to deal with these uncertainties in classroom [48]. Lastly, again differently from the traditional classrooms the teacher should not be authority anymore and s/he should be willing to knowledge scaffold for students [48].



Essential *Teacher Attributes*
1. Familiar with issues being considered. a. Knowledgeable about science content related to the issue. b. Aware of the social considerations associated with the issue. 2. Honest about knowledge limitations. 3. Willing to deal with uncertainties in the classroom. 4. Willing to position self as a knowledge contributor rather than sole authority.

Figure 2.5 Essential *teacher attributes* for supporting SSI-based education (taken from [48])

2.1.2 "A Framework for SSI-Based Education" (by [49])

This framework was created by Presley et al. as a result study of examining the Sadler's framework [48] and the research studies in his book [49]. According to Presley et al. [49] the emergent framework for SSI-based education explains key features of teaching and learning in the context of SSI. However, they claimed that the new framework is not a constant model that provides a list of steps to follow. Rather, this framework presents flexible guidelines to use to construct a successful SSI-based instruction [49]. This new framework is similar to the Sadler's [48] framework in many ways in terms of aspects. In addition to the core aspects of design elements and learner experiences, teacher attributes aspect is added to the core aspects. The classroom environment aspect forms the second layer. Also, as a third layer, peripheral influences are added to the framework that of differently from the Sadler's [48] framework.

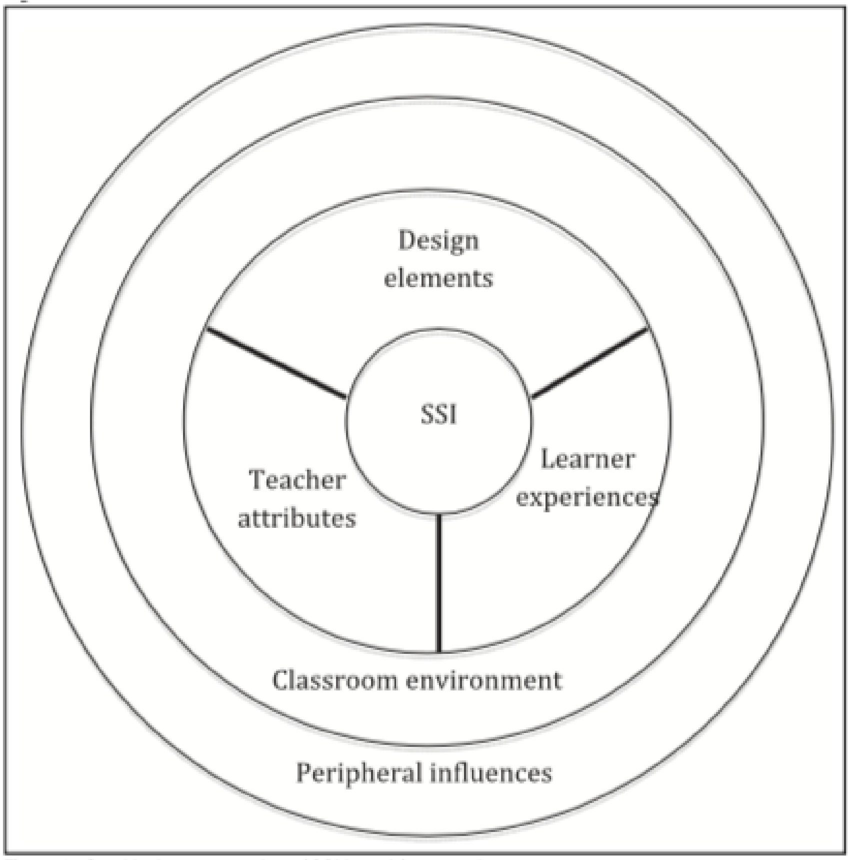


Figure 2.6 "A Framework for SSI-Based Education" (taken from [49])

- *Design Elements*

The word of "essential" replaced with "required" the design elements are exactly the same as the design elements in the emergent framework for SSI-based education [48], [49]. They are divided into two sections as required design elements and recommended design elements. Required design elements are; (1) constructing instruction around a compelling issue, (2) representing the issue at the beginning of the instruction, (3) providing students' opportunity to engage in higher-order practices and (4) providing a culminating activity. The recommended design elements are (1) using media to link classroom activities to the "real world" and (2) using technology to enrich student learning experiences [49].

- *Learner Experiences*

Similarly, to the design elements, the word of "essential" is changed to "required" in learner experiences. The required and recommended learner experiences are exactly the same as learner experiences in the emergent framework for SSI-based education [48]. The required ones are that students should (1) engage in higher-order practices like reasoning, argumentation and decision making, (2) confront scientific ideas and theories behind the issue, (3) collect and/or analyze scientific data related to the issue and (4) discuss about social (economic or politics) dimensions of the issue. The recommended learner experiences which are not necessary but increase the quality of the instruction are (1) confronting students with the ethical dimensions of the issue and (2) placed nature of science themes related with the issue in the instruction [49].

- *Teacher Attributes*

Teacher attributes refer to the characteristics of the teachers who successfully facilitate the SSI-based instruction. Differently from the emergent framework for SSI-based education [48], teacher attributes are placed at the center of the model. It is because successfully implementation of design elements and providing students the learner experiences is possible with the following teacher attributions. The teacher should be (1) familiar with the issue [49]. It means that the teacher should be knowledgeable about the science behind the issue and also aware of the social aspects of the issue [49]. Moreover, the teacher should (2) see himself/herself as a learner and be honest about knowledge limitations [49]. Also, s/he should not see himself/herself as an authority in class; rather position self as a knowledge contributor [49]. Lastly, the teacher should be aware that negotiating an issue in class can create uncertainty and s/he should (3) have willingness to cope with this uncertainty [49].

- *Classroom Environment*

The classroom environment forms the second layer of the SSI framework. It is presented as a layer around the core aspects which design elements, learner experiences and teacher attributes because classroom environment represents the factors that influence the core aspects [49]. Those factors are (1) high expectation for student participation, (2) collaborative and interactive environment, (3) respectful ambience for both teachers and students and (4) feeling safe to share ideas also for both teachers and students [49].

- *Peripheral Influences*

The peripheral influences form the third and outer layer of the SSI framework. This aspect placed around the core aspects which design elements, learner experiences and teacher attributes and also the second layer which classroom environment because it represents the factors that affect all of these aspects [49]. These factors may be from the school, the society and national policies which impact the SSI-based instruction [49]. The key features of this aspect include: (1) Support and encouragement for teachers applying the SSI-based instruction. It means that the school and the region can have significant implications for the implementation of the SSI-based instruction [49]. Teachers often suspect whether they should implement a new instructional strategy or not. Therefore, support from school and district level is essential for teachers' success [49]. However, supporting teachers without materials would not be enough. Therefore, (2) SSI-based materials should be accessible for teachers [49]. It is required for the reasons that teachers may have not expertise to create curriculum material and also time to create a new curriculum material [49]. Moreover, (3) the curriculum should be flexible and makes possible SSI-based instruction for teachers [49]. On the other hand, (4) the local society in which the SSI-based education takes place should be aware of the local issues [49]. In addition, if local society leaders find the local issue controversial, they may pressure teachers or administrators to discourage SSI-based teaching [49]. Therefore, (5) teachers and school staff need to develop strategies to negotiate these concerns [49]. Lastly, (6) curriculum developers and teachers should consider how they are linked to objectives at the state or national level to support the implementation of SSI-based courses in the classroom [49].

2.1.3 "Design of a Socio-Scientific Issue Curriculum Unit" (by [38])

This SSI instructional model is a guide to design for implementation of SSI-based teaching. It was developed by Friedrichsen et al. [38] in order to use this model to easily design science lessons proper to SSI-based instruction.

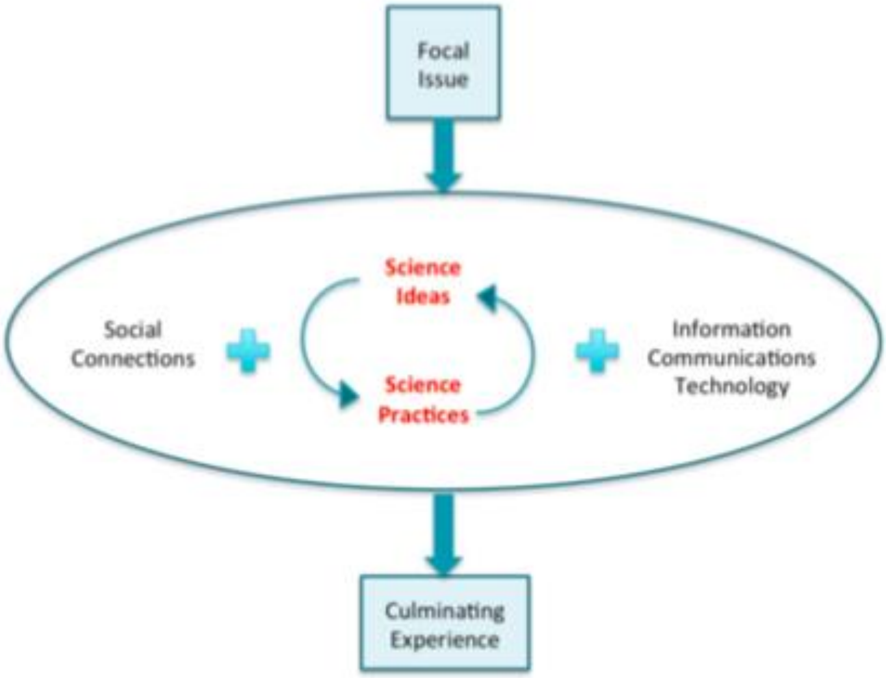


Figure 2.7 The SSI Curriculum Unit Design Model (taken from [38])

Similarly to the previous two models presented above, this model also begins with a focal issue. It means that the SSI-based instruction should start with the compelling issue and students contextualize the followings through the issue. The model introduces three elements that interact as the main component of students' learning experiences: social connections, science ideas and practices, and information and communication technology (ICT). The aim is that students should apply science ideas and practices when they negotiate about the focal issue. Also, students should consider the social connections of the issue and ICT should be integrated to the process. At the end, students should participate in a culminating experience which collect and synthesize their whole experience in the unit [38].

Furthermore, Friedrichsen et al. [38] linked their model with the 5E model (Table 2.1). Both models start with students' engagement to the topic and also, end with a summative activity. However, this linkage between SSI model and 5E model helps to sequence "science ideas and practices" component of the SSI model. The 5E model supports questioning by enabling students to explore the phenomenon of science before scientific explanations are developed. The sequence is opposed to the traditional course approach. In addition, the elaboration step of the 5E model supports a deeper understanding of science ideas and practices by enabling students to apply their knowledge and skills in a new context [38].

Table 2.1 Comparison of SSI and 5E Models (taken from [38])

SSI MODEL	5E MODEL
Focal Issue	Engagement: Engage students with topic and assess students' ideas related to topic
Social connections +science ideas and practices +Information communication Technology	Exploration of phenomenon
	Explanation: Developing a scientific explanation
	Elaboration: Apply scientific explanation in a new context
Culminating Experience	Evaluation

2.1.4 The current Socio-Scientific Issue Teaching and Learning (SSI- TL) Model (by [34])

This model developed by Sadler et al. [34] also has the same theoretical background as the previous models. However, it emphasizes the gaps in the other models and aim to fill these gaps with this new SSI teaching and learning model. It was developed after Sadler et al. [34] examine four design-based research project. Figure 2.8 shows the graphical representation of the model. As can be seen from the model, it has two sections. The first section which is the left side of the figure refers to the learning experiences that students should be provided during a successful SSI-TL. Secondly, the right side indicates the learning objectives that SSI-TL process should reinforce. The learning objectives section is a whole new part that is not in the previous models. Another novelty in this model is that the model is developed proper to the Next Generation Science Standards (NGSS).

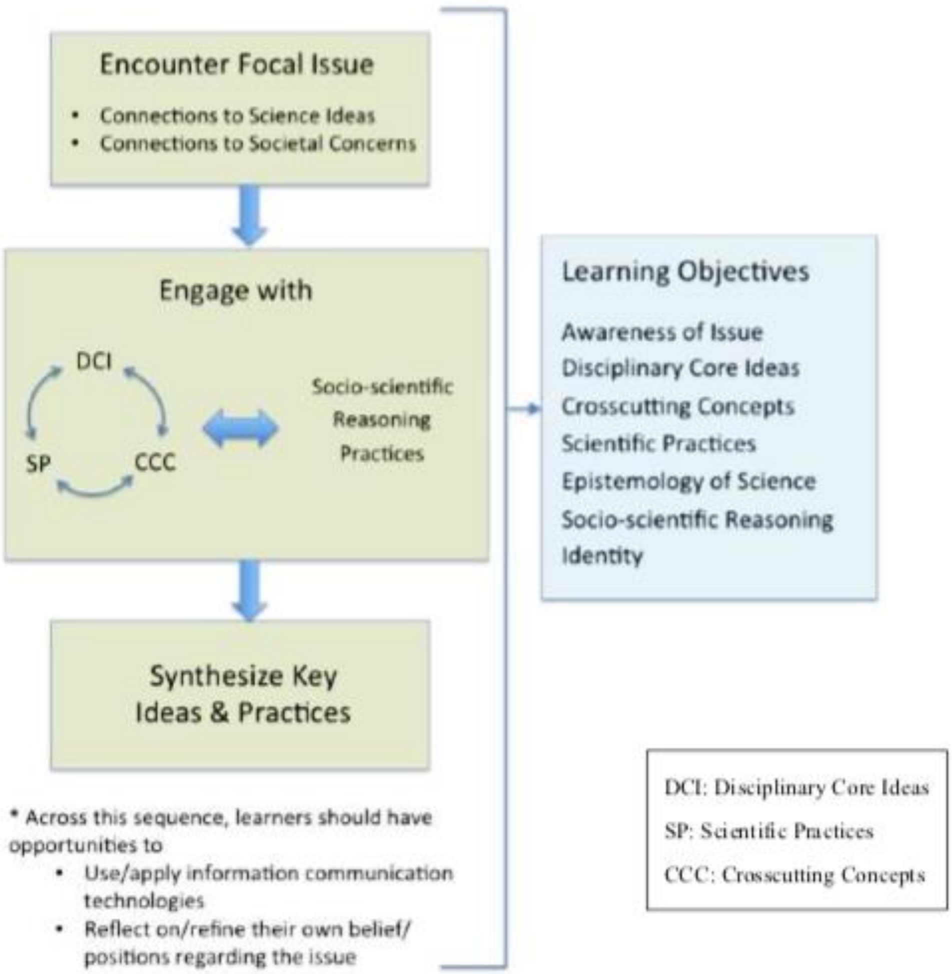


Figure 2.8 The current SSI Teaching and Learning Model developed (taken from [34])

Similarly to the previous models [48], [49] and [38], the SSI-TL sequence starts by presenting the focal issue at the beginning of the unit. When encountering the focal issue, the science idea behind the issue and the social dimensions of the issue is required. The second phase constructs the main teaching and learning experiences. In this phase, properly to the Next Generation Science Standards (NGSS) students engage in three-dimensional science learning along with socio-scientific reasoning practices [50]. The three-dimensional science learning emphasizes disciplinary core ideas (DCI), crosscutting concepts (CCC), and science practices (SP). Disciplinary core ideas refer to the four main discipline areas as;

- physical science,

- life science,
- earth and space sciences
- engineering, technology and applications of science [50].

Then, the crosscutting concepts refer to the patterns used to link different domain of science. The patterns are;

- cause and effect
- scale, proportion, and quantity
- systems and system models
- energy and matter
- structure and function
- stability and change [50].

Lastly, the science practices are;

- asking questions and defining problems
- developing and using models
- planning and carrying out investigations
- analyzing and interpreting data
- using mathematics and computational thinking
- constructing explanations and designing solutions
- engaging in argument from evidence
- obtaining, evaluating and communicating information [50].

In the three-dimensional science learning, disciplinary core ideas, crosscutting concepts and scientific practices are in contact with each other. Also, they are interacted with socio-scientific reasoning (SSR) practices. SSR practices includes the following qualifications; 1) taking into account the complexity of SSI, 2) analyzing issues from multiple perspectives, 3) determining the aspects of the issues subject to ongoing inquiry, 4) using skepticism in the analysis of potentially biased information, and 5) investigating how science can contribute to issues and limitations of science [34]. The SSR practices are placed the model instead social dimensions of issues because SSR required detailed and depth learning experience. The third and last phase is synthesizing key ideas and practices are similar to the culminating experience in the previous model [38]. In this phase students reflect the issue on their own perspectives by interacting with science ideas (including DCI and CCC) and SSR practices without presenting definite solutions. It is because SSI are open-ended problems and definite solutions are improper to the nature of SSI [34].

Moreover, the SSI-TL model includes two additional elements which are not positioned in sequence. It is because these elements should be thought across the three phases in sequence. The first one, similarly to the previous models but not given as a core element, students should have the opportunity to use information and communication technologies (ICT). The second element is that students should have the opportunity to reflect their ideas and positions towards the focal issue. This element is similar to the culminating activity in other models. In this SSI-TL it is not given as a core element because in some studies (e.g. [38]) students refine their ideas towards the issue consistently, so there may not be need to a culminating activity at the end. Therefore, the second element is a recommendation not a core aspect.

The second section of the model which is the right side of the Figure 2.8 indicates the learning objectives. This section is not given in previous models. Learning objectives has seven categories as;

- awareness of issue
- disciplinary core ideas
- crosscutting concepts
- scientific practices
- epistemology of science
- socio-scientific reasoning
- identity [34].

Awareness of issue, disciplinary core ides, crosscutting concepts, scientific practices and socio-scientific reasoning are explained in detail in previous part. Stating them as learning objectives means to accomplish them. Epistemology of science refers nature of science (NOS) mostly. It does not mean that the SSI-TL states whole steps of NOS but in process students learn about it. Lastly, identity means that whether or not students positioned themselves in the light of the new ideas in a conversation [34].

In this thesis, the white butterfly unit is developed proper to the SSI-TL model by Sadler et al. [34]. The focal issue of the unit is “white butterfly” which is a kind of pest told in the following parts. In addition, while developing this unit, model-based learning approach has also been oriented due to its suitability to the issue. Model-based learning is preferred to teach ecosystem issue because learning ecosystems requires representing the relationships in the ecosystem clearly and also the representations should be open to change and develop when learning occurs. Therefore, before discussing white butterfly issue, the model-based learning approach is explained briefly in the following.

2.2 Model-Based Learning (MbL)

Modeling is a fundamental practice in science and also is a central part of scientific literacy [23]. And, model-based learning (MbL) is a learning and teaching approach in science education supports students’ learning via students’ models represent physical phenomena [51]. There is a great amount of study about model-based learning in different perspectives such as cognitive, metacognitive, social, material, and epistemological [51]. In this part, I only give some of the teaching and learning approach studies which guide the modeling sessions of the unit of this thesis. The following studies and I have a consensus on that learning process is proper to the constructivist learning theory [23], [25], [26], [27], [52], [53]. It means learning arises from the interaction between the experiences and ideas and these can be externalized by construction of models and transferred to others. Each of us produces our own mental models by linking new information to the previous information we use to make sense of our experience. For this reason, learning is the process of adjusting our mental models to adapt to new experiences [23]. As I said before there are many studies on model-based learning but there is a few study on how model-based learning is used effectively through instruction [51], [52]. Therefore, Clement [52] developed a basic theoretical framework for model based learning. In this framework, he uses these concepts; preconceptions, natural reasoning skills, intermediate models, learning processes, target model and expert consensus model.

