REPUBLIC OF TÜRKİYE

YILDIZ TECHNICAL UNIVERSITY

GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

DEVELOPMENT AND IMPLEMENTATION OF THE SUSTAINABLE DEVELOPMENT GOALS UNIT: EXPLORING STUDENTS' SYSTEMS THINKING SKILLS AND ETHICAL REASONING

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DOCTOR OF PHILOSOPHY THESIS

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Aslı KOÇULU

Signature

Dedicated to my precious family

and the great leader and hero Mustafa Kemal ATATÜRK…

'Science is the most reliable guide for civilization, for life, for success in the world. Searching a guide other than the science is meaning carelessness, ignorance and heresy.'

Mustafa Kemal ATATÜRK

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Aslı KOÇULU

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LIST OF ABBREVIATIONS

EDR	Educational Design Research
ERiA	Ethical Reasoning in Action
ESDG	Education for Sustainable Development Goals
NGSS	Next Generation Science Standards
NRC	National Research Council
SD	Sustainable Development
SDGs	Sustainable Development Goals
STS	Systems Thinking Skills
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNGA	United Nations General Assembly
WCED	World Commission on Environment and Development

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ABSTRACT

Development and Implementation of the Sustainable Development Goals Unit: Exploring Students' Systems Thinking Skills and Ethical Reasoning

Aslı KOÇULU

Department of Mathematics and Science Education

Doctor of Philosophy Thesis

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In today's world, one of the crucial lessons is to teach students how to think of the world as a system and reason ethically for sustaining our world while improving well-being for people and all living all over the world. Education for Sustainable Development Goals (ESDG) in K-12 education can help improve middle school students' systems thinking skills and ethical reasoning and thus, it can enable students to see the world as a system and take informed decisions by reasoning ethically to achieve sustainable development goals (SDGs). However, there is a lack of educational material to put into practice regarding sustainable development goals (SDGs) at K-12 levels. Therefore, the current study aims to address this need through educational design-based research, leading to the development and evaluation of the implementation of a learn–think–act approach-based Sustainable Development Goals (SDGs) unit. This unit was implemented for 8 weeks to help develop middle school students' systems thinking skills and ethical reasoning. The research group consists of 20 7th grade students enrolled in the 'Environmental Education and Climate Change' elective course given at a public school in Türkiye. The data of the study on systems thinking skills and ethical reasoning were collected from students through the real-life scenario ('Home' documentary), open-ended

questions related to the scenario, and semi-structured interviews before and after the implementation of the SDG unit. Transcriptions of the open-ended questions and semi-structured interviews were analyzed with deductive content analysis based on the rubrics developed by researcher. As a result of the current study, the Sustainable Development Goals unit was developed based on the learn-think-act approach. In addition, the results showed that the learn-think-act based-Sustainable Development Goals unit developed students' systems thinking skills and ethical reasoning in action.

Keywords: Sustainable development goals, education for sustainable development goals, systems thinking skills, ethical reasoning in action, middle school students

ÖZET

Sürdürülebilir Kalkınma Amaçları Ünitesinin Geliştirilmesi ve Uygulanması: Öğrencilerin Sistemsel Düşünme Becerilerinin ve Etik Muhakemelerinin İncelenmesi

Aslı KOÇULU

Matematik ve Fen Bilimleri Eğitimi Anabilim Dalı

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Günümüz dünyasında en önemli derslerden biri, öğrencilere, dünyanın her yerindeki insanların ve tüm canlıların refahını artırırken aynı zamanda dünyamızı sürdürülebilmek için, dünyayı bir sistem olarak nasıl düşüneceklerini ve etik olarak nasıl akıl yürüteceklerini öğretmektir. K-12 eğitiminde Sürdürülebilir Kalkınma Amaçları Eğitimi, ortaokul öğrencilerinin sistemsel düşünme becerilerini ve etik akıl yürütmelerini geliştirmeye yardımcı olabilir ve böylece, sürdürülebilir kalkınma amaçlarına ulaşmak için, öğrencilerin dünyayı bir sistem olarak anlamalarını ve etik akıl yürüterek, bilinçli kararlar almalarını sağlayabilir. Ancak Sürdürülebilir Kalkınma Amaçları (SKA) konusunda K-12 düzeyinde uygulamaya konulabilecek eğitim materyali eksikliği bulunmaktadır. Bu nedenle, mevcut çalışma, eğitim tasarımına dayalı araştırma yoluyla bu ihtiyacı gidermeyi ve öğren-düşün-harekete geç yaklaşımına dayalı Sürdürülebilir Kalkınma Amaçları (SKA) ünitesinin geliştirilmesi ve uygulanması yoluyla değerlendirilmesini amaçlamaktadır. Bu ünite ortaokul öğrencilerinin sistemsel düşünme becerilerini ve etik muhakeme becerilerini geliştirmeye yardımcı olmak amacıyla, 8 hafta boyunca uygulanmıştır. Araştırma grubu, Türkiye'deki bir devlet okulunda 'Çevre Eğitimi ve İklim Değişikliği' seçmeli dersine kayıtlı 20 7. sınıf öğrencisinden

oluşmaktadır. Araştırmanın sistemsel düşünme becerileri ve etik akıl yürütmeye ilişkin verileri, öğrencilerden gerçek yaşam senaryosu ('Ev' belgeseli), senaryoya ilişkin açık uçlu sorular ve yarı yapılandırılmış görüşmeler aracılığıyla Sürdürülebilir Kalkınma Amaçları ünitesinin uygulanmasından önce ve sonra toplanmıştır. Açık uçlu soruların ve yarı yapılandırılmış görüşmelerin transkripsiyonları araştırmacı tarafından geliştirilen rubriklerle, tümdengelimli içerik analizi ile analiz edilmiştir. Sonuç olarak, bu çalışmayla, ortaokul öğrencilerine yönelik öğren-düşün-harekete geç yaklaşımına dayalı Sürdürülebilir Kalkınma Amaçları ünitesi geliştirilmiştir. Ayrıca, sonuçlar öğren-düşün-harekete geç yaklaşımına dayalı Sürdürülebilir Kalkınma Amaçları ünitesinin ortaokul öğrencilerinin sistemsel düşünme becerilerini ve etik muhakeme becerilerini geliştirebildiğini göstermektedir.

Anahtar Kelimeler: Sürdürülebilir kalkınma amaçları, sürdürülebilir kalkınma amaçları için eğitim, sistemsel düşünme becerileri, etik muhakeme, ortaokul öğrencileri

1
INTRODUCTION

1.1 Literature Review

If we sought to solve the problems in the world and make it a better place for all, what goals should we include? Throughout history, people everywhere have faced significant environmental, economic, social and political challenges. For the purpose of coping with these challenges and redirecting humanity towards a sustainable path, 193 countries came together on 20-22 June 2012 at the United Nations Conference on Sustainable Development (or Rio+20) in Rio de Janeiro, Brazil and developed the new global framework considering surveys covering thousands of actors and millions of people from all over the world in a three-year process. This global effort led to the adoption of the 2030 Agenda for Sustainable Development involving 17 Sustainable Development Goals (SDGs) by the United Nations General Assembly (UNGA) on 25 September 2015 (UN, 2015). The universal, transformational, and inclusive SDGs describe the goals thought necessary to cope with local and global challenges for the survival of our world. The purpose of the SDGs is to end local and global challenges that people and other living have been facing and present a global road map for the sustainability of world now and in the future by 2030 (Rieckmann, 2017; United Nations, 2015). In other words, the SDGs were designed for us to take action together on environmental, economic and social challenges like poverty, hunger, health issues, quality education, inequalities, water, energy, climate change, responsible consumption, peace, justice and many other issues related to a sustainable future.

The aim back in 2015 was to actively promote the concept of a global community of citizens with common responsibility to take action towards achievement of all SDGs for the benefit of all people and other living things and for the sustainability of our planet (UNESCO, 2013). However, achieving the SDGs is not a simple task but a complex process and requires a profound transformation in our thinking and reasoning skills. Therefore, we must consider how we can prepare learners of all ages and reconsider what and how we teach to promote the knowledge, attitudes,

skills, competences, values and ethics that help us to make wise decisions and take responsible actions individually and collectively for both local and global challenges (UNESCO, 2020). Integrating the SDGs into K-12 education (specifically called Education for Sustainable Development Goals (ESDG)) is so necessary to prepare students from early ages because it promotes learners' content knowledge, skills, emotions, values, ethics, world views and actions they need to achieve SDGs and to make positive impacts both locally and globally (Ferrer-Estévez & Chalmeta, 2021; Munkebye et al., 2020; Rickinson et al., 2009; Sleurs, 2008).

ESDG is the well-designed educational approach that brings local and global issues into K-12 classrooms and thus, it helps students make wise decisions and implement responsible actions for economic viability, environmental integrity and well-being of society for present and future (Rieckmann, 2017). Students can deal with growing complexity, rapid changes, debatable knowledge claims and unavoidable uncertainty if they learn the SDGs during their K-12 education (Lotz-Sisitka et al., 2015; Hurd & Ormsby, 2020). However, most of the studies in the literature have focused on the teaching of SDGs in higher education and university students' perceptions, knowledge, and awareness about the SDGs (e.g., Avelar et al., 2019; Bezeljak et al., 2020; Brien et al, 2015; Chankseliani & McCowan, 2021; García-González et al., 2020; Giangrande et al., 2019; Albareda-Tiana et al., 2018; Cottafava et al., 2019; Jati et al., 2019; Kopnina, 2018, 2020a,b; Krishna et al., 2022; Kwee, 2021; Leal Filho et al., 2020; 2021; Leiva-Brondo et al., 2021; Manolis, 2020; Novieastari et al., 2022; Omisore et al., 2017; Owens, 2017; Parkin et al., 2004; Smaniotto et al., 2020; Timm & Barth, 2021; Zamora-Polo et al., 2019) while there is a very few research on teaching of the SDGs in K-12 education (e.g., Hoang et al., 2020; Eli et al., 2020; Summers & Kruger, 2003; Wheeler, 2023).

One of the reasons for limited teaching of the SDGs in K-12 levels continues to be the lack of educational materials (learning tools) necessary for students to put into practice the SDGs at K-12 levels (Lee, 2008; Mckeown, 2002; Venkataraman, 2009). Broadly there remains a requirement to develop educational materials that can enable the introduction of the SDGs and to improve students' skills in classes systematically (Leal Filho et al., 2022). Therefore, the first aim of this thesis is to

help address this deficit by presenting a method for generating educational resources (the SDGs Unit) thought necessary to educate students about the sustainable development goals in K-12 education.

ESDG focuses on the progress and strengthening of higher-level competencies for the purpose of enabling learners to participate in and contribute to achieving sustainable development goals processes of different kinds and dimensions (Rieckmann, 2017). One of the higher-level competencies that can be developed by ESDG is systems thinking skills (STS) (Armenia et al., 2022; Capra & Luisi, 2014; de Haan, 2010; Meadows, 2008; Rieckmann, 2012, 2017; Schuler et al., 2018; Sleurs, 2008; Wiek et al., 2011a,b).

Systems thinking skills (STS) is recognized as one of 21st century skills in science education and can be defined as the abilities to analyze complex systems, to recognize and comprehend relationships of components in the system; to consider how systems are embedded within different domains (e.g. environment, economy, society etc.) and different scales (e.g local to global); and to deal with uncertainty (de Haan, 2010; Rieckmann, 2012; Wiek et al., 2011a). National Research Council (NRC) (2012) emphasized that K-12 students should gain systems thinking skills (STS) to grasp and solve the complex challenges of todays' world. In advanced learning, systems thinking skills (STS) are one of the most crucial higher order thinking skills, but some of the most difficult skills to improve. (Molderez & Ceulemans, 2018; Hung, 2008). In the current literature, there are several studies about developing students' systems thinking skills in K-12 education. For instance, Ben-Zvi Assaraf and Orion (2005) examined the development of eighth-grade students' system thinking skills on the hydro cycle in an earth systems-based curriculum. This curriculum included laboratory and outdoor learning inquiry-based activities about the water cycle taxonomy and the transportation of water in earth systems. Their research showed that most of students' system thinking skills made some meaningful progress and some students demonstrated the highest STS level when addressing the hydro cycle. In another study, Evagorou et al. (2009) investigated whether a simulation-based learning environment (a marsh ecosystem) is effective on the progress of students' system thinking skills at elementary level. The interactive simulations highlighting the dynamic nature of systems were used

to simulate the ecosystem of a marsh in the learning environment. The results indicated that the system thinking skills of elementary school students can be developed in a simulation-based learning environment including marsh ecosystem. In another study in K-12 education, Riess and Mischo (2010) explored the effectiveness of special lessons and a computer-simulated scenario in the field of Education for Sustainable Development including the 'ecosystem forest' topic on promoting sixth-grade students' systems thinking in German secondary schools. In their research, four different methods were applied in the implementation process. A first group of students participated in special lessons including a teaching unit on systems thinking. A second group took a course including a computer-simulated scenario whereby learners could experience the short- and long-term dynamics of a forest as a cultivated ecosystem. A third group of students took a course combination of a unit on systems thinking and a computer simulation forest game. The fourth group was taught traditionally consistent with the formal curriculum. According to their findings, students in those groups with both special instruction and computer simulation showed important progress in their conceptual understanding and a reflexive justification of systems thinking. Elsewhere, Ben-Zvi Assaraf and Orion (2010a) examined the progress of 4th grade students' system thinking skills through the hydro-cycle in an inquiry-based earth systems curriculum. The educational program consisted of lab simulations and experiments involving knowledge integration activities and interaction with the hydro-cycle' components and processes in outdoor learning. They concluded that students' system thinking skills were minimal at the beginning and after implementation, most students' systems thinking skills made significant progress and some progressed to a higher level. In another study, Lee et al. (2011) reported on the development of an educational program about global warming that sought to improve high school students' system thinking skills. In this case, students were taught global warming, its effects and its relationships with earth systems. Students with low-level system thinking were seen to have enhanced their STS about global warming, the earth and its sub-systems while the group with high-level systems thinking indicated more organized STS about global warming after the intervention. In other research, Raved and Yarden (2014) examined the effect of a unit about the human circulatory system on the systems thinking skills of junior high school students. The unit covered 12 hierarchical learning activities based on the stages of