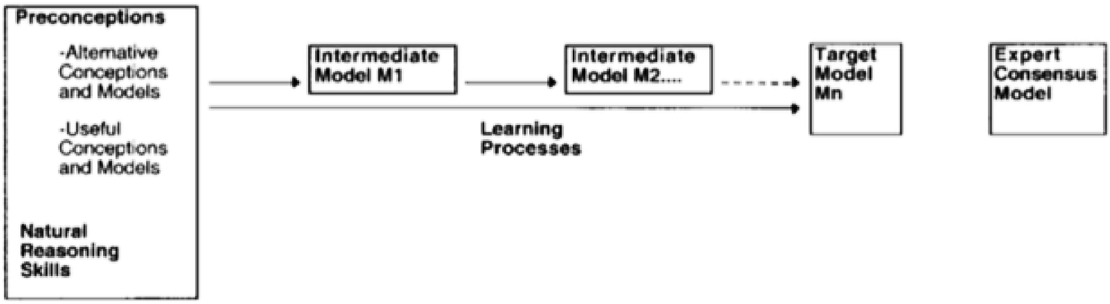


Figure 2.9 “A basic theoretical framework for model based learning” (taken from [52])

This framework uses learners’ preconceptions and natural reasoning skills to construct an intermediate model. Then, through a learning process students construct new intermediate models until they reach the target model or desired knowledge [52].

Although, this framework [52] gives an idea how models shape in learning process, many science teachers need to be supported to use modeling effectively in class [23]. Therefore Schwarz et al. [23] generate a learning progression for scientific modeling. The aim of the learning progression is making modeling accessible and meaningful for learners [23].

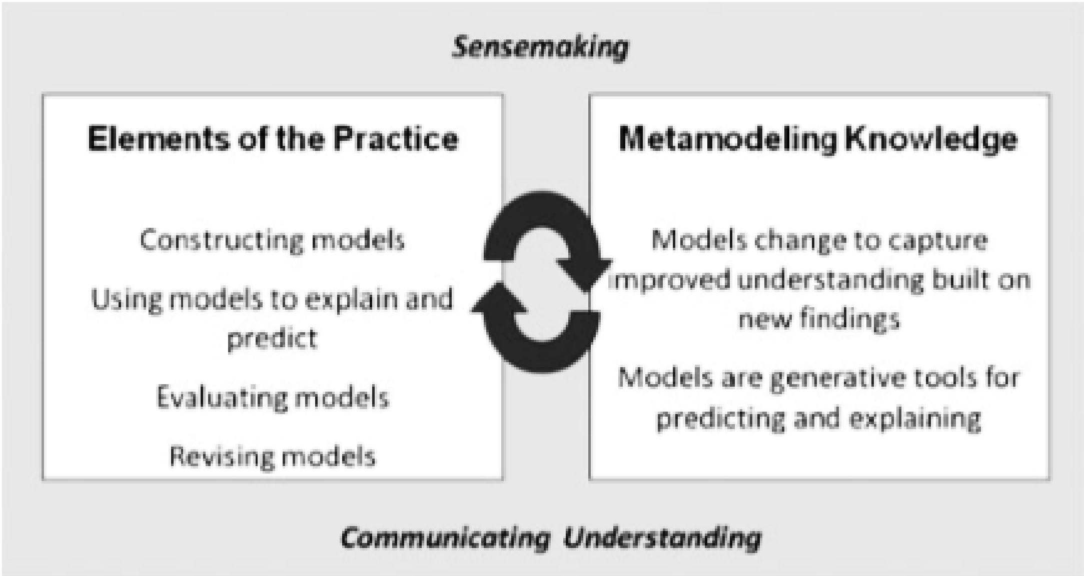


Figure 2.10 Interaction of the elements of the practice and metamodeling knowledge (taken from [23])

According to Schwarz et al. [23], modeling is a practice which as an interaction of the elements of the practice and metamodeling knowledge (Figure 2.10). The elements of the practice are;

- Students construct an initial model according to their pre-knowledge to illustrate, explain, or predict phenomena.
- Students use this model to illustrate, explain, and predict phenomena.
- Students evaluate the model whether or not the model is sufficient to represent and explain patterns in phenomena, and predict new phenomena.
- Students revise the model to increase its explanatory and predictive power, by using additional evidence or aspects of a phenomenon [23].

On the other side, metamodeling knowledge provides students a guide to engage in the practices. If students are aware of that models change to catch improved understanding based on new findings and models are producing tools for predicting and explaining, they benefit from the modeling process more [23].

Similarly to the [52] and [23], Zangori et al. [26] use model-based learning. They use model-based learning for students' sense-making and engagement in model-based reasoning. Also, they adopted model-based learning to SSI teaching and learning and named their adaptation as model-oriented SSI teaching and learning.

In their approach, students use their models to negotiate about socially relevant issues. Students use Schwarz et al. [23] modeling cycle towards SSI. They develop their initial models to reflect their pre-knowledge and experiences about this issue. They use their models to make sense of their understanding about the issue at that time. As learning process continues, students' prior knowledge is challenged and so students evaluate their models. Next, they revise the models to reflect their new understandings. Learning takes place through the dialogue between the student and the model, because the student uses, evaluates and revises the model continuously in the light of new information [26].

Zangori et al.[53], taking their work a step further and developed a new approach to model-oriented SSI teaching and learning and presented this approach as Model-Oriented Issue-Based (MOIB) teaching. Model-oriented issue-based (MOIB) teaching integrates SSI and model-based reasoning and teaching [53]. The reason behind this integration was the great expectation of education programs. As well as MoNE, NGSS emphasize science and engineering practices to support students to understand how scientific knowledge is developed [12], [50]. Moreover, science and engineering practices carry importance for students' development of scientific reasoning skills. However, as Sadler et al. [54] pointed out SSI instruction has not been associated with these practices adequately whereas SSI instruction focused more to the interaction between science and society. However, Zangori et al. [26] claimed students' ability of scientific practices like to develop, process and conclude their science ideas assist their ability to comprehend the interactions between science and society. Therefore, Zangori et al. [26] theorized that science and engineering practices are essentials of SSI instruction. Then, they construct framework for MOIB teaching on SSI instruction and model-based teaching.

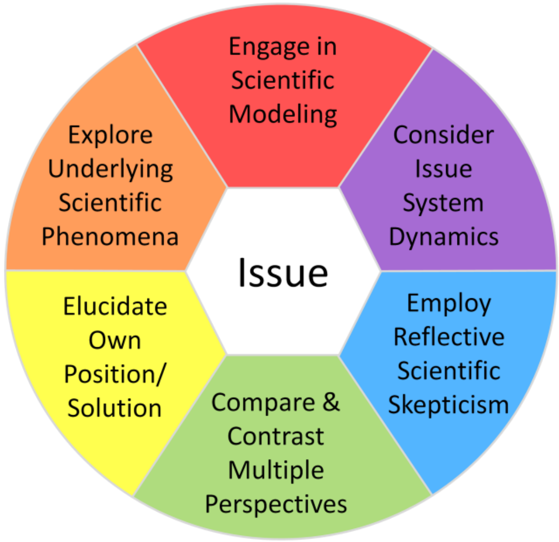


Figure 2.11 Model-Oriented Issue-Based (MOIB) Teaching Model (taken from [55])

According to MOIB teaching model (Figure 2.11), students engage in modeling with a focal SSI to make sense about the main science phenomenon needed to explain the issue. Students examine the science phenomenon and go through the modeling steps to develop, use, evaluate and revise their models in order to comprehend the science behind the focal SSI. This process makes students able to apply their science knowledge to the issue. They can investigate the complexities, perspectives and factors of the issue. The integration of model-based reasoning and SSI-based instruction allows students to conduct meaningful and science relevant perspectives towards real world issues [25], [53].

2.3 "White Butterfly" Issue

The focal compelling socio-scientific issue in this thesis is the white butterfly issue in üuzce ecosystem. "White Butterfly", the Latin name "Hyphantria Cunea Drury", is a pest that damages trees as well as many agricultural crops [56], [57]. This species, known to be of North American origin, has spread over time to Europe and Asia. The white butterfly was seen for the first time in 1975 in Turkey; Edirne, Istanbul (Çatalca, Silivri), and Tekirdağ. Today, it is spread in Marmara, the Black Sea, and North Aegean regions. The white butterfly has been seen in the Central Black Sea Region since 1982 and has become an important pest of almost all fruit trees, especially the large hazelnut fields [56], [57]. “White Butterfly” has been observed in Düzce for about 15 years [58].

The number of progeny of this species varies according to the temperature of the region and the length of the day. Although Turkey has two offspring throughout the year, it can provide 4 progeny in some southern US states [56], [57]. In Düzce, the white butterfly was seen in two periods a year, in May-June and at the end of August. However, in the last two years probably due to acceleration in climate change in Düzce ecosystem three offspring was observed [58], [59]. Climate is a crucial factor for white butterfly as well as all other species because the living conditions of this species depend on humidity and temperature critically. The white butterfly develops better at 70-80% humidity and at temperatures between 22-25 ° C [56], [57]. Possible cause of the third offspring was that April and September are warmer than seasonal normal; white butterfly has begun to give its first offspring in April and the weather is not too cold when entering September, the white butterflies have the opportunity to give one more offspring [58].

The main color of the white butterfly is white, and some male and female individuals have black spots on the upper wings. Men with black wings on their upper wings are usually seen in spring, while white wings without spot are seen in summer (Figure 2.12). The adult form is in the form of a butterfly and the wingspan is about 25-30 mm. The average body length is 11 mm in males and 15 mm in females. Males have antennas covered with dirty white, thin and short hair and females have white antennas (Figure 2.12) [56], [57].

Figure 2.12 (A) Male white butterfly in spring, (B) male white butterfly in summer and (C) female white butterfly (taken from [56], [57])

White butterflies leave their cream-colored eggs as a cluster and stick them with a liquid, usually on the lower surface of the leaf. Egg clusters contain 400-2500 eggs depending on the plant to which they are fed [56].

Figure 2.13 Egg clusters of white butterfly (taken from [56])

The larva is about 1-2 mm when it is newly hatched and its color is clearer (Figure 2.14). Mature larvae are very hairy. The color of the larva may vary depending on the plant and the season. While the color is lighter in the spring, the color darkens towards the autumn (Figure 2.14) [56], [57].

Figure 2.14 (A) A newly hatched larva, (B) larva in autumn and (C) larva in spring (taken from [56], [57])

White butterfly pupa is dark brown in the mummy pupa type. There are 12 typical protrusions on the rear end portion of the pupa. The length of it is 10-15 mm. Female pupae are larger and heavier than male pupae. White butterfly spends the winter as a pupa. Those pupae may be in the damaged trees which meet with the soil, in trees' shells, in trees' cavities, in roof fringes of buildings, in 5 - 6 cm below the soil and under the rocks. They become pupae individually or collectively. The pupae of the first offspring mature in 10-13 days. However, pupae of the second offspring spend winter in pupae [56], [58], [57].

Figure 2.15 White butterfly pupa (taken from [56])

White butterfly is one of the world's most polyphagia (more plant-fed) harmful insects. The white butterfly feeds on more than 600 plants, including fruit trees, forest, and ornamental plants and some herbaceous plants. Its most preferred host plants are mulberry and maple. It is also very common in other plants such as apple, pear, plum, cherry, quince, walnut, alder, willow, oak, poplar. In Turkey and Georgia, the white butterfly is a major pest of hazelnut fields [56], [58]. As the number of larvae is less in the first generation, the larvae in the second generation constitute the main damage. Young larvae eat only the parenchyma tissue of the leaves to cause the leaf to lose its green color and become brown. In the second and third stages, the larvae consume the secondary veins of the leaves with the epidermis and mesophyll layers. Then the growing larvae begin to eat between the vessels. In this period, the damaged leaves seem like tulle. From the last larval period, caterpillars can eat the whole leaf except the main vein and stem. Trees that have been damaged since September can be completely leafless. In the epidemic years, mulberry and maple trees can lose their leaves even in June [56].

Figure 2.16 Damages of white butterfly to the leaves (taken from [56], [57])

There are many ways to struggle with the white butterfly as mechanic, biological or chemical. The methods of mechanical struggling with the white butterfly vary according to the stage of the white butterfly [56], [59], [57].

- Destruction of the pupae - Because the pupae are hidden in building cavities or under the ground, adhesive corrugated cardboards are placed on the paths to the plants and they are prevented from reaching the plants by stuck them. Periodically renewed cartons are collected and destroyed [59], [57].
- Destruction of larvae- Larvae colonies must be collected from non-very high trees and hazelnut fields. Farmers need to cut the leaves that have been laid on the eggs by constantly checking the leaves. This method is very effective when done on time. Telescopic pruning shears can be used for high trees [59], [57].
- Destruction of butterflies - By using attractive visual pitfalls or electrical devices by farmers, the butterflies are collected at a certain point and the butterflies are destroyed after collection [59], [57].

Another way of struggling with the white butterfly is biological struggling. It could be in different ways also [59], [57]. Two of them are:

- Protection of natural enemies- The white butterfly has many natural enemies. Hunter bees, spiders, birds in addition to different parasites and hunter insects are fed with the white butterfly. It is possible to reduce the population of white butterflies by protecting the natural enemies and increasing the number of them [59], [57].
- Biological control with bacteria- Bacterial preparation obtained from Bacillus thuringiensis (Bt) bacteria is very effective against white butterfly larvae, especially during young larval stages. Bacteria cause the butterflies to die. Instead of spraying the whole plant, only the branches with colonies should be sprayed [59], [57].

Lastly, chemical struggling ways are used [59], [57]. It should be avoided unless necessary. However, when it is essential, it is important to detect caterpillar colonies as early as possible and to treat trees. When the white butterfly comes to the butterfly stage, the spraying is not effective because the butterfly fluctuates. In addition, damage to trees is already provided in the caterpillar period. Therefore, chemicals should be applied in June (1st period), in August (2nd period), in September (3rd period), when larvae begin to weave their nets out of the epidermis and begin to weave their nets (in the second and third periods) or when all the eggs in the egg clusters are opened [59], [57].

White butterfly is an issue for Düzce because hazelnut production is one of the main income sources of the province and in Düzce white butterfly is a big problem for the amount of harvest. In addition, white butterflies are so widespread that they not only harm hazelnut trees, they wrap around the ornamental trees and gardens on the roadside and even enter the houses. Therefore, people usually give effort to overcome white butterfly problem by individually and through provincial directorate of agriculture. For this reason, it is possible to see news about the white butterfly in local news (e.g. [60], [61], [62]). Furthermore, in Düzce there are so many factories in the city. Many of those could be easily seen when going from one place to another. Also, the air pollution in the city caused by those factories could be sensed. The lifecycle of white butterfly, reasons of the observing of the third offspring of white butterfly, rapid climate change in Düzce ecosystem, effects of factories or air pollution to the climate change and struggling ways with white butterfly are important points to explain ecosystem issue and biodiversity. All of these points make white butterfly issue a focal compelling issue for a socio-scientific issue based instruction at schools in Düzce. Therefore, in this study white butterfly issue is used as focal compelling issue with the economics, social and political dimensions.

2.4 Framework of the "White Butterfly" Unit

The white butterfly unit was designed proper to the SSI-based instruction model developed by Sadler et al. [34]. Also, in designing process, model based learning approach [26] was used. According to SSI-based instruction model introducing the first lesson by asking students about the focal compelling issue; which is the white butterfly issue in this study is required. Also, a driving question about the issue which makes students explore the science concepts about the issue is used to collect all lessons in the unit around the focal compelling issue. In this unit the question is "How might the population change in "white butterfly" affect the local ecosystems?" Science concepts needed to explore the driving question are;

- Ecological Interactions
- Energy Flow
- Global Warming
- Climate Change
- Air Pollution

Moreover, social ideas and concerns needed to explore the driving question are;

- Economics
- Politics
- Social

Since white butterfly unit is related to ecosystem and the concepts as ecological interactions, global warming, climate change, energy flow, biodiversity, air pollution, lifecycle of the "white butterfly", the disciplinary core ideas is determined as “Life Science” mentioned in NGSS. Also, the disciplinary core ideas are equivalent with “Living Things and Life” in STP [35]. The crosscutting concept of the unit is “Cause and Effect”. The scientific practices which students engaged through the unit are;

- developing and using models
- analyzing and interpreting data
- constructing explanations and designing solutions
- engaging in argument from evidence
- obtaining, evaluating and communicating information [50].

For this unit, unit-level performance expectations are;

- Define ecosystem, species, habitat and population concepts and also give examples to these concepts (MoNE, 7.5.1.1) [35]
- Question the importance of biodiversity for natural life (MoNE, 7.5.2.1) [35]
- Discuss the threats to biodiversity based on research data and produce solution recommendations (MoNE, 7.5.2.2) [35]
- Organize information about white butterflies and local ecosystem (hazelnuts, air pollution, etc.)
- Develop and use multiple models to explain the interaction between population change in “white butterfly” and local ecosystem
- Develop explanations to which factors may influence ecosystems in what way
- Use and interpret graphics, charts and statistics to find relationship between weather, air pollution, hazelnut harvest and population growth of “white butterfly”
- Learn, discuss and anticipate methods (such as preventing air pollution) to deal with “white butterfly”.
- Discuss the effects of interventions on ecosystems, starting with the methods and effects of “white butterfly” struggling.

Through the unit, the disciplinary core idea, crosscutting concepts and scientific practices are in a cycle and always interacted with each other. In order to link these three-dimensional DCI-CCC-SP cycle with socio-scientific reasoning practices students are engaged in modeling. Students are expected to make three models through the unit as a response to the driving question. They develop their first model after the focal issue presented and they informed about the issue. They use their models to explain the relation between the white butterfly population and the ecosystem. After they gain knowledge about the issue, they evaluate their models if the models explain the new patterns or not (for example the relation between whether graphics and population growth of white butterfly). Then they revise their models. This cycle of developing, using, evaluating and revising models is repeated one more time so each student produce three models. At the end students negotiate about how to deal with the "white butterfly" problem in a holistic context. Each student group represents a group from the society like farmers, agriculture officials. It is the culminating activity of the unit which students synthesize their experiences via decision making and policy making.

According to SSI-based instruction model [34], the right side represents the learning objectives as awareness of the issue, disciplinary core ideas, crosscutting concepts, scientific practices, socio-scientific reasoning practices, epistemology in science and identity. Awareness of the issue is accomplished by presenting the issue with local news and also school way activity. How the disciplinary core idea as life science, the crosscutting concept as cause and effect and scientific practices such as developing and using models and socio-scientific reasoning practices are given is stated above. Epistemology in science is discussed with the nature of science (NOS) aspects of first, science is empirically based and second, science is under social and cultural influence. The final objective identity is accomplished with the five open-ended question asked at the "Unit Test". Students state their positions towards the issue by answering those questions. Unit assessments are made with students' models- model based explanations and MoNE Objective Comprehension Test [36] with five open-ended questions at the end of the unit.

3
Methodology

3.1 Method

The aim of this thesis is to investigate 7th grade students' developments of model-based explanations when they study on modeling oriented SSI-based curriculum unit. Design-based research (DBR) method is adopted for the thesis in order to address the research question. The research question is

How do 7th grade students' model-based explanations change through SSI-based instruction?

For this purpose, a modeling oriented SSI-based curriculum unit was developed according to the SSI-based instruction model by Sadler et al. [34] . Also, in designing process, model based learning approach [26] was used. The unit was prepared according to the objectives of the *"Human and Environmental Relations/ Living Things and Life"* unit in STP [36] followed by the 7th grade students in the implementation period. Therefore, the unit developed in this thesis was applied to the 7th grade students who study at a public middle school. At the end of the unit, models generated by students and models' written explanations about the main question of the unit were collected. Also, MoNE Objective Comprehension Test [36] was applied at the end of the unit. Participants, instruction sequence and data collection process are described in detail in the following section.