systems thinking skills. The findings revealed that junior high school students' systems thinking skills improved significantly in terms of recognizing the system' components and the processes, the relationships among different levels of organization of the system, and organizing the systems' components and processes in relationships framework. In another study, Gero and Danino (2016) examined the enhancement of 12th grade students' systems thinking skills through the 'Introduction to Engineering Design' course developed and implemented in Israel. During the course students were asked to plan and implement a real-time control system for an electric motor. The results indicated students' systems thinking skills developed significantly to a large effect size. Hrin et al. (2017) investigated the effect of a different learning environment (systemic approach including systems synthesis questions) on the improvement and assessment of students' systems thinking at high school level. In the scope of the research, a group of students followed the new instructional tool that was based on systemic approach including systemic synthesis questions while other group of students participated in traditionally-oriented instruction about organic chemistry. The findings proved that the experimental group exposed to the systemic synthesis questions reached the highest level of systems thinking. Another study about developing systems thinking conducted by Vachliotis et al. (2021) investigated the effect of a systems approach to teaching and learning strategy to 11th grade students. The study reported on their knowledge of chemistry and the improvement of their systems thinking skills. The results revealed that there is an important relationship between students' learning of chemistry concepts and their levels of systems thinking. In another study, Rachmatullah and Wiebe (2022) examined the effects of paper-based pictorial and computational modeling activities on seventh-grade students' systems thinking. Here, students in a control group learned about simple food web concepts through online module activities and by working through worksheets and drawing food webs. Students in the experimental group learned the energy transfer concept in a simple food web model through computational modeling activities. According to the results, seventh-grade students' systems thinking showed significant increases in both conditions. Another study by Hopper and Stave (2008) examined the systems thinking interventions used in educational settings in K-12 classrooms and proposed an initial set of guidelines to measure and raise an individual's systems thinking level.

As understood from the related literature, systems thinking skills have been a topic for research in a different context such as the earth, biology, climate, global warming, chemistry, ecology, engineering design, medicine, geology and sustainability and environmental issues encountered at different levels of education from pre-school to university level. While systems thinking skills are thought crucial in ESDG contexts, research on the advancement of K-12 students' STS is very rare.

Unlike other studies in the literature, this current study focuses on the improvement of systems thinking skills through the implementation of a learn-think-act based Sustainable Development Goals unit. The approach of ESDG is also closely linked with STS and it may not be practical to focus on them separately because the SDGs provide a basis for integrating them (Cavana & Forgie, 2018; Gregory & Miller, 2014; Hofman, 2015; Hofman-Bergholm, 2018; Mambrey et al., 2020; Reynolds et al., 2018; Wells & McLean, 2013). Systems thinking skills are a necessity if citizens are to make informed decisions about sustaining life on this planet (Jacobson et al., 2015). ESDG can improve students' STS since it enables students to think of possible solutions for both local and global issues by linking the economic, environmental and social aspects and other aspects of problems (Capra & Luisi, 2014). This way of thinking fully coincides with systems thinking, which is often reflected in attempts at interdisciplinary teaching and learning (Sleurs, 2008). Complex issues like SDGs in K-12 education can trigger the development of advanced systems thinking skills identified as the abilities to grasp and interpret complex systems because systems thinking is based on the main idea that the world is a complex system where everything is interconnected in the form of systems with interrelated parts (Draper,1993; Evagorou et al. 2009; Lee et al., 2019; Sleurs, 2008).

Developing students' systems thinking skills through ESDG in K-12 education is thought crucial for several reasons. The National Research Council (NRC) (2012) identifies STS as 21st century skill in science education and K-12 students' systems thinking should be developed to understand and solve the complex challenges of todays' world. ESDG in K-12 helps students understand their world as a complex system which has interconnected and interrelated parts, and the importance of the

world to themselves and future generations. In addition, ESDG in K-12 help students to think systematically and this help them explore local and global issues and their links to their own lives (Capra & Luisi, 2014; Holshouser & Medina, 2021). Therefore, students can understand that their lifestyle choices affect the world deeply and they can learn to find solutions for everyone to live better and make sustainable living a habit. In addition, they can be motivated to act, that everyone can and should do something to take care of our world. In this way, students and communities can be prepared to engage in transformative change and life-long learning, and to actively engage with sustainable development goals throughout their lives. According to Hofman-Bergholm (2018), systems thinking is often the missing tool, one that is necessary to develop the holistic thinking required for us to work toward a sustainable and better future for all. English (2006) and Forrester (2007) stated that improving STS takes less time if it starts at elementary school level, since young learners can be more open minded and less conditioned to perceive the world in terms of unidirectional cause and effect. Open-mindedness makes it easier for students to develop systemic thinking skills (Wamsler, 2018). Therefore, the second aim of this research was to develop students' STS through a learn-think-act based SDG unit suitable for K-12 education.

Another higher-level competency that can be developed by ESDG is ethical reasoning (Guerra et al., 2021; Keitsch 2018). Such skills are thought crucial and there is evidence that employers all around the world look for professionals with advanced ethical reasoning abilities in todays' world. However, the nurturing of ethical decision-making skills is seldom evident in our education systems (Hart Research Associates, 2013; Lau, 2010; Martin, 2008). In the literature, there are several studies about developing students' ethical reasoning in K-12 education. For instance, DeHaan, Hanford, Kinlaw, Philler and Snarey (1997) investigated the effect of three teaching strategies (introductory ethics class, a blended economics-ethics class, a role-model ethics class, a non-ethics comparison class) in terms of promoting students' ethical reasoning at high school level. The findings show that different approaches to teach ethics improved students' ethical reasoning considerably. Another study conducted by McQuaide, Leinhardt, and Stainton (1999) investigated high school students' ethical reasoning when experiencing a computer simulation of a workplace environment. They revealed that students

selected more responsible actions and ethical reasoning at post-measure hypothetical dilemmas. Smith, Strand and Bunting (2002) examined the effect of an outdoor experiential program (during 15-week) on college students' ethical reasoning. According to their results, the nature of outdoor experiential programs positively affected ethical reasoning. In other study, Hallman (2016) investigated the progress and assessment of student' social responsibility and ethical reasoning, revealing that the advancement of students' social responsibility and ethical reasoning is significant during college education because a strong democracy relies upon citizens with skills like social responsibility and ethical reasoning. Ames et al. (2017) investigated the efficacy of a novel modular-based ethical reasoning program, showing that the program has positive impacts on students with lower-level and higher-level ethical reasoning skills. However, to sustain ER skills, additional programs are necessary. In another study, Smith (2017) examined the advancement of students' ethical reasoning abilities through the application of fidelity methodologies to an academic program using the simple model framework for learning development. The results showed that there were significant improvements in students' ethical reasoning skills statistically and practically. Hornor (2021) investigated the strength of college students' confidence in their own ethical reasoning skills over a four-year ethics curriculum, confirming that students' confidence in their own ethical reasoning skills increased after completion of the curriculum.

As understood from the literature, ethical reasoning has been studied in several ways. However, although ethical reasoning skills are thought crucial in ESDG contexts, research exploring K-12 students' ethical reasoning skills in the ESDG context are very rare.

Education for SDGs in K-12 education can be an important way to enhance students' ethical reasoning since SDGs can be thought of as an ethical agenda that encourages and cooperates for the integration of a new global morality (Guerra et al., 2021). The SDGs are considered as an ethical movement because they ensure today's benefits for future generations (Guerra et al., 2021). Ethics can be identified as a form of moral philosophy that describes what is good or bad for both individuals and society, and addresses the nature of obligations/duties that

individuals owe themselves and to each other (Singh, 2015). As in the ethics, universal values like Sustainable Development Goals carry 'the hope of a better world and of a common home better cared for by all' that has not yet been realized (Gadotti, 2010; Guerra et al., 2021). In this respect, ethics is fully interlinked with the Sustainable Development Goals and vice versa. In other words, ethics and SDGs complement and justify each other (Guerra et al., 2021). For instance, social, economic and gender equality cannot be achieved by society without attending to ethical issues. In addition to this, justice and the ending of poverty and hunger could guarantee clean drinking water and a quality education for all while sustaining a more supportive, ethical and egalitarian society, and where sustainable development is an outcome (Guerra et al., 2021). Commitment to ethics could help to facilitate the realization of the SDGs because ethics presents a prescriptive guidance framework on what should be done to guarantee good for both individuals and society, irrespective of the applicability or absence of a legal obligation (Singh, 2015). In other words, achieving SDGs is a an ethical/moral duty which one is not legally bound to fulfill, but which one owes and should perform. Therefore, achieving SDGs without the key international law instruments and enforcement mechanisms require a problem-solving mindset based on ethics in order to deliver on SDG promises.

SDGs have a potential to raise ethical implications (Keitsch, 2018; Khayesi ,2021). For instance, SDGs raise ethical issues in the human–nature relationship directly with regards to sustainable resource use and in the limits of ecosystems, and equal opportunities or just distribution indirectly (Brandi, 2015; Gupta & Vegelin, 2016). To guarantee the survival and quality of life, sustainable development goals should be achieved by balancing the environmental, economic and social aspects in an ethical and equitable manner. Local and global challenges we are facing as humanity highlight a critical requirement for developing decision making skills because ethical shortcomings are very common in our society (James Madison University, 2013; Sanchez et al., 2017; Smith et al., 2017) Sternberg (2012a,b) highlighted that there are no easy answers or solutions to local or global problems we are facing in our modern society. Therefore, ethical reasoning can and should be taught to students in the curriculum all over the world. Sternberg (2012a, 2015). Teaching ethical reasoning helps students make compelling decisions wisely

covering ethical issues. Moreover, he stated that teaching ethical reasoning is important because if our teaching does not promote ethical reasoning, it is not useful for life (Sternberg, 2012a, 2015). Sugahara, Urasaki, Wei and Boland (2010) discovered that ethics learning experiences obtained in secondary schools were useful for enhancing ethical reasoning abilities in the forthcoming years. In order to foster ethical reasoning skills in K-12 education, it is important to develop effective approaches to foster learning outcomes that are congruent with ethical reasoning (Hallman, 2016). Thus, the third aim of this thesis is to develop students' ethical reasoning abilities with ESDG.

1.2 Objective of the Thesis

The main purpose of this research was to develop and implement a learn-think act based Sustainable Development Goals unit that help (1) develop middle school students' systems thinking skills and (2) middle school students' ethical reasoning. In accordance with this purpose, the learn-think-act approach based Sustainable Development Goals unit was developed for middle school students and the development of middle school students' systems thinking skills and ethical reasoning were explored with the implementation of Sustainable Development Goals unit.

1.3 Research Questions

The research questions of this study were as follows:

Research Question 1 (RQ 1): How can be developed and implemented the learn think-act approach-based unit for Sustainable Development Goals?

Research Question 2 (RQ 2): How can middle school students' systems thinking skills be developed through the learn-think-act approach-based unit for Sustainable Development Goals?

Research Question 3 (RQ 3): How can middle school students' ethical reasoning skills be developed through the learn-think-act approach-based unit for Sustainable Development Goals?

1.4 Original Contributions

This research makes some unique/crucial contributions to the related literature in terms of several points. First, most of the studies in the relevant literature have focused the teaching of the SDGs in higher education and university students' perception, knowledge and awareness about the SDGs (e.g., Avelar et al., 2019; Bezeljak et al., 2020; Brien et al, 2015; Chankseliani & McCowan, 2021; García-González et al., 2020; Giangrande et al., 2019; Albareda-Tiana et al., 2018; Cottafava et al., 2019; Jati et al., 2019; Kopnina, 2018, 2020a,b; Krishna et al., 2022; Kwee, 2021; Leal Filho et al., 2020; 2021; Leiva-Brondo et al., 2021; Manolis, 2020; Novieastari et al., 2022; Omisore et al., 2017; Owens, 2017; Parkin et al., 2004; Smaniotto et al., 2020; Timm & Barth, 2021; Zamora-Polo et al., 2019) while there little research effort has been expended on the implementation of the SDGs in K-12 education (e.g., Hoang et al., 2020; Eli et al., 2020; Summers & Kruger, 2003; Wheeler, 2023).

One of the reasons for so few studies of teaching the SDGs at K-12 levels is the lack of educational materials (e.g. units) to put into practice the SDGs for K-12 levels (Lee, 2008; Mckeown, 2002; Venkataraman, 2009). Leal Filho et al. (2022) emphasized that it is an important necessity to develop educational materials that may help introduce the SDGs in classes systematically (Leal Filho et al., 2022). The present research aimed to present an important educational resource (SDGs unit) to train students about sustainable development goals which provides a global blueprint for a sustainable and better future and develop their systems thinking skills and ethical reasoning. In this respect, this research can contribute to the literature in the field of education for sustainable development goals about the training of middle school students for a sustainable future and improve crucial life skills like systems thinking and ethical reasoning.

Second, in the literature, there are several studies about developing students' systems thinking skills (Ateskan & Lane, 2017; Aubrecht et al., 2019; Ben-Zvi Assaraf & Orion, 2005, 2010a,b; Ben-Zvi Assaraf et al., 2013; Can, 2020; Claesson & Svanström, 2015; Connel et al., 2012; Doganca Kucuk & Saysel, 2018; Dutton-Lee, 2015; Eberbach et al.,2021; Ekselsa et al., 2023; Evagorou et al., 2009; Feriver, 2022; Feriver et al., 2022; Gero & Danino, 2016; Gilissen et al., 2020; Glissen et al., 2020; Hopper & Stave, 2008; Hrin et al., 2017; Jin et al., 2019; Karaarslan,

2016; Karaarslan Semiz & Teksöz, 2020; Lee et al., 2011; Orion & Basis, 2008; Öztaş, 2018; Prabawani et al., 2022; Rachmatullah & Wiebe, 2022; Raved & Yarden, 2014; Remington-Doucette et al., 2013; Riess & Mischo, 2010; Ritchie, 2017; Sandri, 2013; Vachliotis et al., 2021; Tejeda & Ferreira, 2014; Sheehy et al., 2000; Shepardson et al., 2014; Sommer & Lucken, 2010; Tripto et al., 2013, 2016, 2018 ; Zulauf, 2007). As understood from this body of literature, STS has been a research topic in different contexts such as the earth, climate, global warming, ecology, biology, chemistry, engineering design, geology, environmental issues and sustainability in different levels of education from pre-school to elementary or middle schools to higher education levels. However, there is no research that has specifically focused on the development of students' systems thinking skills through education relating to the sustainable development goals. It has however been established that the complexity and interrelatedness of the global problems that sustainable development goals comprise can help students develop systems thinking skills. Implementing SDGs at K-12 help students put systems thinking into practice in a dynamic way (Reynolds et al., 2018). As change agents, equipping students with systems thinking skills is crucial for a better world and sustainable future (Demssie et al., 2023). However, there is lacking research about systems thinking-orientated ESDG learning tools that demonstrate the effectiveness of such learning tools on STS in the literature (Green et al., 2021). Therefore, this research aimed to develop middle school students' systems thinking skills through a SDGs unit with practical applications.