3.2 Research Method and Paradigm

In this thesis, it is aimed to examine the improvements in students' model based when they study on SSI-based curriculum unit. For this purpose, DBR method is followed. Although the research is seem similar to the experimental research in terms of design and similar to the action research in terms of aim, the design based research approach is different from both of them. This study, appropriately to the DBR, is open to change in the implementation process unlike experimental research [63], [64]. For example, the teacher added different activities to the 2nd lesson. On the other hand, DBR differs from action research with two main points. First, in action research the teacher designs research to solve the problem which s/he determined. Secondly, aim of the action research is to solve the problem that is special for her/his classroom or students. However, DBR have further theoretical goals than exclusively solving a special problem [63], [64], [65].

In the present study, DBR is adopted to the study because the implementation process should be open to change for the benefits of the students. It means if the study would be an experimental design, different activities about ecosystem terminology could not be added to the unit after the first part of the 2nd lesson. As stated before, additional activities used to teach ecosystem terminology after the teacher's feedback at the end of the lesson. If we had not opportunity to add these activities, students would have difficulties to continue to learn because of incomplete terminology.

On the other hand, the present study followed DBR, was not an action research because it did not aimed to solve a problem of teaching ecosystem unit. It aimed to develop a well-designed and innovative curriculum unit teaching ecosystem issue in a social context.

Paradigm of the study, as well as the researcher, is constructivism. It means that there is no single truth and the truth is shaped according to the perspective of the person. Also, in constructivism it is accepted that knowledge is constructed on the basis of personal experiences [66]. Moreover, the assistant learning approach of this thesis is Model-Based Learning and as mentioned in the *2.2 Model-Based Learning* part, model-based learning roots from constructivist learning theory.

Proper to the constructivist learning theory, lessons' starting point was preconceptions of the students. For example, the first lesson was started by showing white butterfly photos to the students and asked them what they are. In this way students started to tell their experiences and ideas, or knowledge about white butterfly. Moreover, students develop their first models by answering the driving question and those models represented preconceptions and experiences of the students. Those first models were used by students to make sense of their understanding and develop new models proper to their increased knowledge about the issue. Moreover, students' models or explanations were not labeled as true or false, and their developments were examined individually.

3.3 Participants

The unit developed for this thesis was applied to twenty one 7th grade students of a public middle school in Düzce. For unit implementation, 7th grade students were studied because of the reason that was the unit was prepared according to the objectives of the *"Human and Environmental Relations/ Living Things and Life"* unit in STP [35] followed by the 7th grade students in the implementation period.

The school was chosen according to the two criteria. First, the science teacher of the school was important for the implementation process. Although the teacher factor was explained deeply in the section of *3.6 Classroom Environment and Teacher Attribution*, attention was paid to work with a teacher who is mastered in his/her area and aware of the SSI . The second criterion was location of the school because being in trees was an advantage to have a chance to see "white butterfly" in daily life. There were two schools which were appropriate to those criteria but one of the teachers could not complete the unit because of his health problems and so the participant group was bounded one school and twenty one students. As a result, it can be said that purposeful sampling was used when participations of the study were decided.

The students' distribution in gender was not a factor in this study but fifteen female and six male students created participant group. All of the students were living in Düzce since they were born. Some of have hazelnut garden and some of the students' parents worked in hazelnut garden. Therefore, they were familiar with the local ecosystem and the "white butterfly" problem.

3.4 Instruction Sequence of the Unit

The modeling-centered SSI based curriculum unit was prepared according to the objectives of the *"Human and Environmental Relations/ Living Things and Life"* unit in STP [35] followed by the 7th grade students in the implementation period. It was designed for eight lessons. Each lesson plan took times 40 to 120 minutes. The minimum time limited by 40 minutes because in Turkey one lesson hour takes 40 minutes. In total, eight lesson plans took 600 minutes or 15 lesson hours. Therefore, it took four weeks to complete the unit at school. (The outline of the unit is presented in Appendix A)

Driving question of the unit was *"How might the population change in "white butterfly" affect the local ecosystems?"*. Major themes for the unit were ecological interactions, global warming, climate change, energy flow, biodiversity, air pollution, lifecycle of the "white butterfly". Each lesson those themes were supported with activities included actual local news, brochures from the directorate of agriculture, weather graphics, air pollution charts, population growth chart of "white butterfly", hazelnut harvest statistics, etc. Scientific practices were placed in the unit were scientific modeling and argumentation. Three modeling sessions and one argumentation activity were made throughout the unit. Argumentation activity was designed as a culminating activity at the end of the unit.

For this unit, unit-level performance expectations are;

- Define ecosystem, species, and habitat and population concepts and also give examples to these concepts (MoNE, 7.5.1.1)
- Question the importance of biodiversity for natural life (MoNE, 7.5.2.1)
- Discuss the threats to biodiversity based on research data and produce solution recommendations (MoNE, 7.5.2.2)
- Organize information about white butterflies and local ecosystem (hazelnuts, air pollution, etc.).
- Develop and use multiple models to explain the interaction between population change in "white butterfly" and local ecosystem
- Develop explanations to which factors may influence ecosystems in what way
- Use and interpret graphics, charts and statistics to find relationship between weather, air pollution, hazelnut harvest and population growth of "white butterfly"
- Learn, discuss and anticipate methods (such as preventing air pollution) to deal with "white butterfly".

- Discuss the effects of interventions on ecosystems, starting with the methods and effects of "white butterfly" struggling.

Unit assessments are made with students' models- model based explanations and MoNE Objective Comprehension Test (Unit Test) at the end of the unit. There are three modeling sessions through the unit.

In Table 3.1, the lesson sequence is listed. The first column of the table shows the lesson number and time it takes and the other columns are for the lesson focus, learner objectives and activities in the lesson respectively. (Detailed information about the lesson plans is presented in Appendix B)

Table 3.1 Lesson sequence of the white butterfly unit

Lesson (time)	Lesson Focus	Learner Objectives	Activity
1 (40 min)	Presenting the SSI and sharing preliminary information about "white butterfly"	Students will be familiar with "white butterfly" and local ecosystem.	News display Photo display Question-Answer
2 (80 min)	What is ecosystem? Concepts about ecosystem	Students will learn ecosystem, species, habitat and population concepts and also will be able to make connections between these concepts.	School Way Activity Discovery of various ecosystems
3 (80 min)	"white butterfly"	Students will have detailed information about the "white butterfly" and will make predictions about the ecosystem they live in.	Lifecycle of "white butterfly" Field trip to hazelnut garden (if in season) 1st modeling
4 (120 min)	Factors that affect the local ecosystem	Students will explain which factors may influence "white butterfly" ecosystems in what way.	Weather graphics, air pollution charts, population growth chart of "white butterfly", hazelnut harvest statistics, etc. 2nd modeling
5 (80 min)	Struggle with "white butterfly"	Students will argue about how to struggle with "white butterfly" in the light of the information of struggle ways as chemical, biological or mechanic. Or; preventing air pollution	Invited speaker (to talk about the struggle ways) Argumentation
6 (80 min)	Biodiversity	Students will argue about how interventions to the environment affect the ecosystems based on struggle with "white butterfly" and so realize the biodiversity	Argumentation 3rd modeling
7 (80 min)	End-of-Unit Classroom Activity	Students will discuss and make decisions about how to deal with the "white butterfly" problem in a holistic context	Decision Making
8 (40 min)	Assessment	Objective Comprehension Evaluation	Unit Test

The SSI unit designed proper to SSI instructional framework which was developed by Sadler et al. [34]. Therefore, the unit was started a lesson which the SSI presented. In the first lesson, local news about “white butterfly” was used to introduce the SSI. Then, the lesson was continued with “white butterfly” photos to organize students’ preliminary information about “white butterfly” and local ecosystem (hazelnuts, air pollution, etc.).

The lessons were continued a school way activity which have been designed by the author to teach concepts about ecosystem. After students learned the main terms, to consolidate the terms students worked on different ecosystems.

In the third lesson, students got detailed information about the “white butterfly” through lifecycle of “white butterfly” brochure prepared by the Ministry of Agriculture and “white butterfly” presentation. Students made their first modeling in this lesson to the question of “How might the population change in “white butterfly” affect the local ecosystems?” After the model drawings, students described the relationships in the drawings they have made on another sheet.

In the fourth lesson, which was a bit longer than other lessons, students worked on weather graphics, air pollution charts, population growth chart of “white butterfly” and hazelnut harvest statistics to explore factors that affect the local ecosystem. This lesson was important because students made inferences about the interactions in the local ecosystem by working on real statistical data. Then, students were faced the question of “How might the population change in “white butterfly” affect the local ecosystems?” again and made the second modeling according to their inferences. After the model drawings, students described the relationships in the drawings they have made on another sheet.

In the next lesson, although an official from the ministry of agriculture had been invited to present how to struggle with “white butterfly”, his time did not match with lesson hours so the presentation prepared by Düzce Provincial Directorate of Agriculture was made to students by the teacher. After students learnt struggle ways as chemical, biological or mechanic, local news about struggle ways were distributed and also discussed. During the discussion session, in addition to the methods of struggle against “white butterfly” it was expected that students offer suggestions for preventing the population increase, of “white butterfly” by taking into consideration the living conditions of the “white butterfly”.

The sixth lesson was designed as a discussion lesson which students argued about how interventions to the environment affect the ecosystems based on struggle with “white butterfly” by guiding of the teacher. It was discussed how interventions that only target one living in ecosystems affect other living things by considering the “white butterfly” and hazelnut example. In this context, the importance of biodiversity was emphasized by considering other ecosystems. After discussions, students were asked to make the third, by means the last model to the question of “How might the population change in “white butterfly” affect the local ecosystems?” It was expected that the model include the causes and possible consequences of the increase in the number of “white butterfly”, taking into consideration the factors influenced by the life cycle of the “white butterfly”. After the model drawings, students described the relationships in the drawings they have made on another sheet.

The next lesson was designed as an end-of-unit classroom decision making activity. It was inspired from policy making activities. In that activity, students were made groups as farmer, citizen, agriculture engineer, ministry of agriculture official, non-governmental organization member and negotiated about how they should struggle with the white butterfly problem. This lesson was observed by researcher in order to have idea about students’ understandings more.

In the last lesson, unit assessment was done with a unit test, namely Objective Comprehension Evaluation Test, taken from the MoNE website and some open-ended questions about the lesson before. This Objective Comprehension Evaluation Tests were published for each unit as a nationwide assessment tool. Those tests generally consists of 12-36 multiple choice questions. For the “Human and Environmental Relations/ Living Things and Life” unit, the published test was included 12 questions according to unit goals.

3.5 The process of Unit Design

When I was studying on graduate schools at Istanbul, I moved to Düzce due to work, in April. After I started to live in Düzce, the first thing catch my attention was an insect which was white butterfly. Firstly, I saw it in the garden of the university when I waited for the bus. There were many caterpillars with white fur around trees and even some of them felt on my bag. Then, I took a photo of it and after the day I asked questions to staff who work in the same faculty. After I learnt its name as “white butterfly”, I read some news about it. When I was starting to my thesis, the white butterfly issue was on my mind.

I started to design this unit by deciding if the white butterfly issue is a socio-scientific issue or not. In order to answer this question, the “Issue Selection Guide” [67] helped me too much. According to the guide, first I read much news at local newspapers deeply and tried to understand how white butterfly affects society. The most said problem about the white butterfly at news was that increasing in white butterfly population causes to decrease in the harvest amount of hazelnut. Additionally, people try different ways to struggle with white butterfly but they cannot be successful at a satisfactory level. After this basic information about the white butterfly, I decide that white butterfly and its relation with ecosystem is an issue for Düzce. Then, I reviewed literature for scientific background of white butterfly. I learned "Hyphantria Cunea Drury" is the Latin name of this insect. Although there are many articles about "Hyphantria Cunea Drury", none of them explain its situation in daily life. In order to learn real world side of the white butterfly problem and ask questions about the complex interactions of it I made an appointment with Düzce Provincial Directorate of Agriculture and Forestry. I met with head of this directorate, I asked him what white butterfly is, how it damage plants, what its relation with hazelnut harvest, when the white butterfly become problem for Düzce, what Düzce Provincial Directorate of Agriculture and Forestry do for this problem, how much it costs, what people can do to makeover this problem, etc.. I want to thank to head of Düzce Provincial Directorate of Agriculture and Forestry Harun KABAOĞLU, he spends more than two hours to answer my questions and also he gave me the presentation that he used in seminars about white butterfly. After I collected enough data about white butterfly issue, I shared them with my adviser. We negotiate about this issue with all sides and he also confirmed that issue as focal compelling issue of the unit. After I turned to Düzce and start to study on the unit plan draft. Because I was reading a lot of study about the SSI, I had some idea how to introduce and precede an issue in a unit. I preferred SSI-Based teaching model because it was suitable my teaching and learning style as I explained deeply in 3.9 Personal Stance part. After I decide to use SSI-Based teaching model, I determined the objectives of the unit according to both MoNE standards and SSI-Based teaching model. Then, I listed the topics that must be taught proper to the teaching model and placed modeling sessions to the unit plan. At the same time, I had been started to search a teacher to apply this unit to his/her class. When I finished the first draft, I shared it with the teacher. He gave me lots of ideas about both flux of the unit plan and activities in the plan. I shared those with my adviser and after the fifth meeting with him and the teacher, the unit plan was completed. Then I started to detail each lesson in the unit plan which is given in appendix part. I worked on each lesson plan separately with my adviser and with the teacher. After the lesson plans and the materials in lessons like news, presentations, images, and statistics were completed, the permission procedures were applied. Finally, the teacher starts to implicate the unit plan at the second semester of 2017-2018 education years. After each lesson, he shared me his lesson notes and advices about the next lesson. According to his advices, some activities added or deleted in lessons. Or, some lessons we took help from the school book.

3.6 Classroom Environment and Teacher Attribution

Classroom environment and teacher attribution are important factors for SSI-based instruction. As mentioned in the *3.3 Participants* part, the teacher was the criterion to determine the implementation school.

As a researcher, I did not prefer to instruct students by myself. It was because of the reason that each classroom has its own culture; it means students have a way of communicating which has been developed in time. Therefore, adopting a new instructor to this culture require time to both the instructor and students. In this case, students might not be relaxed for a while. For a study which is limited in four weeks, the adaptation time is important so researcher was not preferred as an instructor. In this way, students did not feel any change and continue learning as usual.

However, there was a disadvantage of this choice. Classroom environment and instruction details were not observed by researcher in this way. In order to compensate this, each lesson the teacher noted remarkable events, students' reactions and also he gave feedback to the researcher after each lesson.

Before starting the unit, students were informed about the unit as usual. The time for the unit, activities and requirements were mentioned. Mostly, students were interested in making modeling. Therefore, throughout the unit, students were curious. Also, students were aware that their contribution to the lessons with different perspectives was important, so they expressed themselves actively by giving comments, asking questions, reflecting their ideas towards others ideas. Because the topic was controversial, as a character of SSI, students accepted each idea was valuable and so they did not judge each other.

When it comes to the contribution of the teacher, it is doubtless that the teacher was the person who contributed most to the successful completion of this unit. The teacher had experience six years in science teaching at the same school. Also, he was a master student and has already taken the SSI courses in his program. However, for the study, the teacher was trained by the author to perform the unit effectively and properly. The researcher and the teacher worked together and always in communication through unit implication process. Moreover, the teacher attributed to the arrangement of the activities in the unit plan.

Because the teacher was knowledgeable about SSI-based instruction and also about the "white butterfly" problem, the training was completed in a short time. The teacher has hazelnut garden and so experienced the "white butterfly" problem by himself in time. Therefore, when he was directing students in argumentation in lessons, he was able to ask related questions and give examples from his own experiences. Moreover, he was aware of the economic and social dimensions of the "white butterfly" problem. However, he was careful to not express his idea and direct students proper to framework of the SSI-based instruction.

In addition to the teacher, the other staff of the school from administrators to office-girl was very helpful and gave support throughout the unit implication process.

3.7 Data Sources

The aim of the thesis is to investigate 7th grade students' improvements in model-based explanations when they study on modeling-centered SSI-based curriculum unit. For this purpose, a modeling-centered SSI based curriculum unit was developed. The unit was prepared according to the objectives of the "Human and Environmental Relations/ Living Things and Life" unit in STP [35]. In order to check the unit reached its goals or not, the objective comprehension test published by MoNE [36] which was included 12 multiple choice questions according to unit goals of "Human and Environmental Relations/ Living Things and Life" unit was applied and evaluated.

On the other hand, main data of this thesis is the models and their explanations which were created by the twenty one 7th grade students who were instructed the modeling-oriented SSI-based curriculum unit.

3.8 Data Analysis

Analysis of data was completed in four steps. Three of these steps were to analyze models and explanations which students were generated through the unit implementation. The fourth one was to analyze the objective comprehension test which was applied at the end of the unit.

First step was development of rubrics. In order to analyze models and explanations two rubrics were generated as a) components rubric, and b) explanatory process rubric which were developed based on the study of Zangori et al. [26] study. In their study, they used three rubrics as a) components rubric, and b) sequences rubric and c) explanatory process rubric. They used sequences rubric to analyze sequences show carbon input or output. However, in this study there is no sequence which students show to explain the relation. Therefore, two rubrics were used. In order to verify rubric adaptation is true or not, I e-mailed with Laura Zangori and asked her using these two rubrics is enough to evaluate students' development of model-based explanations. I attached this e-mail the unit plan and randomly selected student's models. She turned my mail quickly and gave some advices about rubrics by confirming to use just two rubrics as components rubric, and explanatory process rubric. These rubrics were shaped with both Zangori's advices and contributions of the my adviser.

The second step was scoring models and explanations, and checking inter-rater reliability. In order to achieve inter-rater reliability, the models and explanation were analyzed with a second expert. The second expert was a science teacher who read the unit plan and also 2.3 White Butterfly Issue part. Researcher and the 2nd scorer scored five students models and explanations which was 24% of the data. After a few conversation on the scoring ways, a new set of data (again 5 students' models and explanations) was analyzed independently. At the end, the Cohen's Kappa reached the value 0.83, $p<0.001$ indicate "near perfect agreement" between scorers [68].

The next step was analysis of the scores with SPSS (Statistical Package for the Social Sciences). At this step, the scores obtained from the rubrics were analyzed to check whether there was a significant increase between the modeling scores from 1st modeling to 3rd modeling. Since it was a repeated process on one student group, Friedman test was used to analyze whether there was a significant difference between the modeling scores or not. Then, Wilcoxon test was applied to determine the difference between scores of model 1 and model 2; model 1 and model 3; model 2 and model 3. The detailed information about the technique and process was given in Chapter 4 Analysis and Results.

The fourth and last step of data analysis was scoring of students' unit test (Objective Comprehension Test by MoNE [36]).

3.9 Personal Stance

I always define myself as a professional student because both being teacher and being research assistant require learning constantly. Being curios, searching anything which I wonder, reading about it is cycle of my life. I was started to work in Düzce in April that means the "white butterfly" caterpillars were around. When I first saw them, I took a photo of them and ask questions to staff who work in the same faculty. After I learnt its name as "white butterfly", I read a lot of news about it. Therefore as a socio-scientific topic, it was on my mind.

On the other hand, I had experience as a science teacher at a private school which was focused on high school entrance exam. When I was working on this school, I always confused about why students learned the topics by memorizing it. From my experiences, it was because of that they could not relate the topics with real life. However, if they can relate the topic with real life and have a goal about this issue, they can learn not memorize. With this idea, I turned back to my graduate school achievements and realize that the SSI-based instruction as a teaching method is the most proper one to my personal teaching expectation. Therefore, I wanted to work on socio-scientific issue teaching and learning method.

From those experiences as I mentioned above, I decided to study on “white butterfly” problem with socio-scientific issue teaching and learning method. Then, with the help of my adviser, I have designed the SSI-unit plan about the “white butterfly” problem.

3.10 Trustworthiness

Quality of a study is provided by four factors in qualitative studies, they are; credibility, transferability, dependability and conformability [66], [69]. In the present study models and explanations were analyzed qualitatively, so those four factors were considered for trustworthiness. In this study, for credibility, triangulation strategy is used. It means, models of the students analyzed with another science teacher who has expertise on science education. On the other hand, to provide transferability, detailed information about participants, data sources, methods and data analysis process was given. Then, for dependability, inter-rater reliability method was used. The models and explanations were analyzed with a second expert, they scored five students models and explanations which was 24% of the data. Then their scores was analyzed and the Cohen’s Kappa calculated as the value 0.83, $p<0.001$ indicate “near perfect agreement” between scorers. Lastly, for conformability, scorer triangulation was used and also personal stance was stated deeply.

4
Analyses and Results

4.1 Rubric Development

Analysis of data process was started by generating two rubrics for the models and their explanations. As stated before, each student draw models as a response to the driving question three time points through the unit. Then, just after drawing model, they write explanation to models to both answer the driving question and explain the drawings. Because the modeling sessions consists of two parts as drawing and explanation, two rubrics were developed. First rubric was components rubric (Table 4.1) and the second was explanatory process rubric (Table 4.2). The phrase cause refers to the factors that result in increasing white butterfly population and effect refers to the results of white butterfly beings.

Table 4.1 Components Rubric

Levels	Description
0	No related component with ecosystem or white butterfly
1	No cause or effect component but white butterfly related component(s)
2	One (or more) cause or effect component
3	At least one cause and at least one effect component
4	Multiple effect components with one cause component
5	Multiple cause components with one effect component
6	Multiple cause components and multiple effect components
7	Level 6 + component(s) related to struggling ways

These rubrics were developed by taking Zangori et al. [26] study as an example. This study was an example because both of the studies use modeling and explanation in a SSI-based instruction. In order to verify the rubrics of this study, researcher took opinions and advices of both Zangori and thesis adviser as experts.

Table 4.2 Explanatory Process Rubric

Levels	Description
0	Does not explain an interaction between ecosystem and white butterfly
1	Explains only effect(s) of white butterfly to the ecosystem
2	Explains only cause(s) of increasing population of white butterfly
3	Explains an interaction between ecosystem and white butterfly with both causes and effects
4	Level 3 + additional factors like struggling ways with white butterfly

Because the relationship between white butterfly and Düzce ecosystem could be explained by cause and effect, the proper crosscutting concept was cause-effect for this unit, therefore the rubrics was developed by taking account the components and explanations as cause or effect. For example, a component shows a tree harmed by white butterfly is an effect component, because it is the result of white butterfly beings (Figure 4.1).

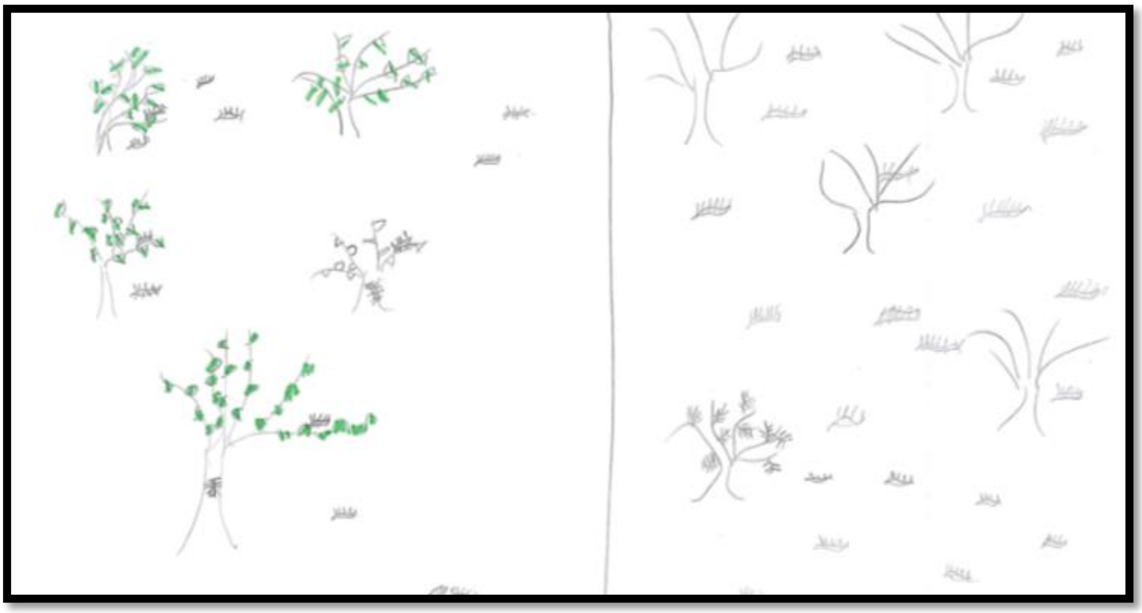


Figure 4.1 Drawings of Student-16 shows effects of white butterfly to trees

On the other hand, a component show increasing temperature is cause component, because increasing temperature results in increasing white butterfly population (Figure 4.2).

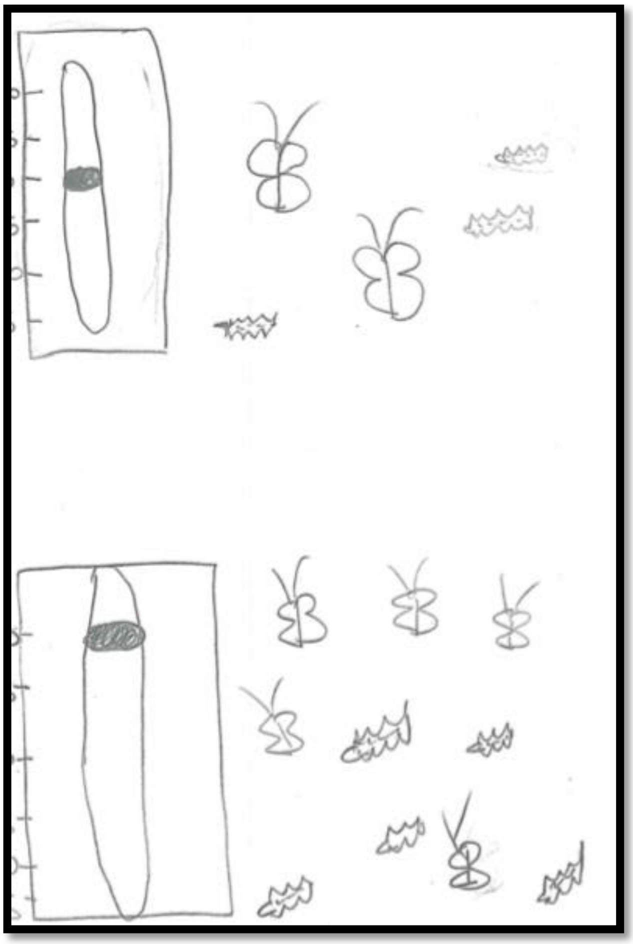


Figure 4.2 Drawing of Student- 3 shows increasing in temperature causes increasing in number of white butterfly

Both of the rubrics take "effects" into account of first because effects of white butterfly are observable for students. However, "causes" of increasing population of white butterfly could not be easily observed. In order to understand the reasons behind the increase, students should make some inferences from the instruction. Therefore "causes" rest in higher level than "effects" in rubrics.

On the other hand, rubrics are different from each other in terms of levels. First components rubric has eight level and explanatory process rubrics contains five levels. The ranking mechanism between rubrics is similar. For example, zero level refers to there is not a related drawing or explanation about the issue. Then, levels increase from "effects" components/ explanations to "causes" components/ explanations.

4.2 Scoring of Models as Components and Explanations

Scoring of the models and explanations took a long time because in order to achieve inter-rater reliability models were evaluated and scored by two scorer (researcher and a science teacher). At the beginning, randomly selected five (24% of the data) students' models and explanations were scored independently by the two scorer. Then, scores were analyzed with SPSS to get Cohen's Kappa value. In the first round, the value was 0.63, $p<0.001$ means substantial agreement between scorers. After that, some meetings about the scoring ways were done and a new set of data (again 5 students' models and explanations) was analyzed independently. Then, the Cohen's Kappa calculated as 0.83, $p<0.001$ indicates "near perfect agreement" between scorers [68]. After that, the first five data and the remaining data were analyzed by the researcher.

Table 4.3 Descriptive Statistics (N=17)

	Components		**Explanatory Process**	
Model Iteration	Mean (max=7)	Std. Dev.	Mean (max=4)	Std. Dev.
1	1,65	0,93	1,25	0,85
2	3,59	1,37	2,10	1,14
3	5,18	1,91	3,11	0,76

At this point, it should be stated that some of the students were absent in some modeling sessions, three students missed 3rd modeling session and one student missed 1st modeling session, therefore N=17 in statistics. Because the sample size was too small and four students were not added to the analysis in SPSS due to missing values, for further analysis missing values replaced with the series mean and so 21 participant counted in statistics. In order to be able to replace missing values, missing values analyze was made and estimated means (EM) significant value was calculated as 0.129. Since $p>0.05$ means missing values are randomly distributed, replacement missing values with series mean was accepted. Replacing missing values with series mean is required to take into account the non-missed models and explanations scores. Also, this replacement does not affect the mean of the missed series. For example, a student missed the 3rd modeling session, the SPSS erases his/her all scores for analysis. It means, although the student present in the 1st and 2nd modeling sessions, the means of components and explanatory process scores for the 1st and 2nd sessions were calculated without his/her scores. Therefore, the means were wrong. However, by replacing missing values, his/her scores are added to the calculation. Also, for the 3rd modeling scores which s/he was absent, 3rd modeling components and explanatory process means are calculated and written to the place of missing values. Therefore, the 3rd sessions' means are not changed. By this replacement of the missing values, all of the series means are calculated correctly. Here is the descriptive statistic table for N=21;

Table 4.4 Descriptive Statistics (N=21)

	Components		**Explanatory Process**	
Modeling Sessions	Mean (max=7)	Std. Dev.	Mean (max=4)	Std. Dev.
1	1,60	0,86	1,25	0,83
2	3,95	1,47	2,10	1,14
3	5,22	1,72	3,11	0,70

In the Table 4.4, "mean" refers to the average scores for the related modeling sessions. For the components part, students' scores increase from 1,60 point to 5,22 point. Moreover, for the explanatory process, students also got higher scores and average of the scores went 1,25 to 3,11. It means as instruction was continued, students made more cause and effect relations between ecosystem and white butterfly population. Furthermore, they became able to reflect their development to both model drawing and explanations. In order to see the change of average model scores clearly, a graphical representation may be useful (Figure 4.3).

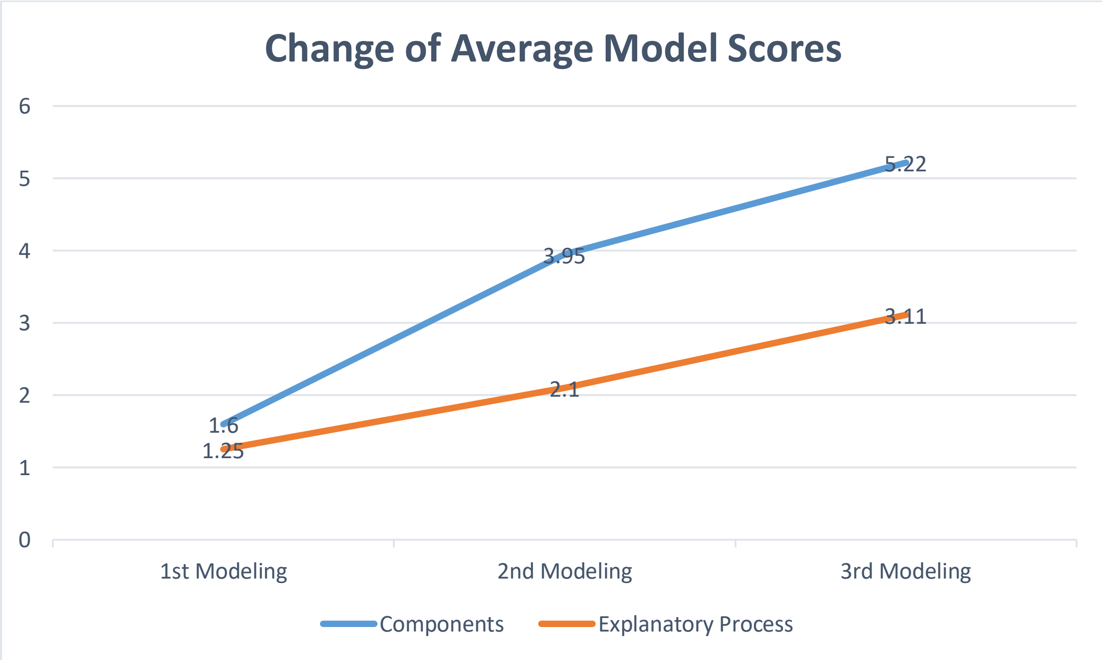


Figure 4.3 Change of average model scores for components and explanatory process

Behind the points and graphics, adjoining students' three models also shows the development. For example Figure 4.4, Figure 4.5 and Figure 4.6 show Student-12's models.

Figure 4.4 Student-12's 1st model

In the Figure 4.4 which is Student-12's first model, s/he drew white butterfly in a normal day as how s/he observes it. White butterfly larvae are climbing to the house walls and trees, and also they are eating leaves on the tree. Moreover, a white butterfly is flying around. Components score level of this model was 3. On the other hand, although s/he drew only effects of white butterfly, on his/her explanation paper s/he mentioned about both effects and causes of increasing number of white butterfly as "they (white butterfly larvae) are climbing our houses and going in through the windows. Also, they are eating leaves and they decay the trees. Their numbers are increasing because whether is becoming hot in last years". Therefore, his/her explanatory process score was 3 for the first modeling.

Figure 4.5 Student-12's 2nd model

In the Figure 4.5 which is Student-12's second model, s/he got 5 score on components rubric with this model. S/he drew the factors that affect white butterfly population like increasing temperature (in the first box of the figure, the girl says "puff… it's too hot") and white butterfly larvae around. Also, in another box s/he drew air pollution factor as smoke from the chimneys of houses. On the other hand, s/he drew again and effect of white butterfly as damaged hazelnut garden (on the upper right box). The drawing in the last box, which shows falling white butterfly pupae due to rain, exposes a misunderstanding of the student. This misunderstanding is not completely wrong because if it rains, white butterfly larvae or pupae fall from the tree. However, this example shows some of the students could not relate rain and humidity. Therefore, they could not reach the level of understanding that rain cause humidity and so increasing in white butterfly population. This misunderstanding was observed in two more students and then a brief explanation about the rain and humidity factor was made in class by the teacher.

His/her explanations were parallel to his/her drawings. It means s/he explained both effects and causes of increasing white butterfly population as *"they are damaging hazelnut gardens and so less nuts are harvested and garden owner gain less money… there are too much (white butterfly) because we pollute the air by burning coal and so global warming occurs and the air is becoming more hot. They (white butterfly) like hot weather and reproduce more… on the other hand, they don't like rain because when it is rainy, they (white butterfly larvae or pupae) fall from tree and die…"* By this explanations, s/he got 3 score from the explanatory process rubric.

Figure 4.6 Student-12's 3rd model

In the Figure 4.6 which is Student-12's third model, s/he drew again both causes of the white butterfly population increase and effects of that increase to the leaf and a hazelnut tree. However, in that model beside causes and effects two additional components were drawn. S/he drew two struggling ways with white butterfly, first one is mechanical way and secondly chemical way. With this additional components, s/he got 7 score from the components rubric. S/he explain these ways as *"…if we step on them when we see, their number will be decrease without using chemicals and harming other living things; however, stepping on them will not be enough if they are too much, so we should call officials to spray and kill them…".* S/he got 4 score from the explanatory process rubric.

Furthermore, Student-12 models show another development in terms of modeling. The first model consists of only one box, the next one is divided into four and the last one divided into six boxes. It refers to how the components about the issue on student's mind is developed.

Another example from students' models is given in Figure 4.7, Figure 4.8 and 4.9.

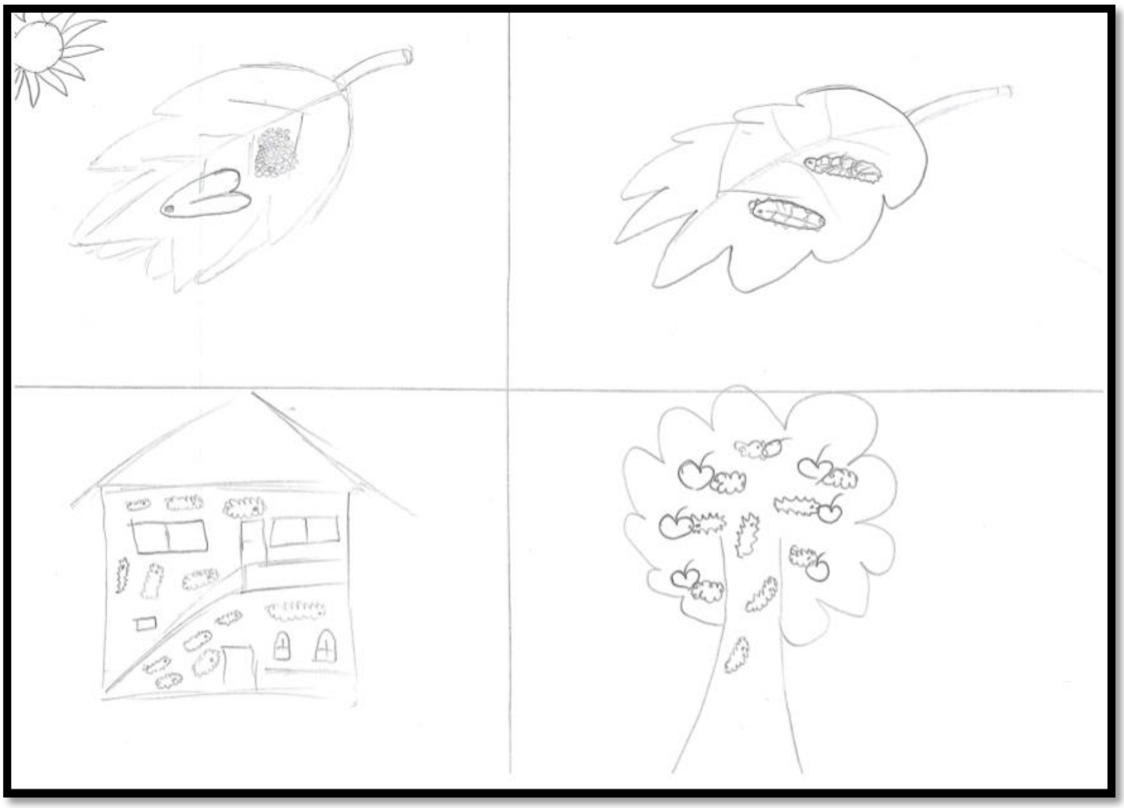


Figure 4.7 Student-7's 1st model

In Figure 4.7, s/he drew white butterfly in a four different situations. The first one shows egg cluster of white butterfly on a leaf. In the second, white butterfly eggs are becoming larvae. The third and fourth drawing shows effects of white butterfly to a house and a tree. Therefore, his/her components rubric score was 2 for this model. S/he explains his/her drawing as "number of white butterfly increase when the air is sunny, they grow up on leaf of trees and become larvae. The larvae harm to trees and houses, also they harm people by introducing houses…". Because s/he explained only effects of white butterfly, his/her score was 1 on the explanatory process rubric score.