Third, the current research makes an original contribution in terms of developing students' ethical reasoning through ESDG. In the literature, there are several studies about developing students' ethical reasoning (Ames et al., 2017; Bielby et al., 2011; DeHaan et al., 1997; Hallman, 2016; Hornor, 2021; Lewis et al., 2019; McQuaide et al., 1999; Smith et al., 2002; Sugahara et al., 2010; Smith, 2017; Vesala-Varttala et al., 2021; Willey et al., 2012). The development of ethical reasoning skills through ESDG is vital both for living an ethical and sustainable life and building a sustainable and ethical world for all. ESDG can enhance students reason ethically on many scales (i.e environment, economic, social) rather than on one scale (i.e only environment) (Schlottmann, 2008). In addition, developing students' ethical reasoning help them assess their own beliefs and values, consider critically about

ethical issues, and apply an ethical reasoning process to take sound decisions about local and global issues (Hornor, 2021). Enhancing students' ethical reasoning with ESDG help students make decisions by thinking economic, environmental, and to try and understand the social consequences for future generations of human and non-human beings. (Biedenweg et al., 2013). Although developing ethical reasoning has many afore mentioned benefits, no research can be found about developing ethical reasoning through ESDG in the literature. Education for Sustainable Development Goals (ESDG) can have fruitful outcomes to improve students' ethical thinking (Vesala-Varttala et al., 2021). Therefore, this research aimed to present learn-think-act based SDGs unit that enhance middle school students' ethical reasoning skills.

1.5 Limitations and Assumptions

The limitation of this study was given at below:

- The implementation period is limited to the Spring semester of 2022-2023 academic year.

The assumption of this study was given at below:

- It is assumed that the students participating in the research gave sincere answers to the data collection tools that would reflect their real situations.

1.6 Definitions

Sustainable Development (SD): 'the development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987, p.43).

Sustainable Development Goals (SDGs): 17 global goals adopted by the United Nations in 2015 which are a universal call to achieve by 2030 to end local and global challenges that people and other living have been facing and present a global road map for people, planet, prosperity, peace and partnership (UN,2015)

Education for Sustainable Development Goals (ESDG): Education that aims to teach learners the knowledge, attitudes, skills, competences, emotions, values, ethics, world views and actions to address interconnected local and global challenges (i.e poverty, hunger, lack of water, different kinds of inequalities, lack

of quality education, climate change, unsustainable use of resources, and economic growth etc.) and make informed decisions and take action individually and collectively to transform society and care for the planet now and in the future (Rieckmann, 2017)

Systems Thinking Skills (STS): the abilities to analyze complex systems; recognize and comprehend relationships among components of systems; to consider how systems are placed within different domains (e.g., environment, economy, society) and different scales (e.g., local to global), and to deal with uncertainty (de Haan, 2010; Rieckmann, 2012; Wiek et al., 2011a).

Ethical Reasoning in Action (ERiA): the decision-making process where individuals make moral judgements on what is right or wrong by weighing the benefits and potential consequences of their actions (Alkhuzaee et al., 2022; Sternberg, 2012a,b).

2
RESEARCH BACKGROUND

2.1 Sustainable Development

In today's world, sustainable development is a widely used and significant term that is now used all over the world. Sustainable development is continually evolving and this makes it doubly difficult to define (McKeown, 2002). It can be defined mainly as 'the development that meets the needs of the present without compromising the ability of future generations to meet their own needs' (WCED, 1987, p.43). Sustainable development includes three intertwined dimensions: environmental, social and economic and there are intrinsic links among environmental, social and economic well-being (Torjman, 2000) (Figure 2.1).

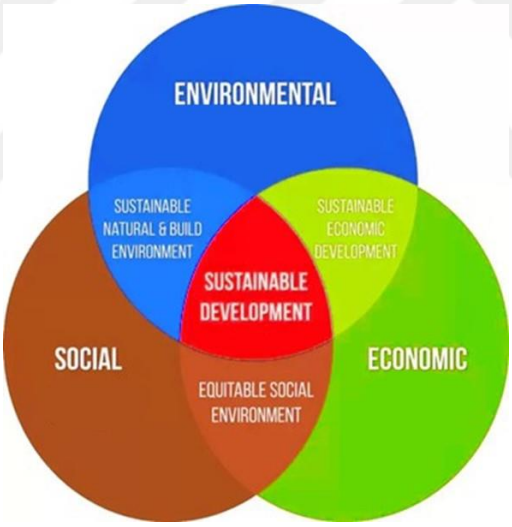


Figure 2.1 Three dimensions of sustainable development

The dimensions of sustainable development are defined as (Harris, 2000, p.5-6):

> 'Environmental dimension: The environmental dimension includes maintaining a stable resource base, consuming non-renewable resources only as far as investment in adequate substitutes and avoiding over-explotation of renewable resource systems or environmental sink functions, maintenance of biodiversity, atmospheric stability, and other ecosystem functions.

Social dimension: The social dimension involves achieving distributional equity and adequate provision of social services (e.g gender equity, health, education etc.).

Economic dimension: The economic dimension covers abling to produce goods and services on a continuing basis, to avoid extreme imbalances damaging industrial or agricultural production, and to maintain manageable levels of government and external debt.'

2.2 Sustainable Development Goals (SDGs)

In order to transform our world and redirect humanity towards a sustainable path, the UNGA adopted 17 Sustainable Development Goals (SDGs) and 169 targets (the 2030 Agenda for Sustainable Development) on 25 September 2015 (UN, 2015) (Figure 2.2). The Sustainable Development Goals (SDGs) (also known as the Global Goals) are a universal call to take action to end global challenges that our global society is facing and to guarantee that by 2030 all people enjoy peace and prosperity (OXFAM,2019; United Nations, 2015).



Figure 2.2 Sustainable development goals (SDGs) (UN, 2015) (Necessary permission to use this image was obtained from United Nations)

The SDGs is a plan of action for people, prosperity and the planet, as well as for universal peace and collaborative partnership (UN, 2015). Therefore, the SDGs can be grouped under 5 pillars (People, Planet, Prosperity, Peace, Partnership). This can help students grasp why achieving sustainable development goals are significant in terms of many aspects like people, prosperity, planet, peace, partnership and how

each goal addressing local or global issues by 2030 (Barakat, et al., 2016; MCIC, 2018) (Figure 2.3).

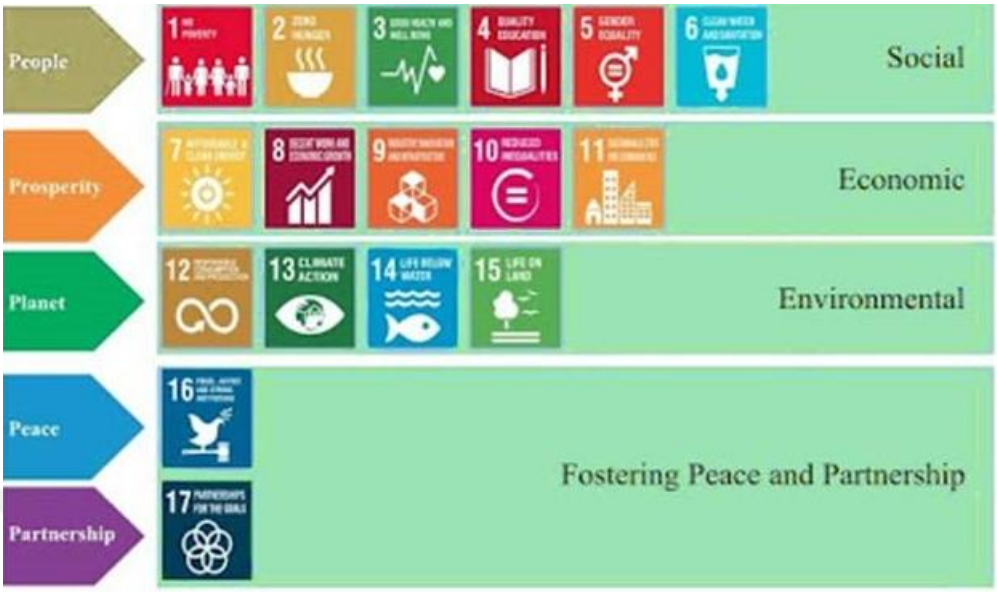


Figure 2.3 Five pillars of sustainable development goals (UN, 2015)

The 'People' pillar includes goals related to the social dimension and these goals aim to end poverty and hunger in all their forms and dimensions and guarantee that all human beings can fulfill their potential in equality and dignity and in a healthy environment (UN,2015) (Figure 2.4). SDG 1, SDG 2, SDG 3, SDG 4, SDG 5 and SDG 6 are the goals in people pillar of sustainable development goals. Explanations about goals are given in Figure 2.4.

	SDG 1: No Poverty End poverty in all its forms everywhere
	SDG 2: Zero Hunger End hunger, achieve food security and improved nutrition and promote sustainable agriculture
	SDG 3: Good Health and Well-Being Ensure healthy lives and promote well-being for all at all ages
	SDG 4: Quality Education Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
	SDG 5: Gender Equality Achieve gender equality and empower all women and girls
	SDG 6: Clean Water and Sanitation Ensure availability and sustainable management of water and sanitation for all

Figure 2.4 'People' pillar of SDGs

The 'Prosperity' pillar includes goals are related to the economic dimension and aim to guarantee that all human beings can enjoy fulfilling and prosperous lives and that social, economic and technological progress occurs in harmony with nature' (UN,2015) (Figure 2.5). SDG 7, SDG 8, SDG 9, SDG 10, and SDG 11 are the goals contained in this pillar of the sustainable development goals. Explanations about these goals are given in Figure 2.5.

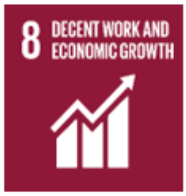
	SDG 7: Affordable and Clean Energy Ensure access to affordable, reliable, sustainable and modern energy for all
	SDG 8: Decent Work and Economic Growth Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
	SDG 9: Industry, Innovation and Infrastructure Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
	SDG 10: Reduced Inequalities Reduce inequality within and among countries
	SDG 11: Sustainable Cities and Communities Make cities and human settlements inclusive, safe, resilient and sustainable

Figure 2.5 ‘Prosperity’ pillar of SDGs

The ‘Planet’ pillar includes goals are related to the environmental dimension and aim to protect the planet from deterioration, involving through sustainable management of natural resources, sustainable consumption and production, and taking urgent action on climate change to support the needs of present and future generations (UN,2015) (Figure 2.6). SDG 12, SDG 13, SDG 14 and SDG 15 are the goals set out in the planet pillar. Explanations about these goals are given in Figure 2.6.

	SDG 12: Responsible Consumption and Production Ensure sustainable consumption and production patterns
	SDG 13: Climate Action Take urgent action to combat climate change and its impacts
	SDG 14: Life below Water Conserve and sustainably use the oceans, seas and marine resources for sustainable development
	SDG 15: Life on Land Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss

Figure 2.6 'Planet' pillar of SDGs

The 'Peace' pillar includes goals related to peace, justice and strong institutions and sets out to promote peaceful, just and inclusive societies which are free from fear and violence (UN,2015). SDG 16 is the single goal in the peace pillar of sustainable development goals. An explanation of SDG 16 given in Figure 2.7.

	SDG 16: Peace, Justice, Strong Institutions Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels

Figure 2.7 'Peace' pillar of SDGs

The 'Partnership' pillar includes goals thought necessary to implement the 2030 agenda through a global partnership based on a spirit of global solidarity with the

participation of all countries, all stakeholders and all people (UN, 2015). SDG 17 is the goal in this pillar and is further explained in Figure 2.8

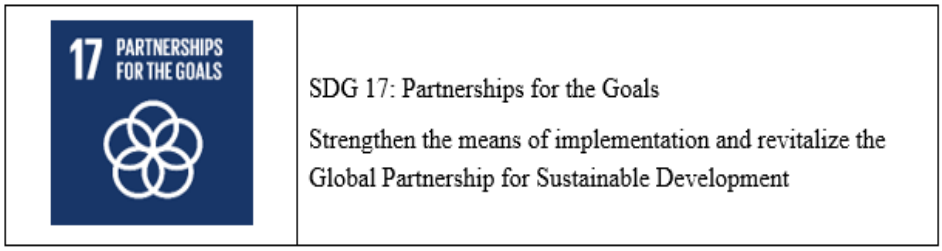


Figure 2.8 'Partnership' pillar of SDGs

2.3 Education for Sustainable Development Goals (ESDG)

Sustainable development goals are complex to teach but achieving all SDGs depends on quality education. Therefore, many of the current forms of education may not be compatible with the sustainable development goals. For instance, education that promotes economic growth only may cause a rise in unsustainable consumption patterns (Hopkins & Mckeown, 2002; Mckeown, 2002; Rieckmann, 2017). In the 2030 Agenda for Sustainable Development, it is emphasized that societies should be environmentally, economically, and socially sustainable to ensure the continuity of humanity and other living without compromising future generations and planet dynamics (Ribeiro & Orion, 2021; UN, 2015). Therefore, teaching sustainable development goals require a transformational and holistic life-long learning process that equip students with knowledge, skills and competences in finding ways and possible solutions to determine and link the environmental, economic and social aspects of global problems (Leite, 2022; Nazar et al., 2018; Rieckmann, 2017). The well-established approach of teaching sustainable development goals has been called 'Education for Sustainable Development Goals (ESDG)' which is an education for the future (Kopnina, 2020a). ESDG encourages everyone to take wise decisions and responsible actions for economic viability, environmental integrity and a just society for present and future generations (Rieckmann, 2017; Sterling, 2016). In other words, ESDG equally addresses all three pillars of sustainable development—environment, economy and society (Venkataraman, 2009). ESDG is a fundamental part of quality education that

promotes cognitive, social and emotional and behavioural dimensions of learning (Odell et al., 2020; Rieckmann, 2018; UNESCO, 2020). Therefore, ESDG has been internationally recognized as a main education strategy to prepare individuals as global citizens with sustainable development' principles and values, the knowledge of sustainable development issues, and the skills and motivation to apply this knowledge to their own actions at local, regional, national and global levels (Öhman & Östman, 2019a; Östman et al., 2019; UNESCO, 2012, 2014a).

Integrating SDGs into K-12 education is crucial if want to raise our students to have necessary knowledge about SDGs, and skills and competencies for being global citizens (UNESCO, 2020). With the ESDGs included in K12 education, students can be educated to think on the current and future environmental, economic social and cultural effects of their own actions from a local and a global perspective (de Haan, 2010; Rieckmann, 2012, 2017; Wiek, et al., 2011a,b). ESDG can help students acquire cognitive, socio-emotional and behavioral learning outcomes so that they can cope with the challenges of each SDG. Rieckmann (2017) determined cognitive, socio-emotional and behavioral learning objectives for each SDG in collaboration with UNESCO. The cognitive learning objectives involves necessary knowledge and thinking skills to grasp the SDGs better and the challenges to achieve SDGs. The socio-emotional learning objectives includes social skills like self-reflection skills, attitudes, values and motivations so that learners can communicate, negotiate and collaborate for SDGs. The behavioral learning objectives covers action competencies. For example, learning objectives for SDG 1 (No Poverty) defined by Rieckmann (2017) are: (1) cognitive learning objective: The learner explains the causes and impacts of poverty, (2) socio-emotional learning objective: The learner shows sensitivity and empathy to the issues of poverty (3) behavioral learning objective: The learner proposes solutions related to poverty. In the present study, the learning objectives about each SDG were determined in line with the objective domains (cognitive, socio-emotional and behavioral) for SDGs described by Rieckmann (2017) in collaboration with UNESCO.