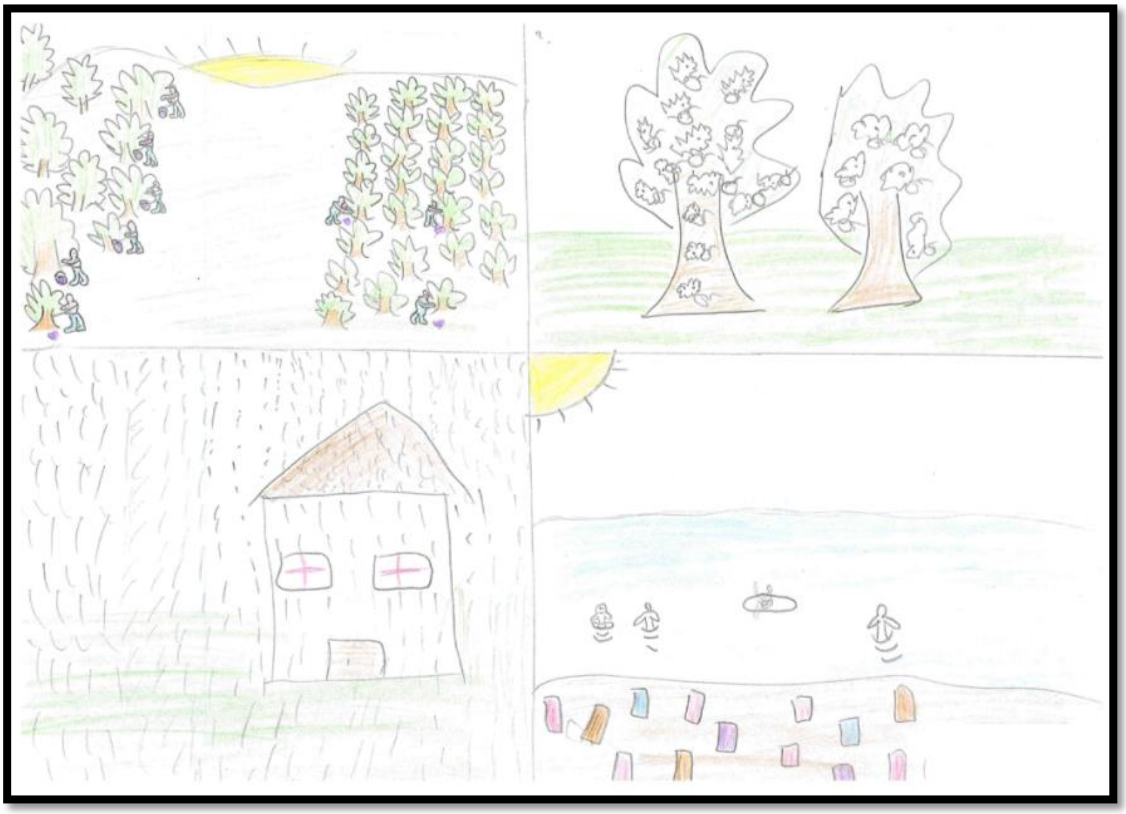


Figure 4.8 Student-7's 2nd model

In Figure 4.8, s/he explains his/her drawing in four part as proper to his/her drawings. S/he says that *"In the first picture I drew hazelnut gardens and people who collect nuts. They are good places for white butterfly. In the second picture, I drew white (butterfly) larvae which are eating leaves. And, in the third picture I drew rain causes to humidity. At the last picture, I drew air temperature and people in the sea. Humidity and hot whether cause to be more white butterfly."* S/he got 5 score for components rubric and 3 points for explanatory process rubric.

Figure 4.9 Student-7's 3rd model

Figure 4.9 shows Student-7's 3rd model. This model also consists of four parts. In this model s/he again drew white butterfly larvae on house's wall and on a tree. Also, she drew hazelnut garden and people on the sea means hot air temperature. This model consists of the collection of 1st and 2nd models. From components rubric s/he got 6 score and from explanatory process rubric 3 score. It means his/her explanations did not improve according to 2nd modeling.

Differently from the Student-12, Student-7 drew each models in four parts. It means there is no increase in the number of the parts of the models. However, there is a development in models in terms of both components and explanations. Although, Student-7 could not reach the highest levels in rubrics, at the end s/he achieve the relation between white butterfly and ecosystem with multiple causes and effects.

4.3 Analyses of the Scores

Although change of average scores for components and explanatory process, and students' models show development, it is not known that is this development statistically significant, or not. In order to be able to make this interpretation, first Friedman Test was applied to a) components scores and b) explanatory process scores. The Friedman test is non-parametric alternative of the repeated measures ANOVA (Analysis of Variance) in SPSS. It is used to test whether there is a significant difference between repeated measurements of a sample. In this analysis, Friedman test was used because the data was non-parametric and sample size (N=21 <30) assumed small size. Therefore, Friedman test and Wilcoxon test as post-hoc analysis were used.

Table 4.5 Mean ranks of components and explanatory process in Friedman Test

	Components	**Explanatory Process**
Modeling Sessions	Mean Rank	Mean Rank
1	1,10	1,33
2	2,10	1,79
3	2,81	2,88

Table 4.6 Friedman test statistics of components and explanatory process

	Components	**Explanatory Process**
N	21	21
Chi-square	34,421	31,465
df.	2	2
Asymp. Sig.	,000	,000

The Friedman test results (Table 4.5 and 4.6) indicated that there is significant difference between modeling sessions, $p<0.05$, in terms of both components and explanatory process. However, this test did not show the difference in between which sessions. Thereore, post-hoc analysis was required and Wilcoxon signed-rank test was applied to both components scores and explanatory process scores.

Table 4.7 Wilcoxon signed-rank test statistics of components and explanatory process

	Components		**Explanatory Process**	
Modeling Sessions Comparisons	Z	Asymp. Sig. (2-tailed)	Z	Asymp. Sig. (2-tailed)
2, 1	-3,743[a]	,000	-2,578[a]	,010
3, 1	-3,928[a]	,000	-3,951[a]	,000
3, 2	-3,536[a]	,000	-3,689[a]	,000

a. Based on negative ranks

According to the test results, there was a statistically significant difference in modeling sessions QK = 34,421, p< 0,05. Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied, resulting in a significance level set at p < 0,05. There were significant differences in component scores between 1st modeling and 2nd modeling (Z=3,743, p< 0,05), and between 1st modeling and 3rd modeling (Z =3,928, p< 0.05) and between 2nd modeling and 3rd modeling (Z =3,536, p< 0,05). Similarly, there were significant differences in explanatory process scores between 1st modeling and 2nd modeling (Z=2,578, p< 0,05), and between 1st modeling and 3rd modeling (Z =3,951, p< 0.05) and between 2nd modeling and 3rd modeling (Z =3,689, p< 0,05). These results indicated that 7th grade students' model-based explanations develop through SSI-based instruction.

4.4 Scoring of Objective Comprehension Test

The objective comprehension test (Appendix C) was applied to the students at the end of the unit. This test consists of 12 multiple choice questions about the ecosystem and biodiversity. These questions was prepared by MoNE proper to the objectives of the "Human and Environmental Relations/ Living Things and Life" unit. Moreover, except the 11st question, other questions are suitable for objectives of the "White Butterfly Unit". The 11st question is about specific enangered species. During the implementation of the unit, students learned about endangered species in biodiversity part of the unit but those specific examples did not given directly.

Answer key of the test also published by MoNE. Therefore, scoring of the test was too much easier than scoring models.

This test applied to the students to assess whether they gain the unit main content knowledge, or not. According to the grading system in Turkey, test scores are evaluated according to the scale on Table 4.8.

Table 4.8 Score evaluation scale of the unit test results

Scores	Description
0-24	No gain
30-44	Insufficient
45-54	Acceptable
55-69	Satisfactory
70-84	Good
85-100	Excellent

For this scale, test results of the students were given in Figure 4.7. According to the result 86% of the students reached satisfactory and higher levels. It means most of the students' gained enough content knowledge.

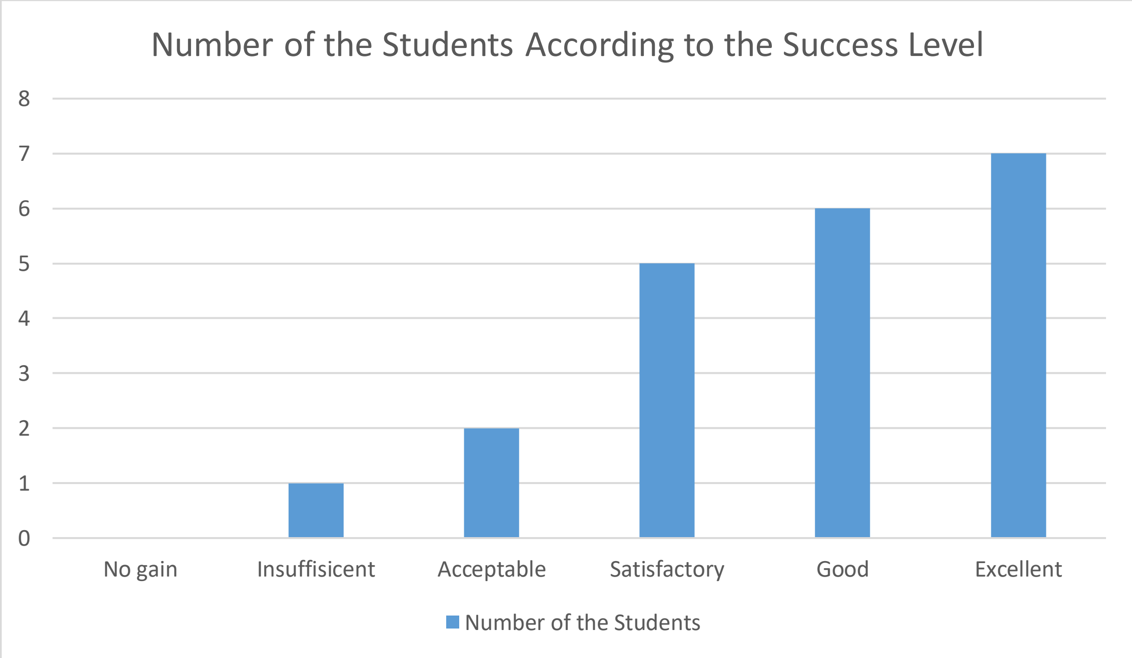


Figure 4.10 Students' unit test results

One of the all students was in the insufficient group with 33,33 points on the test, so s/he answered only 4 of the 12 questions right. Parallel to the her/his test results, s/he got 2, 2, 3 scores on the components rubric and 1, 1, 1 scores on the explanatory process rubric relatively. In another words, s/he did not show success both on modeling sessions and unit test. Moreover, two students were in the acceptable group with 50 points, means that they answered half of the questions correctly. Their test results also parallel with their model scores. They got 3 and 4 from components rubric and, 2 and 3 from explanatory process rubric from the 3rd modeling session. Although students' results show parallelism in terms of success level, it could not be claimed that test results depends on SSI-based instruction completely. It is because the learning process is open to external factors. Therefore, test results and modeling results were not correlated statistically.

4.5 The Teacher's Opinions Before, During and After the Study

As stated in the section of *3.6 Classroom Environment and Teacher Attribution,* there was a training time before the unit implementation and also when preparing the unit, I got advice from him. At those times, we have talked about the SSI, SSI-based instruction and using model-based learning with SSI.

Before the implementation, I asked him if he use SSI and in lessons or not. He said that he never designed an SSI-based unit but made some SSI-based argumentation activities in classroom. He said that *"… for example, for the "Domestic Waste and Recycling" issue at the beginning of this semester, I gave homework to the students and wanted them to search about the costs and benefits of the recycling some materials in terms of social, economic, environmental and political aspects. After that, in classroom we made a decision-making activity and discussed about which materials should be recycled and which are not…"* For this homework, he did not evaluate the argumentation quality in class, but he gave scores according to the preparation of the students. Therefore, he had prejudice towards SSI-based instruction due to assessment and evaluation process. Moreover, he did not prefer model-based learning in class because again he thought that it was hard to evaluate fairly.

As much as the using SSI-based instruction and model-based learning in class, the teacher was afraid of students' participation to the lessons. It was because the teacher said that *"probably, students hesitate to participate to the lessons because they are not familiar using news or data sets in class. Also, I think that the data set activity would be difficult for them…"*

During the implementation process, his ideas changed from negative to positive and he said that his students were very enthusiastic about the lessons and had great efforts to fulfill the task in every lesson. In addition, the drawing activities were very enjoyable for them, everyone was doing their work without disintegrating at the beginning of his desk.

After the implementation of the unit, I asked the same question to the teacher and he said that his opinions changed too much. Firstly, he thought that *"using an SSI-based instruction is more effective than short-term SSI-based activities because SSI-based instruction has more than one point and develops students' many abilities through the unit. Moreover, evaluation process is not so complicated when think it as a lesson not a thesis."*

Finally, when I completed the data analysis and shared the results with the teacher, I learned that he had decided to begin his doctoral program and to study about SSI-based teaching in the classroom. He also thanked me for inspiring and encouraging him.

5
Conclusion and Recommendations

5.1 Discussion of the Results

The aim of the present study was to investigate the development of 7th grade students' model-based explanations through SSI-based instruction. According to the results given in *Chapter 4 Analyses and Results*, it can be concluded that students' model-based explanations developed significantly. This results are consistent with other studies which used model-based learning and SSI-based instruction together [25], [26], [27]. According to the results (Table 4.7), there was a statistically significant difference in between all modeling sessions. It means for both components and explanatory process rubric scores, there was a significant difference between 1-2, 1-3 and 2-3 in favor of the last modeling session. In another words, students' model-based explanations increased through the SSI-based instruction significantly. This results show similarity to the results of Zangori et al. [26] study with one change. They also found statistically significant difference in between modeling sessions. However, for components rubric, at the second modeling session students reached "saturation point" (the mean= 3,98; max=6) and so scores of the third modeling (the mean= 4,28; max=6) to the second modeling did not indicate a significant difference [26]. Moreover, the study of Zangori et al. [27] also showed that students' model-based explanations developed through SSI-based instruction. In that study, they compared students' pre- and post-models as before and after the instruction about groundwater [27]. They collected data from five classes and he results of the study showed a significant difference between students' pre- and post-models in terms of model-based explanations [27]. Furthermore, Peel et al. [25] study results is consistent with the present study results. In this study, similarly to the Zangori et al. [27] study, pre- and post-models were used to analyze students' development of model-based explanations about anti-biotic resistence [25]. According to the results of the study, there was a significant increase in the students' use of natural selection factors and connections in between students' pre- and post-models [25]. Taken together the results of those studies [25], [26], [27], it can be concluded that SSI-based teaching supported students in terms of 1) thinking more complex than a single cause-effect relation, 2) constructing scientific content knowledge behind the issue [26].

Moreover, Peel et al. [25] and Zangori et al. [26] studies' results showed another similarity with the present study. In addition to the developments in the students' model-based explanations, these studies also revealed students' misconceptions about the issues [25], [26]. As seen in Figure 4.5, some students could not comprehend rain and humidity relation in the ecosystem and thought simply as rain causes to fall of white butterfly larvae from the trees. This was two students' misconceptions revealed in this study. This example also shows students' limited ability to inference non-visible components of ecosystem stated in [30]. Also, it showed the power of modeling to reveal students' misconceptions [70], [71].

Students' models was often following the steps of modeling framework [52] (Figure 2.9). First models (Figure 4.4 and Figure 4.7) represent preconceptions of the students as how they see white butterfly in daily life. This representation of the students confirm the results of studies [30], [31], [32]. They also indicated that students show tendency to draw visible components of ecosystem when they asked to model [30]. As the instruction continues, students started to add non-visible components to their models as temperature, air pollution, etc. (Figure 4.5, Figure 4.6, Figure 4.8 and Figure 4.9) as predicted by [30]. Parallel to this development, scores of the students on both components rubric and explanatory process rubric increased. For the first modeling session, the mean of components rubric was 1,60 (max=7) and the mean of explanatory process rubric was 1,25 (max=4) (Table 4.4). Then, for the third and last modeling session, the means were 5,22 (max=7) and 3,11 (max=4) relatively for components and explanatory process rubrics (Table 4.4). It means, at the beginning students' models include generally effect (visible factors like climbing to the wall) of white butterfly to the ecosystem and towards the end students placed effects and cause (non-visible factors like increasing in temperature) components and relations to their models.

On the other hand, students' scores from components and explanatory process rubrics give a chance to interpret the level students reached. It means, according to the last rubric score means, it can be said that most of the students could not comprehend the effects of struggling with white butterfly (as a pest) on the ecosystem. The means were 5,22 (max=7) and 3,11 (max=4) relatively for components and explanatory process rubrics (Table 4.4). For components rubric Level 7=Multiple cause components and multiple effect components, and component(s) related to struggling ways (Table 4.1); and for explanatory process rubric Level 4= Explains an interaction between ecosystem and white butterfly with both causes and effects and additional factors like struggling ways with white butterfly (Table 4.2). According to the means, students rarely discussed about the struggling ways and so effects of the external factors on ecosystems.

Moreover, at the end of the unit, an Objective Comprehension Test [36] was applied to the students in order to check whether they gain enough content knowledge or not. According to the test results, 86% of the students reached satisfactory and higher levels. It means, most of the students gain enough content knowledge in MoNE criterion. This results are consistent with other studies which used SSI-based instruction [25], [26], [27], [41], [42].

5.2 Implications and Recommendations

For Participants

The participant number of the study was limited with 21 students. Also, some students missed some lessons and so 59 models were collected as data instead of 63 models. This caused to elimination of 4 students from statistical analyses in SPSS. Then, this problem was solved by missing value transformation. Although, the problem seems to have been solved, the effect of missing lessons to the students could not be brought into open. Moreover, because of the sample size Friedman non-parametric test was preferred rather than repeated measures of ANOVA. Therefore, for further studies increasing the number of the participants and controlling the attendance of the students to the lessons would be increase the chance for strong data analyses.

For Unit Development

Development of a SSI-based curriculum unit is like walking on a rocky pathway. It is because when we trying to do best in SSI teaching, we should not miss the curriculum requirements. The lessons in class are bounded with national curriculum and objectives and at the end of the middle school, students have some exams like high school entrance exam based on the curriculum and objectives. Moreover, time for each unit is again limited by curriculum. The *"Human and Environmental Relations/ Living Things and Life"* unit is bounded ten lesson hours in curriculum but the "White butterfly Unit Plan" took 15 lesson hours. It was a problem but I could not shorten the time more. This problem was solved by the teacher's self-devotion. He created time for this unit by ending up the unit before a bit early.

A general recommendation for this situation can be made as creating more flexible curriculum make SSI-based instruction feasible for teachers. Moreover, school books were not helpful to facilitate SSI-based instruction at least on this unit. Therefore, school books also needs a review in terms of SSI examples.

Moreover, in the unit development process, I visited the school and aware of the technological background is limited. Therefore, I revised many activities to not use computer and internet. For example, the news distributed in class (Appendix C) may be reached by searching on the internet by students. This was a deficiency for the unit because SSI-based teaching and learning framework requires using of information communication technology (ICT) [34]. For further studies, ICT should be incorporated to the unit.