2.4 Learn-Think-Act Approach

A Learn-Think-Act approach is one of the most suitable ways of teaching sustainable development goals (SDGs) as a key pedagogical approach that complements the SDGs and global citizenship in education (OXFAM, 2019). This approach provides an organizational tool for the development of educational activities that enable learners to enhance their points of view about global interdependence and interconnectedness that create the capacity and willingness to act to solve global issues (Putman & Byker, 2020).

The approach involves clear recognition of the relationship between understanding, reflection and action as in SDGs. That is, the approach helps students to learn about local and global issues, to think critically and also find ways to use their learning themselves in meaningful and appropriate way (OXFAM, 2019). A Learn-Think-Act approach provides transformative learning for students by empowering them to change their ways of perceiving and thinking about the world. (Mezirow, 2000; Slavich & Zimbardo, 2012). A Learn-Think-Act Approach enable students explore, develop and express values and opinions and make informed choices about how they engage with SDG issues. A Learn-Think-Act Approach aims to help learners get the knowledge, attitudes, skills, values, and ethics connected with becoming global citizens (OXFAM,2019; Putman & Byker, 2020; UNESCO, 2014a).

A Learn-Think-Act Approach consists of 3 main parts. The ‘Learn’ part of the approach suggests that learners can deepen knowledge and comprehension which supports the improvement of abilities for thinking and acting on SDGs. The ‘Think’ part covers that learners can identify additional learning needs and manage self-directed action they choose to take with creative and critical thinking. The ‘Act’ part encourages learners to further learning and thinking thanks to action and reflection (OXFAM, 2019). With this approach, students engage with activities promoting the improvement of skills like systems thinking and ethical reasoning in action. Education for SDGs is at the interface among learning, thinking and action, with intrinsic or compassionate values at the heart. Enhancing values is accepted as a crucial part of enhancing learners to solve complex bigger-than-self problems like defined in the SDGs (OXFAM, 2019). Figure 2.9 exemplifies how learning and thinking about global issues can catalyze action while taking action often enables

learners to develop their knowledge and understanding of issues and to consider critically both the issues and their action choices.

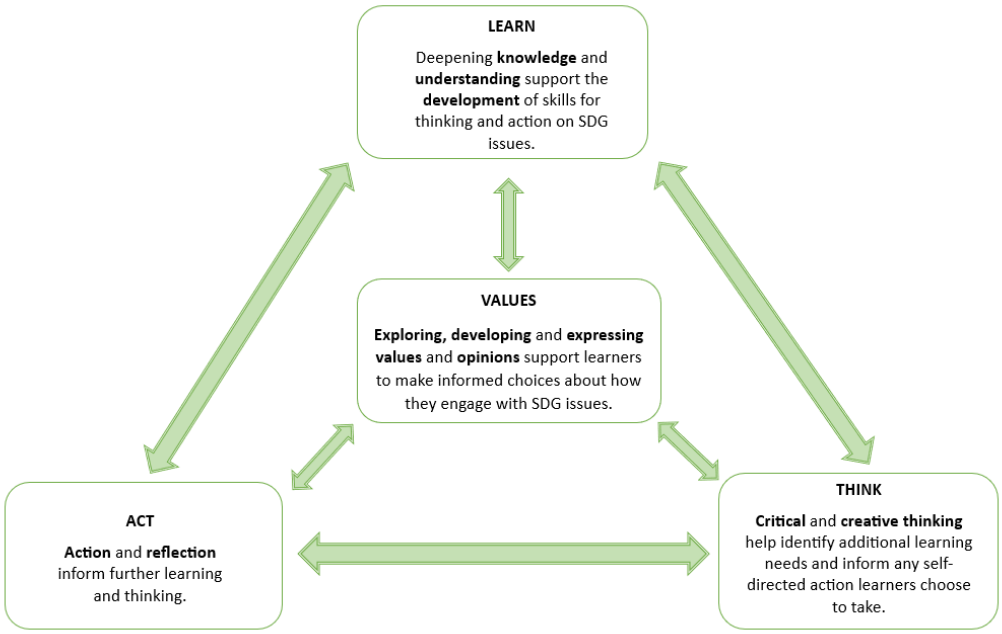


Figure 2.9. Learn-Think-Act framework **(**OXFAM, 2019)

2.5 Systems Thinking Skills (STS)

Complex systems are an increasing and affective part of our lives since globalization has grown and countries have become more interconnected (Arnold & Wade, 2015; Lee et al., 2019; Molderez & Ceulemans, 2018; Richmond, 2010; Sleurs, 2008). Goldstone and Wilensky (2008) emphasized that complex systems include crucial ideas and provides an integrating context across many science domains, for this reason they are a main focus for science education. Understanding complex systems, consisting of many interrelated levels interacting in dynamic ways, is fundamental to comprehending science and also difficult to grasp (Hmelo et al., 2000; Hmelo-Silver et al., 2007; Jacobson & Wilensky, 2006; Liu & Hmelo-Silver, 2009). In science education, system thinking skills are regarded as a basic requirement for us to learn about complex issues, and the functions of complex systems (Elsawah et al., 2021; Evagorou et al., 2009; Jin et al., 2019; Karaarslan Semiz & Teksöz, 2023; Lee et al., 2019; Zhang & Ahmed, 2020). Systems thinking is one of the most valuable educational goals in science education not only since it

can enrich learners' lives in ways that will be meaningful to them as they tackle all manner of complex problems, but also because it is good for society to have citizens who can think systemically (Hogan & Weathers, 2003). Since complex systems comprise of several components interacting among them in different ways, integrating system thinking skills into the teaching global issues like climate change enable a better understanding of its causes, changes, and consequences (Roychoudhury et al., 2017) Systems thinking has increasingly been more important to be scientifically and ecologically literate citizens (Eberbach et al., 2021). Systems thinking help individuals perceive the world as a complex system and supports the understanding of its interrelationships and interconnectedness (Kasser et al., 2013). The complexity and interconnectedness of the world requires thinking in systems (Sleurs, 2008). The National Research Council (NRC) (2012) recognized systems thinking as 21st century skills and defined 'the ability to understand how an entire system works, how an action, change, or malfunction in one part of the system affects the rest of the system; adopting a big picture perspective on work. It includes judgment and decision-making; system analysis; and systems evaluation as well as abstract reasoning about how the different elements of a work process interact' (pp. 63–64). Similarly, Next Generation Science Standards (2013) put systems thinking skills at the forefront as a crucial cross cutting concept across multiple STEM domains. Therefore, systems thinking skills is widely seen as of critical importance across many different fields such as business, agricultural production systems, the provision of national health services, environmental conflict management, natural resource management, human resource management, organisational learning and change, education, decision making and consensus building, social theory and management, philosophy, biology and sustainability issues, etc. (Nguyen et al., 2012). Skillful use of STS could have prevented the disasters like the Great Depression, the Challenger space shuttle disaster and World War II, or at least decreased or avoided the impacts of many major environmental disasters (Arnold & Wade, 2017). In addition, systems thinking skills can enhance the economy, technology, health care, international relationships, schools, laws, organizations, etc. Although systems thinking are very useful skills, they are not sufficiently emphasized in mainstream education (Arnold & Wade, 2017). Our world is complex and interconnected. Therefore, our students should be able to think in a holistic manner rather than to rely on fragmented ways

of thinking like seeing problems in isolation or being limited to only considering short-term solutions. By enabling our students to be systems thinkers, we can help them to see issues as a whole and put their thinking into practice by organizing their learning both inside and outside of school.