For Unit Implementation Process

As stated in *3. 6 Classroom Environment and Teacher Attribution* part, the unit was implemented by the teacher of the class. It was my choice as a researcher because I did not prefer to instruct students by myself to not disrupt the class's aura. It means if the class was taught by another instructor, probably they would not be relaxed for a while and so their contribution to the class discussions and also explanations would be limited. Another limitation of the instructing class as a researcher is stated by [41] data analysis process may be affected by researcher ideas because of witnessing the class discussions. Therefore for further studies I advise to work with teachers of the classes. I heed it not only for the limitations above but also to show feasibility of SSI-based instruction in classes.

On the other hand, some disadvantages of not being in class as a researcher but I mentioned how we overcome this situation in part of *3. 6 Classroom Environment and Teacher Attribution*. Firstly, as a researcher you should aware of what you will need in the analysis process. Then you should transfer to the teacher clearly and s/he should have willingness to both implication and collaboration. Therefore, s/he may take some notes or records of important events in class. Or, after the each lesson, a detailed conversation about the lesson between teacher and researcher may be helpful according to the needs of information.

5.3 Conclusion

The aim of the thesis was to investigate the development of 7th grade students' model-based explanations through SSI-based instruction. For this aim, an SSI-based curriculum unit was developed according to the SSI-based instruction model by Sadler et al. [34]. Moreover, model-based learning approach ([26]) is used to support the unit. The "white butterfly" issue, which is a local pest, is assigned as the SSI focus of the unit. Objectives of the unit were prepared proper to the objectives of the *"Human and Environmental Relations/ Living Things and Life"* unit in STP [35] followed by the 7th grade students in the implementation period. The unit developed in this thesis was applied to twenty-one 7th grade students who study at a public middle school at Düzce. The unit consists of 8 lessons through 15 lesson hours so it takes 4 weeks. Through the unit, each student develop three models and wrote an explanation for these models. They develop these models according to the unit driving question which was *"How might the population change of "white butterfly" interact with the local ecosystems?"*. In order to analyze models and explanations, at the end of the unit models generated by students and models' written explanations were collected. Moreover, in order to assess content knowledge of the students, a unit test (developed by MoNE, [36]) was applied to the students and analyzed separately.

Analyses of the models and explanations made according to two rubrics generated by the researcher. Firstly, components rubric was used to analyze drawings on the models. Then explanations were analyzed by explanation process rubric. Results of these analyses showed that students' model-based explanations developed significantly. This result was concluded with the help of the Friedman test and Wilcoxon tests which were used via SPSS. On the other hand, models and their explanations were evaluated qualitatively and some misconceptions of the students were found. Moreover, according to the test results of the Objective Comprehension Test, 86% of the students reached satisfactory and higher levels. It means, most of the students gain enough content knowledge in MoNE criterion.

These results are consistent with the other studies which used model-based learning and SSI-based instruction [25], [26], [27]. Three of the studies used modeling sessions in an SSI-based developed unit and found that model-based explanations of students developed through the instruction.

Moreover, raising up scientifically literate students is a major aim of many national education curriculums [12], [19]. In order to achieve this aim, students should have basic information about science topics, use scientific practices, recognize the relationship between person, environment and society, develop reasoning skills, scientific thinking habits and decision-making skills by using socio-scientific subjects [7], [12]. SSI-based teaching and learning model is a well-designed teaching approach to achieve scientific literacy [37], [54]. Engaging scientific practices, introducing socially relevant and crucial issues, and developing students reasoning skills are possible with this model. Therefore in this thesis, model-based learning approach and a local issue are embedded to SSI-based curriculum unit to teach ecosystems and biodiversity unit in a social context. According to the results of the study, it can be concluded that it was a successful study which makes contribution to the scientific literacy levels of students.

A
"White Butterfly" Unit Plan

Major Themes for the Unit

- **Scientific themes:** Ecological Interactions, Global Warming, Climate Change, Energy Flow, Biodiversity, Air Pollution, Lifecycle of the "white butterfly"
- **Scientific practices:** developing and using models, analyzing and interpreting data, constructing explanations and designing solutions, engaging in argument from evidence, obtaining, evaluating and communicating information
- **Socio-Scientific Issue:** Population change in "white butterfly" and its effects on local ecosystems
- **Driving Question:** How might the population change of "white butterfly" interact with the local ecosystems?

Concepts needed to explore the driving question

- Science Concepts
- Ecological Interactions
- Energy Flow
- Global Warming
- Climate Change
- Air Pollution

Social Ideas and Concerns

- Economics
- Politics
- Social

Unit-level performance expectations

Students;

- Define ecosystem, species, habitat and population concepts and also give examples to these concepts (MoNE, 7.5.1.1)
- Question the importance of biodiversity for natural life (MoNE, 7.5.2.1)
- Discuss the threats to biodiversity based on research data and produce solution recommendations (MoNE, 7.5.2.2)
- Organize information about white butterflies and local ecosystem (hazelnuts, air pollution, etc.).
- Develop and use multiple models to explain the interaction between population change in "white butterfly" and local ecosystem
- Develop explanations to which factors may influence ecosystems in what way
- Use and interpret graphics, charts and statistics to find relationship between weather, air pollution, hazelnut harvest and population growth of "white butterfly"
- Learn, discuss and anticipate methods (such as preventing air pollution) to deal with "white butterfly".
- Discuss the effects of interventions on ecosystems, starting with the methods and effects of "white butterfly" struggling.

Unit assessment(s)

- Models- model based explanations
- MoNE Objective Comprehension Test (Unit Test)

Lesson sequence

In Table A.1, the lesson sequence is listed. The first column of the Table A.1 shows the lesson number and time it takes and the other columns are for the lesson focus, learner objectives and activities in the lesson respectively.

Table A.1 Lesson sequence of white butterfly unit

Lesson (time)	Lesson Focus	Learner Objectives	Activity
1 (40 min)	Presenting the SSI and sharing preliminary information about "white butterfly"	Students will be familiar with "white butterfly" and local ecosystem.	News display Photo display Question-Answer
2 (80 min)	What is ecosystem? Concepts about ecosystem	Students will learn ecosystem, species, habitat and population concepts and also will be able to make connections between these concepts.	School Way Activity Discovery of various ecosystems
3 (80 min)	"white butterfly"	Students will have detailed information about the "white butterfly" and will make predictions about the ecosystem they live in.	Lifecycle of "white butterfly" Field trip to hazelnut garden (if in season) 1st modeling
4 (120 min)	Factors that affect the local ecosystem	Students will explain which factors may influence "white butterfly" ecosystems in what way.	Weather graphics, air pollution charts, population growth chart of "white butterfly", hazelnut harvest statistics, etc. 2nd modeling
5 (80 min)	Struggle with "white butterfly"	Students will argue about how to struggle with "white butterfly" in the light of the information of struggle ways as chemical, biological or mechanic. Or; preventing air pollution	Invited speaker (to talk about the struggle ways) Argumentation
6 (80 min)	Biodiversity	Students will argue about how interventions to the environment affect the ecosystems based on struggle with "white butterfly" and so realize the biodiversity	Argumentation 3rd modeling
7 (80 min)	End-of-Unit Classroom Activity	Students will discuss and make decisions about how to deal with the "white butterfly" problem in a holistic context	Decision Making
8 (40 min)	Assessment	Objective Comprehension Evaluation	Unit Test

B
“White Butterfly” Lesson Plans

Lesson 1: Presenting the SSI and sharing preliminary information about “white butterfly

Time: 40 minutes

Goals for the Lesson:

- Students will organize their information about “white butterfly” and local ecosystem (hazelnuts, air pollution, etc.).
- Students will be familiar with “white butterfly” and local ecosystem.

Driving Question: How might the population change of “white butterfly” interact with the local ecosystems?

Lesson Assessment: Responses to the questions in the lesson

Resources: Local news about “white butterfly”, “white butterfly” photos

Instructional Sequence:

Timing	*Activities*	*Materials/Supplies*
10 min	The teacher distributes the local news about the White Butterfly to the students; and students are expected to review the news.	Local news about "white butterfly"
15 min	The teacher asks the students what they hear about the white butterfly and what they know about it. After taking the preliminary information; the teacher shows the "white butterfly" photos as three stages (larva, caterpillar, butterfly) to the students and after each photo; the teacher asks if they had ever seen the White Butterfly before İf they said yes, s/he asks when, where and how often. After marking the answers separately for the three stages, general conclusions are made about the seasons and places that students see "white butterfly". For example; in spring and summer in the wooded areas, as seen in nuts gardens.	"white butterfly" photos
10 min	After the inferences made, students are asked about the reasons why Düzce is an ideal place for the lives of "white butterfly". The views are guided by class discussion as to the relevance of hazelnut gardens and climatic conditions. The question of what the students think about the ecosystem (air pollution, low pressure, foggy weather, etc.) is questioned.	
5 min	The question is how the increase in the number of "white butterfly" can be affected and how this increase can affect the environment. Students are asked to think without answering the question.	

Lesson 2: What is ecosystem? Concepts about ecosystem

Time: 80 minutes

Goals for the Lesson:

- Define ecosystem, species, habitat and population concepts and also give examples to these concepts (MoNE, 7.5.1.1)
- Students will learn ecosystem, species, habitat and population concepts and also will be able to make connections between these concepts.

Driving Question: How might the population change of "white butterfly" interact with the local ecosystems?

Lesson Assessment: Responses to the questions in the lesson

Resources: "School Way" Activity, Ecosystem photos

Instructional Sequence:

Timing	*Activities*	*Materials/Supplies*
25 min	With the activity "school way", students will be taught ecosystem, species, habitat, population concepts and students will be able to connect these concepts.	"School Way" Activity
20 min	Students are asked to give examples of other ecosystems. Whether the answers given by the students are ecosystems or not is discussed. The ecosystem definition is highlighted.	
20 min	Various ecosystems are examined. (Land, Sea, Forest, etc.)	Ecosystem photos
15 min	Local ecosystem is analyzed.	

Lesson 3: "White Butterfly"

Time: 80 minutes

Goals for the Lesson:

- Students will have detailed information about the "white butterfly" and will make predictions about the ecosystem they live in.
- Develop and use multiple models to explain the interaction between population change in "white butterfly" and local ecosystem
- Develop explanations to which factors may influence ecosystems in what way

Driving Question: How might the population change of "white butterfly" interact with the local ecosystems?

Lesson Assessment: Models and their written explanations

Resources: "White butterfly" brochure, "white butterfly" presentation

Instructional Sequence:

Timing	*Activities*	*Materials/Supplies*
25 min	The "white butterfly" brochures prepared by the Ministry of Agriculture are distributed to the students and the life cycle of the white butterfly is taught.	"White butterfly" brochure
15 min	Students are briefed on scientific modeling.	
20 min	Students are asked to make a model. It is expected that the model will include the causes and possible consequences of the increase in the number of "white butterfly", taking into consideration the factors influenced by the life cycle of the white butterfly.	
20 min	After the model drawings, students are asked to describe the relationships in the drawings they have made on another sheet.	
5 min	Drawings and explanations are collected together for evaluation purposes.	

Lesson 4: Factors that affect the local ecosystem

Time: 120 minutes

Goals for the Lesson:

- Students will explain which factors may influence "white butterfly" ecosystems in what way.
- Develop and use multiple models to explain the interaction between population change in "white butterfly" and local ecosystem
- Use and interpret graphics, charts and statistics to find relationship between weather, air pollution, hazelnut harvest and population growth of "white butterfly"

Driving Question: How might the population change of "white butterfly" interact with the local ecosystems?

Lesson Assessment: Models and their written explanations

Resources: Data set

Instructional Sequence:

Timing	*Activities*	*Materials/Supplies*
30 min	Students are grouped. Each grub is given data sets with annual weather graphs, air pollution statistics, hazelnut harvest charts, white butterfly population charts. First of all, students are expected to evaluate and relate data within the group.	Data set
30 min	Then they are asked to present their group's deductions to their classmates.	
15 min	Students are guided on issues such as air pollution, global warming, and climate change, and if necessary students can research individually about those issues.	
20 min	After discussions, students are asked to make a model. It is expected that the model will include the causes and possible consequences of the increase in the number of “white butterfly”, taking into consideration the factors influenced by the life cycle of the white butterfly.	
20 min	After the model drawings, students are asked to describe the relationships in the drawings they have made on another sheet.	
5 min	Drawings and explanations are collected together for evaluation purposes.	

Lesson 5: Struggle with "white butterfly"

Time: 80 minutes

Goals for the Lesson:

- Students will explain which factors may influence "white butterfly" ecosystems in what way.
- Students will argue about how to struggle with "white butterfly" in the light of the information of struggle ways as chemical, biological or mechanic. Or; preventing air pollution
- Use and interpret graphics, charts and statistics to find relationship between weather, air pollution, hazelnut harvest and population growth of "white butterfly"

Driving Question: How might the population change of "white butterfly" interact with the local ecosystems?

Lesson Assessment: Responses to the questions in the lesson

Resources: Struggle ways presentation, Local news about struggle ways

Instructional Sequence:

Timing	*Activities*	*Materials/Supplies*
20 min	A presentation prepared by Düzce Provincial Directorate of Agriculture is made to students about how to struggle with "white butterfly"	Struggle ways presentation
20 min	Local news about struggle ways are distrubuted and also discussed after the presentation.	Local news about struggle ways
40 min	In addition to the methods of struggle against "White butterfly" it is expected that students will offer suggestions for preventing the population increase, of "White butterfly" by taking into consideration the living conditions of the "white butterfly". After that, the suggestions are noted and discussed.	

Lesson 6: Biodiversity

Time: 80 minutes

Goals for the Lesson:

- Discuss the effects of interventions on ecosystems, starting with the methods and effects of "white butterfly" struggling.
- Develop and use multiple models to explain the interaction between population change in "white butterfly" and local ecosystem
- Develop explanations to which factors may influence ecosystems in what way
- Question the importance of biodiversity for natural life (MoNE, 7.5.2.1)
- Discuss the threats to biodiversity based on research data and produce solution recommendations (MoNE, 7.5.2.2)

Driving Question: How might the population change of "white butterfly" interact with the local ecosystems?

Lesson Assessment: Models and their written explanations

Instructional Sequence:

Timing	*Activities*	*Materials/Supplies*
15 min	Students argue about how interventions to the environment affect the ecosystems based on struggle with “white butterfly” by guiding of the teacher.	
20 min	It is discussed how interventions that only target one living in ecosystems affect other living things by considering the “white butterfly” and hazelnut example. In this context, the importance of biodiversity is emphasized by considering other ecosystems.	
20 min	After discussions, students are asked to make a model. It is expected that the model will include the causes and possible consequences of the increase in the number of “white butterfly”, taking into consideration the factors influenced by the life cycle of the white butterfly.	
20 min	After the model drawings, students are asked to describe the relationships in the drawings they have made on another sheet.	
5 min	Drawings and explanations are collected together for evaluation purposes.	

Lesson 7: End-of-Unit Classroom Activity

Time: 40 minutes

Goals for the Lesson:

- Students will discuss and make decisions about how to deal with the “white butterfly” problem in a holistic context

Driving Question: How might the population change of “white butterfly” interact with the local ecosystems?

Lesson Assessment: Students' arguments during the activity

Instructional Sequence:

Students are asked who is affected by the white butterfly problem. According to the requests, students are divided into groups such as farmers, agricultural directorates, agricultural engineers, factory owners.

The groups first discuss the way in which they should follow the white butterfly problem among themselves. Then a panel environment is created where the groups come together and each group presents their own ideas and suggestions. The groups listens each other in turn and then go to the discussion section. In cases where it is seen necessary in this process groups can first make internal debate and then reply.

Panel’s environment is monitored by the investigator to be used as an aid to evaluation.

Lesson 8: Assessment

For end-of-unit evaluation, the Objective Comprehension Evaluation test by MoNE is applied.

For assessment linked to the previous lesson, the following questions are asked to the students about the defendant;

1. “Which group represents your group (farmer, factory owner, etc.)?”
2. “Do you agree with the opinions of your group?”
3. “Which of the criticisms directed at your group led you to question your thoughts more?”
4. “Have you joined any of the criticism?”
5. “As a result, what are your views on how to reduce / prevent the damage of “white butterfly” in Düzce?”

C
"White Butterfly" Lesson Materials

Materials of Lesson 1: Local news about "white butterfly", "white butterfly photos

Amerikan Beyaz Kelebeği, Düzcelileri canından bezdirdi [63]

Düzce'de yerleşim alanlarını Amerikan Beyaz Kelebeği tırtılları bastı. 'Yatak odalarımıza kadar giriyorlar' diyen Düzceliler çözüm bulunmasını istiyor

Düzce'de, yaz başından itibaren daha çok fındık bahçelerinde görülen Amerikan Beyaz Kelebeği, yerleşim alanlarındaki bahçe ve binaların duvarlarını da sarmaya başladı. Vali Zülkif Dağlı, belediye başkanları ve ilgili kurum müdürlerini toplayıp kelebekle mücadelede alınacak önlemleri konuştu.

Kentte Haziran ayı başından itibaren fındık bahçelerinde görülen ve yaprakları yiyerek üreticileri zarara uğratan Amerikan Beyaz Kelebeği, son dönemde yerleşim alanlarında etkili olmaya başladı. Kentte evlerin bahçeleri ve ağaçlarda daha çok etkili olan kelebekler, binaların dış cephe duvarlarında da görülmeye başlandı. Birçok noktada görülen kelebek, kent sakinlerini canından bezdirdi.

"YEŞİL DÜZCE, KURTLU DÜZCE OLDU."

Aziziye Mahallesi Muhtarı Aydın Koç, kelebeğin her yerde görüldüğünü, evlerin içine kadar girdiğini söyleyerek şöyle konuştu.

"Artık insanlar bununla mücadele edemiyor. Kurumların mücadelesi yetmiyor. Yeşil Düzce, kurtlu Düzce oldu. Biz yeşil Düzce olarak kalmasını istiyoruz. Ziraat mühendislerinden aldığımız bilgiye göre ben kendi bahçemdeki kelebekle mücadele etsem bile komşum etmediği zaman bir işe yaramıyor. Artık biz bunun uzmanı olduk. Devletin buna çözüm bulması lazım, bütçe hazırlaması lazım. Havadan ilaçlama yapılması lazım. Çünkü yemeklerimize, yatak odalarımıza kadar girdi. İnsanlar canından bezdi. Biyolojik olarak da mikrop yayıyor mu, hastalıklara neden oluyor mu bilmiyoruz. Bunu çok ciddiye alıyoruz. İnşallah gerekli önlemler alınır. Bütün meyvelerimiz de bu şekildi. Bu meyveleri yiyoruz. Bu konuda yetkililerden yetkili ve etkili çözüm üretilip sonuçlar alınmasını istiyoruz."

Mahalleli Nagihan Çıtak da, "Özellikle sabahları çok oluyor. Geceden duvarlara birikiyorlar. Sabahları temizliyoruz. Ancak evin içine kadar giriyor. Akşamları tekrar kontrol ediyoruz. Tek tük kalanlar oluyor. Onları da temizliyoruz" dedi.

Öte yandan Vali Zülkif Dağlı, belediye başkanları ve ilgili kurum müdürleri ile valilikte toplantı yaparak kelebekle mücadelede alınacak önlemleri konuştu. Vali Dağlı, toplantıda alınacak kararların daha sonra açıklanacağını söyledi.

Düzce'de Amerikan Beyaz Kelebeği vatandaşın kâbusu oldu [60]

Düzce'nin birçok noktasında etkili olan Amerikan Beyaz Kelebeğinden özellikle çiftçiler ve vatandaşlar dertli. Vatandaş "İlaçlama yaptık ama faydası olmadı" derken, valilik konuyla ilgili kurum müdürleri ile toplantı yaptı.

Düzce'de birçok alanda etkili olan ve halk arasında tırtıl olarak bilinen Amerikan Beyaz Kelebeği vatandaşları canından bezdirdi.

İHA'nın haberine göre, vatandaşlar evleri saran böcekler için yetkililerin bir an önce yardım istiyor. Karaca Mahallesi'nde yaşayan Aziz Gökçe isimli vatandaş, "Böceklerin ilaçlanması gerekiyor. Evlerin içine kadar girebiliyorlar. Yetkililerin ilaç yapmasını bekliyoruz. Vatandaşlar da ilaç yapıyorlar ama hem etkili olmuyor hem de vatandaşlar ilaç yaparken ağaçlara zarar veriyorlar" dedi.

Karaca Mahallesi Muhtarı Bahattin Gümüş, böceklerin evlerin duvarlarında gezdiğini belirterek, "Evlerin duvarlarına kadar çıkıyorlar. Ağaçlardaki yaprakları yiyorlar. Böyle giderse gelecek yıl Düzce kurak bir şehir olacak. Yetkililerden bu böcekler için çözüm bulmasını ve ilaç yapılmasını istiyoruz. Öyle ki böcekler camilerimizin bahçesindeki ağaçlara ve cami duvarlarını da sardılar.

Cami bahçesinde oturan cemaatin üzerine ağaçlardan ve duvarlardan düşüyorlar. Bu suretle böcekler camilerin içine kadar giriyorlar. Cami cemaati de birbirinin sırtından böcekleri temizliyor. Hem namazını kılıyor hem de böceklerle mücadele etmeye çalışıyor" ifadelerinde bulundu.

74 yaşındaki Mehmet Canpolat ise "Her tarafta böcekler var. Geçen sene de vardı ama bu sene arttı. Hatta fındıklara bile saldırıyorlar. Evlerde, evlerin duvarlarında dolu var. Böceklerle yaşamak zor olur ama ne yapalım" şeklinde konuştu.

“White Butterfly” Photos (Relatively Pupa, Egg Clusters, Larva, Buuterfly)

Materials of Lesson 2: "School way" activity, Ecosystem photos

Okul yolu aktivitesi

Öğretmen tahtanın bir ucuna ev diğer ucuna ise okul çizer. Daha sonra öğrencilerden sırayla okula giderken yolda neler gördükleri söylemelerini ister. Öğrenciler saydıkça tahtaya; başka evler, arabalar, insanlar, elektrik direkleri, çöp kovaları, kediler, köpekler, kuşlar vs. eklenir.

Daha sonra öğrencilere aslında yolda olan ama çizimde göremediğimiz şeyler nelerdir diye sorulur. Öğrencilerden hava, toprak, egzoz dumanı gibi cevaplar alınır.

Tahtadaki çizimlerden sonra öğrencilere projeksiyonla orman görseli gösterilir.

Daha sonra iki görsel arasında bağlantı kurulması istenir.

Ortamlardaki canlı cansız varlıklar gruplandırılıp ortak noktalardan yola çıkılarak ekosistem, tür, habitat ve popülasyon kavramlarının tanımları yapılır ve analojik olarak eşleştirilir.

Orman Ekosistemleri

Dağ Ekosistemleri

Çöl Ekosistemleri

Deniz (Tuzlu Su) Ekosistemleri

Materials of Lesson 3: "White butterfly" brochure, "white butterfly" presentation

Tanımı Yaşayışı ve Zarar Şekli

Kelebeğin esas rengi beyaz, bazı erkek ve dişi bireylerde üst kanatlarda siyah nokta şeklinde lekeler mevcuttur. Krem renginde olan yumurtalarını paket halinde bırakır, bir sıvı ile birbirine ve yaprağa yapıştırır.

Amerikan beyaz kelebeği ergini ve yumurtaları

Kışı pupa halinde geçirir. Kışlayan pupalardan çıkan birinci döle ait kelebek uçuşu mayısın ilk haftası ile üçüncü haftasında, ikinci döle ait kelebek çıkışları ise temmuzun üçüncü haftasında olur. Dişiler yumurtalarını genel olarak yaprakların alt yüzlerine bırakırlar. Larvalar yumurtadan çıkarken, yumurta kabuklarını kısmen yiyerek yuvalarını örmeye başlarlar.

Amerikan beyaz kelebeği larvası

Zararlı, ağaçların toprak ile birleştiği yerlerde, ağaç kabuğunda ve çok yaşlı ağaçların kovuklarında, binaların çatı saçakları arasında bir koza içinde pupa olur. Yılda 2-3 döl verir.

Amerikan beyaz kelebeği pupası

Yumurta kümelerinden çıkan larvalar, yapağın alt yüzünde ipeksi ağlar örer, sonra ağı artırmak suretiyle daldaki diğer yapraklarla ilk yaprağı bağlarlar ve ağlar içinde beslenirler.

Amerikan beyaz kelebeği zararı

Olgunlaşmaya başlayan larvalar ağ kümelerinden çıkarak bireysel yaşamaya başlar ve yaprakları sadece ana damarları kalacak şekilde yerler. Ayrıca körpe ve olgunlaşmaya başlayan meyveleri de yiyerek ürünün azalmasına veya tamamen yok olmasına neden olurlar.

Amerikan beyaz kelebeği zararı

MÜCADELESİ

Mekanik Mücadele

Kısa gövdeli ağaçlara bırakılan yumurta paketleri toplanıp bahçeden uzaklaştırılmalıdır.

Haziran ve ağustos aylarında zararlı ile bulaşık ağaçlarda ağ içinde bulunan larva kümeleri kesilip bahçeden uzaklaştırılmalıdır.

Birinci ve ikinci dölün çıktığı aylarda(haziran-ağustos) zararlı ile bulaşık ağaçlarda 3-4 cm eninde oluklu karton şeritler(tuzak bantlar) veya 50-60 cm uzunluğunda ve 10-15 cm eninde telis çuval ve benzeri kuşaklar ağaçların gövdelerinde bir veya iki yerde iple sarılmalıdır.

Ağ ile birlikte toplanan larva kümeleri, içinde larva ve pupa bulunan kuşaklar, parazitoit çıkışına izin veren ancak zararlının doğaya bulaşmasını engelleyen tel kafeslere konularak zararlının imha edilmesi sağlanır. Ancak doğal düşmanların çıkışı sağlanır.

Biyolojik Mücadele

Pupaların %70'in üzerinde parazitlenebildiği saptanmıştır. Doğal dengeyi bozmamak amacıyla özellikle dut ve orman alanlarında bulunan zararlının mücadelesi mutlaka biyopreparatlarla yapılmalıdır.

Kimyasal Mücadelesi

Zorunlu olmadıkça kimyasal mücadele uygulanmamalıdır. Ancak, popülasyonun yüksek olduğu veya zararlının epidemi yaptığı yıllarda kimyasal mücadele önemli olmaktadır.

Ancak kimyasal mücadele yapılırken doğal düşmanlarının varlığı düşünülmeli ve doğal düşmanlara en zararsız olan preparatlar kullanılmalıdır.

Kimyasal mücadele; Haziran (1.döl), Ağustos (2.döl), 3.döl çıkarsa Eylül ayında larvalar epidermis arasından çıkıp ağlarını örmeğe başladıkları zaman(larvalar 2.ve 3. dönemde) veya yumurta kümelerindeki bütün yumurtalar açıldığında başlamalıdır. Fındık yetiştirilen alanlarda eylül ayından itibaren yağmurların başlaması ve özellikle geceleri hava sıcaklıklarının düşmesi nedeniyle 3.döl zarar yapmamaktadır. Her döle karşı bir ilaçlama yapılır ve yeterlidir.

KULLANILACAK BİTKİ KORUMA ÜRÜNLERİYLE İLGİLİ OLARAK REÇETE YAZMA YETKİ BELGESİNE SAHİP KİŞİLERE BAŞVURULMASI GEREKMEKTEDİR

BİTKİ KORUMA ÜRÜNLERİ ÖNERİLEN DOZDA VE ZAMANDA KULLANILMALIDIR

Hazırlayan: Çiğdem KÖSE
Ziraat Müh.

ÇİFTÇİ EĞİTİM SERİSİ
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FINDIK ARAŞTIRMA İSTASYONU MÜDÜRLÜĞÜ

AMERİKAN BEYAZ KELEBEĞİ
(*Hyphantria cunea*)

GİRESUN-2013

1

AMERIKAN BEYAZ KELEBEĞİ

2

Pupa Evresi

3

Larva/Tırtıl Evresi

4

Kelebek Evresi

Amerikan Beyaz Kelebeği beyaz renkli olup, bazı bireylerde üst kanatlarda siyah lekeler vardır. Kışı pupa halinde geçirir. Mayıs ayının ilk haftasında erginler çıkar. Yumurtalarını yapraklara bırakır. Larvası siyah renkli olup, üzerinde turuncu renkli benekler ve bu beneklerden çıkan kıllar bulunur.

5

Amerikan Beyaz Kelebeği Yumurta kümelerinden çıkan larvalar yaprağın alt yüzeyinde ağ örerek diğer yaprakları da birleştirirler. Larvalar sadece yaprak damarları kalacak şekilde beslenirler. Ayrıca olgunlaşmaya başlayan meyveleri de yiyerek zarar yaparlar.

6

Amerikan Beyaz Kelebeğinin Zarar Verdiği Bitkiler
Dut, kiraz, elma, armut, erik, vişne, fındık, ceviz, asma, ve şerbetçiotu.

- Amerikan Beyaz Kelebeği anavatanı ABD olup 1975 yılından itibaren Ülkemizde görülmektedir.
- İlimizde yaklaşık 15 yıldır görülmekte ve yılda iki dönemde (Haziran ve Ağustos sonu Eylül başı), son zamanlarda Nisan aylarında başlayıp 3 dönemde görülmektedir.
- 4-5 yılda bir popülasyonda bir yükselme görülmektedir.
- İklim ve besin ihtiyacı böceğin yaşam alanlarını belirlemektedir.
- Çok fazla sayıda yumurta yaptığından yeni alanlara bulaşması hızlı olabiliyor.

- Kışlamış formları Mayıs aylarında kelebek olarak ilk çıkışlarını yaparak yeni nesil bireyleri oluşturmak amacıyla yumurta paketlerini ağaçların yapraklarının alt yüzeylerine koyarlar.
- Yapraklarla beslenen tırtıllar kese oluşturup ağ örerek yaşamlarına devam ederler.
- Beslenmesini tamamlayan her birey kışlamak için toprağın çatlakları, çatı araları ve evlerin duvarlarına tırmanırlar.

9

Amerikan Beyaz Kelebeğinin Davranışları

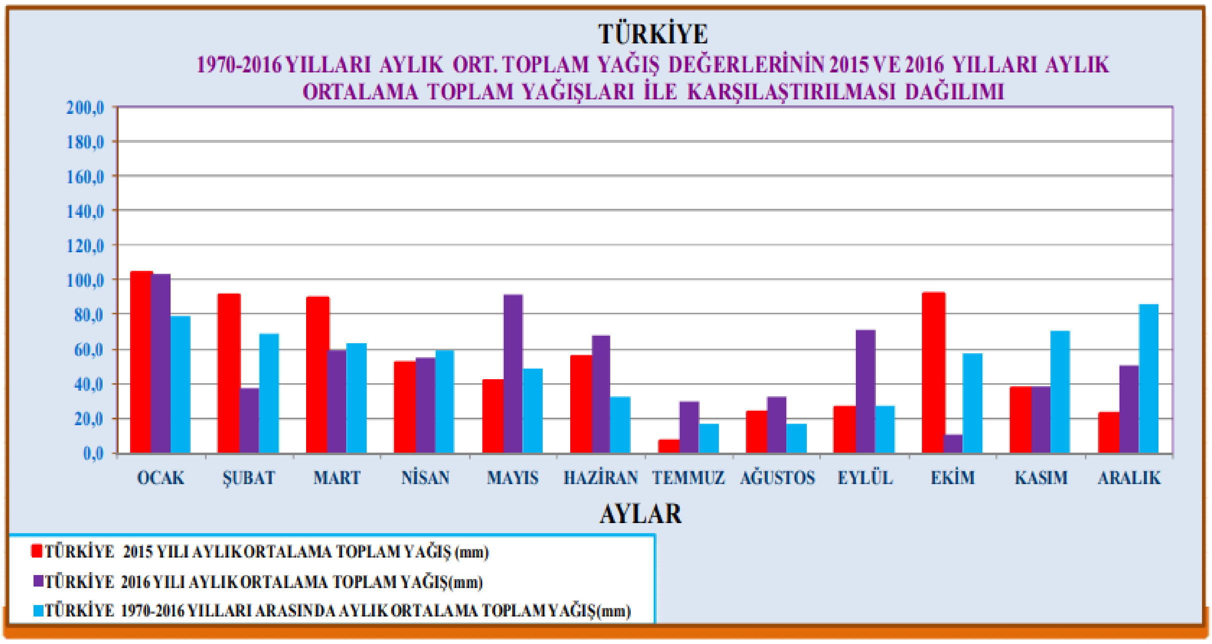
- Erginler kilometrelerce uçabilir. Erkekler daha uçucudur.
- Erginler geceleri uçar gündüzleri dinlenir.
- Yumurtalarını dalların ucuna doğru yer alan yapraklara koymayı tercih eder. Yumurtalarını yaprağa kuvvetlice yapıştırdığı için şiddetli yağmur yağsa bile yumurtalar yerinde kalır.
- Yumurtadan çıkan genç larvalar yaklaşık 10 gün ayrılmadan birlikte beslenir. Genç larvaların hayatta kalması için bu önemlidir.
- Genç larvalar beslenirken aynı zamanda yaprakları içine alacak şekilde ağ örerler. Ağlar bazen birden fazla dalı ve yapraklarını içine alır.

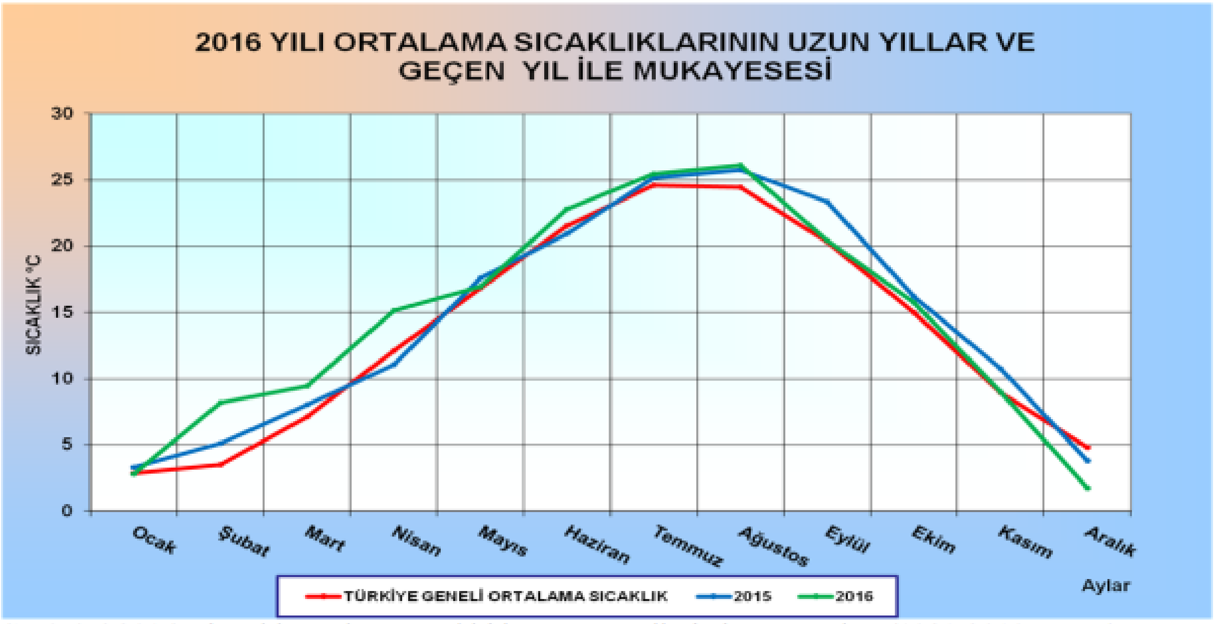
10

Materials of Lesson 4: Data Set

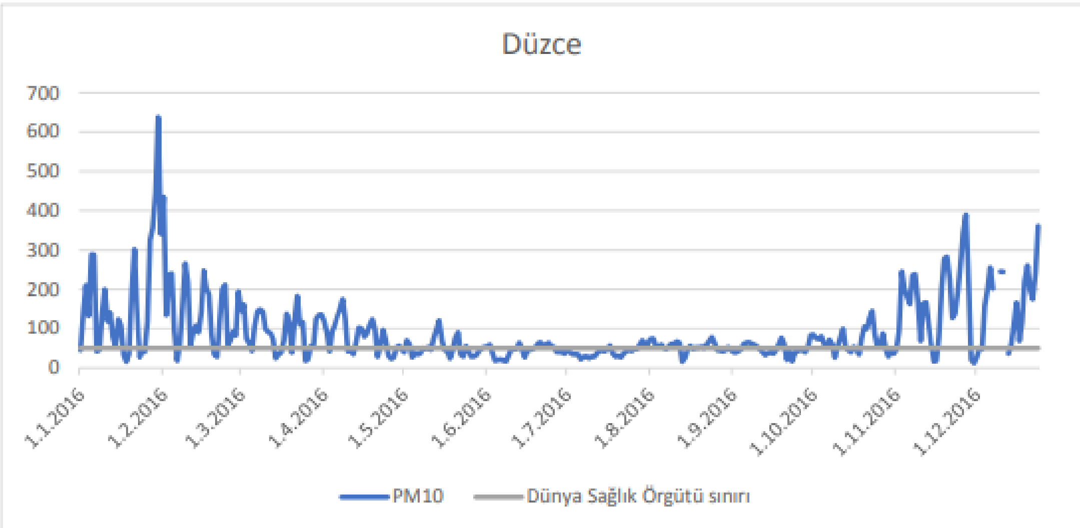
DUZCE	Ocak	Şubat	Mart	Nisan	Mayıs	Haziran	Temmuz	Ağustos	Eylül	Ekim	Kasım	Aralık	Yıllık
	Ölçüm Periyodu (1962 - 2016)												
Ortalama Sıcaklık (°C)	3.8	5.2	7.8	12.3	16.7	20.5	22.6	22.4	18.7	14.3	9.6	5.8	13.3
Ortalama En Yüksek Sıcaklık (°C)	8.1	10.1	13.4	18.8	23.3	27.0	29.0	29.0	25.8	20.7	15.5	10.1	19.2
Ortalama En Düşük Sıcaklık (°C)	0.3	1.2	3.4	7.2	11.1	14.5	16.8	16.8	13.3	9.7	5.1	2.2	8.5
Ortalama Güneşlenme Süresi (saat)	1.5	3.6	3.5	5.2	7.0	8.4	9.1	8.3	6.4	4.2	2.5	1.5	61.2
Ortalama Yağışlı Gün Sayısı	15.3	13.6	13.7	12.3	11.6	9.6	6.3	6.0	7.7	11.0	12.1	15.4	134.6
Aylık Toplam Yağış Miktarı Ortalaması (mm)	90.5	70.1	73.6	60.7	62.0	59.0	42.5	51.1	51.5	81.3	81.4	102.3	826.0
	Ölçüm Periyodu (1962 - 2016)												
En Yüksek Sıcaklık (°C)	24.5	26.9	32.2	34.7	39.0	39.0	42.4	42.0	38.3	38.2	30.2	29.2	42.4
En Düşük Sıcaklık (°C)	-20.5	-17.3	-13.6	-3.0	0.4	6.6	8.8	7.6	4.5	-1.2	-6.8	-16.5	-20.5

b) Aylık Toplam Yağış Verisinin 1970-2016 Aylık Ortalama Değerlerinin 2015 ve 2016 Aylık Değerlerle Karşılaştırılması:





Şekil 2.4 2016 yılı aylık ortalama sıcaklıklar ve normallerinden sapmaları (1981-2010'a göre)



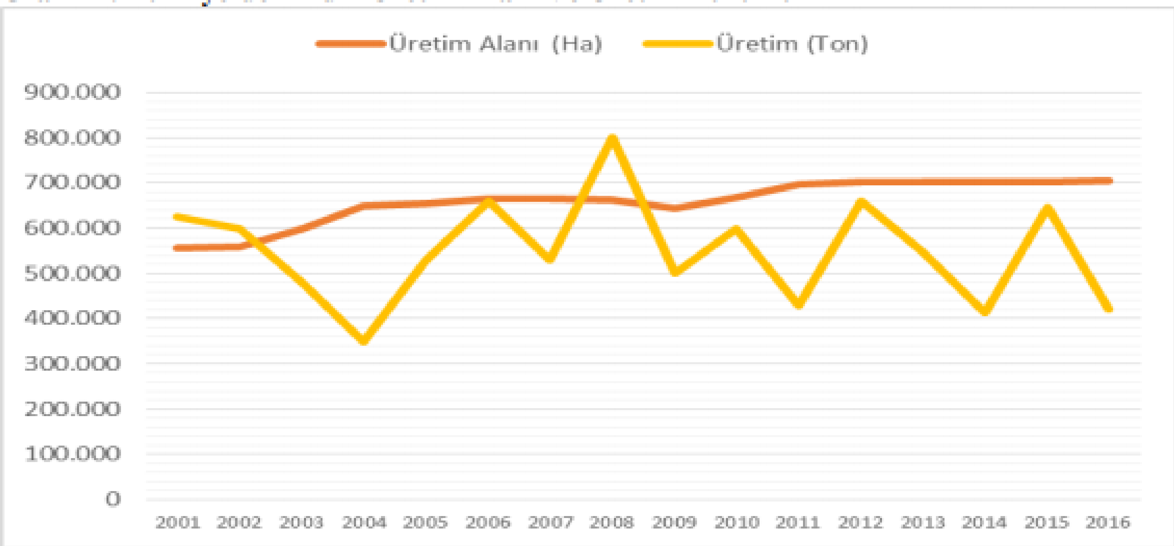
Şekil 3: WHO-DSÖ sınır değeri ve ölçüm sonuçlarının yıl içinde dağılımı (Düzce). (T.C. Çevre ve Şehircilik Bakanlığı, 2016)

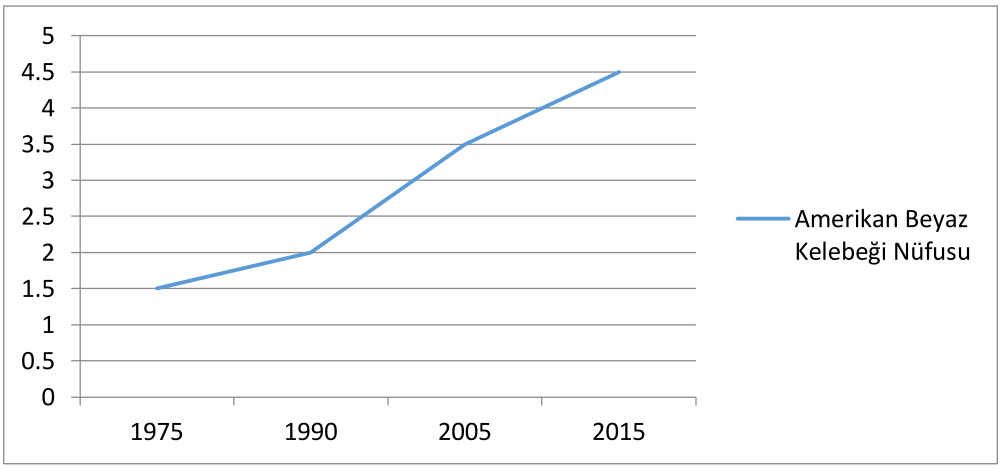
TABLO 6. TÜRKİYE'DE FINDIK YETİŞTİRİLEN İLLER (2015)

İLLER	ÜRETİCİ SAYISI	ALAN (He)	ÜRETİM(Ton)	ORAN %
Artvin	6.189	8.665	6.314	1.0
Bartın	4.286	6.000	6.765	1.1
Bolu	778	1.089	366	0.05
Düzce	44.775	62.685	69.344	10.7
Giresun	83.651	117.111	105.023	16.25
Gümüşhane	573	802	723	0.1
Kastamonu	5.336	7.471	5.213	0.9
Kocaeli	5.758	8.062	7.530	1.2
Ordu	162.274	227.183	200.938	31.10
Rize	2.576	3.607	1.303	0.2
Sakarya	51.856	72.598	82.708	12.8
Samsun	64.731	90.623	90.857	14.0
Sinop	1.215	1.701	1.175	0.2
Tokat	2.001	2.802	3.511	0.5
Trabzon	46.678	65.350	39.126	6.0
Zonguldak	16.852	23.593	22.572	3.5
16 İl Toplamı	499.529	699.341	643.468	99.6
Diğer İller toplamı	2.347	3.287	2.532	0.4
Türkiye Toplam	501.876	702.628	646.000	100

Kaynak: TÜİK-GTHB,2015

Grafik 2: Türkiye'de Fındık Üretim Alanı Ve Üretim Durumu





Materials of Lesson 5: Local news about struggle ways, Struggle ways presentation

Amerikan Beyaz Kelebeği ile mücadelede yeni dönem [64]

Fındık bahçelerinde Düzceli üreticilerin baş belası olan Amerikan Beyaz Kelebeği'ne karşı biyolojik mücadele başladı.

Pilot bölge seçilen Gümüşova Elmacık Köyü'nde fındık bahçesine kelebeğin doğal düşmanı böcek lavaları salındı.

Düzce'nin Gümüşova İlçesi'nde fındıkta Amerikan Beyaz Kelebeği ile biyolojik mücadele başlatıldı. Pilot bölge seçilen Gümüşova Elmacık köyünde, Ziraat Odası, İlçe Tarım Müdürlüğü ve Düzce Üniversitesi işbirliğinde uygulama hayata geçirildi.

Düzce Üniversitesi Ziraat Ve Doğa Bilimleri Fakültesi Bitki Koruma Bölümü Öğretim Üyesi Prof. Dr. Sevcan Öztemiz'in gerçekleştirdiği uygulama öncesinde, zararlının mücadele zamanına karar vermek için ışık tuzakları kuruldu. Işık tuzakları, gece aktif gündüzleri dinlenme halinde olan Amerikan beyaz kelebeğini yakalamak için tercih edildi.

Beyaz kelebeğin ilk dölüne karşı başarılı mücadele gerçekleştirildiğini söyleyen Öztemiz, ikinci dölün zamanlamasını anlatarak, doğru zamanda doğru mücadele ile zararlıya karşı başarılı olunacağını belirtti.

Fındık bahçesinde biyolojik mücadele kapsamında faydalı böcek salındığını söyleyen Öztemiz, bu böceklerin kelebeğin yumurtasını parazitleyeceğini böylece daha yumurta halindeyken böcekle mücadele başlayacağını dile getirdi. Öztemiz, Amerikan beyaz kelebeğinin birçok doğal düşmanı olduğunu da belirtti.

Gümüşova Ziraat Odası Başkanı Mafil Tavlı, Elmacık Köyü'nde Amerikan Beyaz kelebeğinin yoğun şekilde görüldüğünü söylerken, mücadelede için yapılanları anlattı. Köyün her yerine tuzak kurulduğunu söyleyen Tavlı, bir tuzağa yaklaşık 500 kelebeğin yakalandığını belirtti.

Amerikan Beyaz Kelebeği ile Mücadele Yöntemleri

1

Amerikan Beyaz Kelebeği Mücadelesi

YIL	HARCANAN ÖDENEK (TL) (İl Özel İdaresi Kaynağı)
2013	88.500
2014	55.616
2015	83.267
2016	29.670
2017	50.000
TOPLAM	307.053

2

Yöntem 1: Mekanik mücadele

- **Pupaların imhası**- Pupalar bina oyuklarında ya da toprak altında saklandıkları için bitkilere çıkış yollarına yapışkanlı oluklu kartonlar yerleştirilerek pupaların buralara yapışıp kalması ile bitkilere ulaşması engellenir. Belirli aralıklarla yenilenen kartonlar toplanarak imha edilir.

3

4

Yöntem 1: Mekanik mücadele

- **Tırtıl kümelerinin imhası**- Çok yüksek olmayan ağaçlardan ve fındık ocaklarından tırtıl kolonileri toplanarak imha edilmelidir. Çiftçilerin yaprakları sürekli kontrol ederek yumurta bırakılmış yaprakları kesmesi ile olur. Zamanında yapıldığında bu yöntem oldukça etkilidir. Yüksek ağaçlar için teleskobik budama makasları kullanılabilir.

5

6

Yöntem 1: Mekanik mücadele

- **Kelebeklerin imhası**- Çekici görsel tuzaklar ya da elektrikli cihazlar kullanılarak kelebeklerin belli bir noktada toplanması ve toplandıktan sonra imha edilmesidir.

7

Çekici Görsel Tuzak Asılması



8

Yöntem 2: Biyolojik mücadele

- **Doğal düşmanların korunması**- Amerikan Beyaz Kelebeğinin çok sayıda doğal düşmanı vardır. Avcı arılar, örümcekler, kuşlara ilave olarak değişik asalak ve avcı böcekler Amerikan Beyaz Kelebeği ile beslenmektedir. Doğal düşmanların korunması ve sayısının arttırılması ile Amerikan Beyaz Kelebeklerinin nüfuslarının azaltılması mümkündür.

9

Yöntem 4: Bakteri ile Biyolojik Mücadele

- *Bacillus thuringiensis* (Bt) bakterisinden elde edilen bakteriyel preparat Amerikan Beyaz Kelebeği larvalarına karşı özellikle genç larva dönemlerinde oldukça etkilidir. Bakteri sayesinde kelebekler hastalanarak ölmektedirler. Bütün bitkiyi ilaçlama yerine sadece kolonilerin bulunduğu dallar ilaçlanmalıdır.

10

Yöntem 5: Pestisit Uygulama

- Çeşitli kimyasal ve bakterilerden oluşan pestisit adı verilen karışımlar beyaz kelebeklerin büyümelerini yavaşlatarak olgunlaşmadan ölmelerine sebep olmaktadırlar.

11

Yöntem 6: Kimyasal Mücadele

- Kimyasal mücadelede önemli olan tırtıl kolonilerinin mümkün olduğunca erken tespit edilerek ağaçların ilaçlanmasıdır. Kelebek evresine gelindiğinde ilaçlama kelebek uçarak yer değiştirdiği için etkili değildir. Ayrıca zaten ağaçlara zarar tırtıl döneminde verilmektedir.

1. *Diflubenzuron: Dimilin SC 48, Kormilin WP vd..*
2. *Triflumuron: Alsystin WP 25, Also 25 WP, vd..*
3. *Cypermethrin*

12

13

14

Bu mücadelelerin etkili olabilmesi için halk bilinçli olmalıdır; bunun için halka düzenli eğitimler verilmelidir.

- Köy ve Mahalle Muhtarlarına Zararlının Anlatılması

Materials of Lesson 8: Objective Comprehension Evaluation test by MoNE

Ölçme, Değerlendirme
ve Sınav Hizmetleri
Genel Müdürlüğü

Kazanım Kavrama Testi **12**

7. SINIF
FEN BİLİMLERİ

İnsan ve Çevre

1. Aşağıda verilenlerden hangisi popülasyon örneği değildir?

A) Van Gölü'ndeki inci kefalleri
B) Amazon Ormanlarındaki ağaçlar
C) Aladağlardaki kızılçamlar
D) Karadeniz'deki hamsiler

2. Bir ekosistemi oluşturan faktörlerden bazıları aşağıda verilmiştir.

1. Toprak	5. Rüzgar
2. Su	6. Tilki
3. Mantar	7. Güneş ışığı
4. Sincap	

Buna göre, bu faktörlerin "canlı" ve "cansız" olarak gruplandırılması hangi seçenekte doğru verilmiştir?

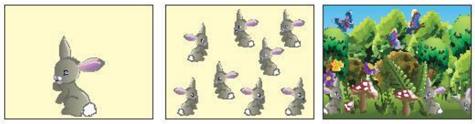
	Canlı faktörler	Cansız faktörler
A)	1, 3, 4, 6	2, 5, 7
B)	3, 4, 6, 7	1, 2, 5
C)	1, 2, 3	4, 5, 6, 7
D)	3, 4, 6	1, 2, 5, 7

3. Tabloda verilen açıklamalar ile kavramlar eşleştirildiğinde hangi kavram açıkta kalır?

Açıklamalar	Kavramlar
• Belirli bir bölgede yaşayan canlı ve cansız varlıkların karşılıklı etkileşim halinde olduğu yaşama birliği	• Popülasyon
• Bir bölgede yaşayan aynı türe ait canlıların oluşturduğu topluluk	• Tür
• Bir canlı türünün doğada yaşadığı, ürediği bölge	• Ekosistem
	• Habibat

A) Tür B) Popülasyon
C) Ekosistem D) Habitat

4.



I II III

Numaralanmış görseller ile ilgili, aşağıdaki ifadelerden hangisi söylenemez?

A) I. tür, II. popülasyon, III. ise ekosistem örneğidir.
B) Toprak ve su, III.nün cansız faktörlerindendir.
C) III., I ve II.deki canlıların habitatıdır.
D) Mikroorganizmalar ve hava, III.nün faktörleri arasında yer almaz.

5. I. Bitki
II. Hayvan
III. Mantar
IV. Mikroskobik canlılar

Yukarıda verilenlerden hangileri bir ekosistemin biyo-çeşitlilik yönünden zengin olmasını sağlar?

A) I ve II. B) I, II ve III.
C) I, II ve IV. D) I, II, III ve IV.

6. I. Deniz
II. Hava
III. Çöl

Verilenlerden hangileri ekosistem örneğidir?

A) Yalnız I. B) Yalnız III.
C) I ve III. D) II ve III.

7.

Kaktüs Deve

Yukarıda verilen canlılarla ilgili,

I. Habitatları aynıdır.
II. Aynı popülasyonda yer alırlar.
III. Çöl ekosisteminin canlılarıdır.

ifadelerinden hangileri doğrudur?

A) Yalnız I. B) I ve III.
C) II ve III. D) I, II ve III.

8. Bir öğrenci hazırladığı tabloda, çeşitli ekosistemlere ait özellikleri numaralayıp yazmış ve bu özelliklerin hangi ekosisteme ait olduğunu işaretleyerek belirtmiştir.

	EKOSİSTEMLER			
	Orman	Çöl	Deniz	Göl
I. Tatlı su ekosistemleridir.				✓
II. Ağaç ve çalılık bol miktarda bulunur.	✓			
III. Canlı türü ve sayısı oldukça azdır.		✓		
IV. En zengin besin kaynağı mercanlardır.			✓	

Bu öğrencinin yaptığı işaretlemelerden hangileri doğrudur?

A) I ve II. B) II ve III.
C) II, III ve IV. D) I, II, III ve IV.

9. **Aşağıdakilerden hangisi biyo-çeşitliliği tehdit eden faktörlerden biri değildir?**

A) Organik tarım B) Erozyon
C) Aşırı avlanma D) Küresel ısınma

10. **Aşağıda verilen durumlardan hangisi, yağmur ormanlarında canlı çeşitliliğini etkileyen çevre faktörlerinden biri değildir?**

A) Yağış miktarının fazla olması
B) Topraktaki mineral yoğunluğunun az olması
C) Sıcaklığın normal değerlerde olması
D) Doğal kaynakların zengin olması

11.

1. Sincap	4. Vatoz
2. Moa	5. Mamut
3. Panda	6. Afrika fili

Bir dergide verilen yukarıdaki tablodan; Eda, dünyada nesli tükenmekte olan canlıları; Yusuf ise nesli tamamen tükenmiş canlıları seçecektir.

Buna göre Eda ve Yusuf'un yaptığı seçimler, verilenlerden hangisi olmalıdır?

	Eda	Yusuf
A)	1, 2 ve 5.	3, 4 ve 6.
B)	3 ve 5.	2, 4 ve 6.
C)	3, 4 ve 6.	2 ve 5.
D)	4, 5 ve 6.	1, 2 ve 3.

12. **Aşağıdaki seçeneklerden hangisi biyo-çeşitliliğin korunması için alınan önlemlerden değildir?**

A) Bilinçsiz ve aşırı avlanmanın önüne geçilmesi
B) Geri dönüşüme önem verilmesi
C) Besin zincirinin devamlılığının sağlanması
D) Toprağın sık aralıklarla bol miktarda gübrelenmesi

Bu testin cevap anahtarına ulaşmak için yandaki karekodu okutunuz.

D

Permission Letter

T.C.
DÜZCE VALİLİĞİ
İl Milli Eğitim Müdürlüğü

Sayı : 10240236-20-E.10068514 23/05/2018
Konu : Araştırma İzni

VALİLİK MAKAMINA

İlgi : a) 22/08/2017 tarihli ve 35558626-10.06.01-E.12607291 sayılı (2017/25) Genelge.
b)Yıldız Teknik Üniversitesi Fen Bilimleri Entitüsü Müdürlüğünün 09/05/2018 tarihli ve E.1805090489 sayılı yazısı.

Yıldız Teknik Üniversitesi Matematik ve Fen Bilimleri Eğitimi Anabilim Dalı Fen Bilgisi Eğitimi (İngilizce) tezli yüksek lisans öğrencisi Benzegül ÇELİK'in ilgi (b) yazı ekinde bulunan **"Yerel Ekosisteme Özgü Beyaz Kelebek Türü Üzerinden Geliştirilen Sosyo Bilimsel Temelli Ünite ile Ortaokul Öğrencilerinin Bilimsel Modele Dayanan Muhakeme Becerilerinin Gelişiminin İncelenmesi (Tehe Effect of Socioscientic Issue Based İnstruction on Science Literaccy of Middele School Students)"** konulu tezi kapsamında ilimiz merkezinde bulunan Konuralp Ortaokul 7. sınıf öğrencilerine uygulamak istemektedir.

Uygulamaya yönelik izin talebi, ilgi (a) Genelge'de belirtilen esaslar doğrultusunda incelenmiştir. Söz konusu araştırmanın eğitim ve öğretimi aksatmayacak şekilde, gönüllülük esasına dayalı olarak uygulanması ve uygulamalarda sadece ekte bulunan mühürlü formun kullanılması şartı ile yürütülmesi Müdürlüğümüzce uygun mütalaa edilmektedir.

Makamlarınızca da uygun görüldüğü takdirde Olurlarınıza arz ederim.

Murat YİĞİT
İl Milli Eğitim Müdürü

OLUR
23/05/2018

Adem KELEŞ
Vali a.
Vali Yardımcısı

Ek:
1-Mühürlü Form (10 sayfa)
2-Komisyon Kararı (1 sayfa)

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Publications from the thesis

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Conference Papers

1. Çelik, B. and Topçu, M. (2018). Student Development of Model-Based Reasoning about Ecological Interactions in Modeling- Centered Local Socioscientific Issues Based Unit. In: *International Science and Mathematics Education Congress*. İstanbul: ERPA, p.205.