System thinking is regarded as a high order thinking skill and can be improved in K-12 levels with a long-term curriculum (Ben-Zvi Assaraf & Orion, 2010a; Kali et al., 2003). The Earth is recognized as one of the largest possible systems forming a countless number of sub-systems (Mehren et al., 2018). With the systems approach to Earth science research in education, students can investigate all the different aspects of the Earth's components and phenomena as a single system and grasp the connection between different research fields related to the earth's various environments (Batzri et al., 2015). Systems thinking describes the world as consisting of interacting systems. Systems thinking is a form of holistic thinking (Sterling et al., 2005). Ben-Zvi Assaraf and Orion (2005) developed and presented eight emergent hierarchic characteristics of STS in the context of earth systems. This model consisted of three sequential levels and was structured in a hierarchical pyramid structure in the context of earth systems education. The three levels are: (a) analysis of system components (characteristic STS 1); (b) synthesis of system components (characteristics STS 2, STS 3, STS 4, STS 5); and (c) implementation (characteristics STS 6, STS 7, STS 8). Each group of skills is used as the basis for the development of the next level's skills (see Table 2.1). In the present research, the systems thinking skills hierarchical model developed by Ben-Zvi Assaraf and Orion (2005) was taken into consideration.

Table 2.1 Systems thinking skills hierarchical model

Hierarchial Level	**Systems Thinking Skills**
Analysis of system components	1- The ability to identify the components of a system and processes within the system.
Synthesis of system components	2- The ability to identify simple relationships between or among the system's components.
	3- The ability to identify dynamic relationships within the system.
	4- The ability to organize the systems' components, processes, and their interactions, within a framework of relationships.
	5-The ability to identify the cyclic nature of systems.
Implementation	6-The ability to recognize hidden dimensions of the system—to understand natural phenomena through patterns and interrelationships not seen on the surface.
	7- The ability to make generalizations—to solve problems based on understanding systems' mechanisms.
	8- The ability to think temporally: retrospection and prediction. Understanding that some of the presented interaction within the system took place in the past, while future events may be a result of present interactions.

2.5.1 Developing Systems Thinking Skills with ESDG

Working for sustainable development goals requires addressing intractable sustainability problems such as poverty, climate change, and resource scarcity (Lönngren & Svanström, 2016). Systems thinking is essential to solve local and global challenges and problems which require understanding and thinking many elements or components and their direct and indirect impacts (Mambrey et al., 2022). Therefore, today's learners need to be engaged to think and act systemically so they can take direct and indirect actions to solve local and global issues. That is, learners should have their eyes opened to grasp how global issues are interlinked and influenced by many factors (e.g., environmental, economical, social, or cultural) within a specific location (Byker, 2013; Freire, 1970).



Figure 2.10. Interaction between SDGs (UN, 2015) (Necessary permission to use this image was obtained from the United Nations)

The SDGs are interrelated and the framework is indivisible (Figure 2.10). In other words, there are links between the environment and aspects of sustainable development goals such as poverty alleviation, health, income generation, and agriculture (Smith, 2011). That is, when you work on any SDGs, you are very likely also working on other SDGs (Vladimirova & Le Blanc, 2016). For example, quality education (SDG 4) reduces poverty (SDG 1) by increasing people's income (SDG 8) (World Bank, 2015; UNESCO, 2015) or quality education (SDG 4) is crucial to raise awareness and change attitudes, beliefs, values, and behaviors towards environmental issues (SDG 13, SDG 14, SDG 15) (UNESCO, 2014b).

SDGs promote cooperation among different domains and help to avoid compartmentalization (Albers, De Winter & Voeten, 2017). Sustainable development goals are a complex and integrated concept including dynamic relationships within economic, environmental and social aspects which in turn include several aspects that are interrelated in a complex way, such as health, cultural and political aspects (Martin, 2008; Palmberg et al., 2017; United Nations, 2015). Sustainable development goals links individuals and society to other people in local and global manner and to their natural environment (UNECE, 2011). One way to analyze issues in sustainable development goals is the use of systems thinking skills (Hickey, 2021). Sustainable Development Goals emphasize key environmental issues related to socio-economic aspects of development through systems thinking (Sanneh, 2018). This is why teaching SDGs includes a purposed development of students' higher order cognitive skills like systems thinking skills since knowledge is not sufficient for meaningfully dealing with global complex issues (Voulvoulis et al., 2022; Zoller, 2015). Similarly, systems thinking skills includes describing the system of environmental, economic, and social factors in interaction that cause complex problems and help people understand the complexity of sustainable development goals (Guthrie, 2023; Palmberg et al., 2017; Sweeney & Sterman, 2007). Systems thinking is connected to local and global issues, thus, it involves interdisciplinary thinking holistically and comprehending causality as a significant requirement for getting involved in sustainable development issues (Shidiq & Permanasari, 2020). Systems thinking provides methods and principles that practitioners learn about and intervene in real world problems. Therefore, it can cause constructive change (Soderquist & Overakker, 2010). That is, systems thinking provides students a new way of thinking and acting to grasp and manage and solve complex problems both in a local or global context (Blatti et al., 2019; UNECE, 2011). In other words, systems thinking guides students to see systemic problems in a holistic manner. The challenges in the world are complex and need inputs from a various discipline to address them, involving points of view on environmental, economic and social systems and cause-and effect correlations among them (Holling, 2001).

Systems thinking, as one of the integrative thinking methods, enables people to deal with the challenges of achieving the sustainable development goals. To succeed we

all need to have a way to grasp how change in one part of the world can affect other parts and an awareness of how today's choices can affect tomorrow's world. In this context, systems thinking is a valuable skill in achieving sustainable development goals which requires an integrative perspective (Martin, 2008; UNECE, 2011). For instance, maintaining a sustainable fishery (one of the sustainable development goals (SDG 14: Life below water) depends on multiple individuals like fishermen environmental scientists, individuals who process and sell fish and people who consume them. Therefore, this challenge requires comprehending economics, science, mathematics, business and psychology. Both systems thinking and SDGs support multidisciplinary lessons which enhance cognitive ability, critical thinking, and skills to deal with ambiguity better, and the increase of appreciation for bias and ethical issues among students (Fisher & Systems Thinking Association, 2023). Therefore, systems thinking is a part of sustainable development goals and could involve the topics such as health of the ecosystems, participate democracy, justice and equity, economy that sustainable development covers. All the topics in sustainable development goals presents a system (Cloud, 2005; Hjorth & Bagheri, 2006). Systems thinking is usually known as an effective way to reframe the SDGs in order to emphasize their integration and reflect on crucial directions towards building sustainable societies. Developing systems thinking with ESDG presents the potential of a richer view for students and plays an active role for the transformative changes needed for society to move towards a sustainable world (Kioupi & Voulvoulis, 2019; Rieckmann, 2018).

Sustainable development goals and systems thinking skills are both about comprehending change and developing relationships. Working towards sustainable development goals includes qualities like recognising and managing complexity, considering in more inclusive way, a less compartmentalised, different ways of making systems more sustainable, the development in the situation instead of simple problem solving and designing for sustainable development. The link can be better understood with putting two words together: 'sustainable system '(Sterling et al., 2005).

Systems thinking is becoming more and more crucial when coping with global challenges, from poverty to energy to health services because it gives opportunities to examine the links and interactions among systems' elements and address these

seemingly compelling systems problems in our society (Boardman & Sauser, 2008; Connell et al., 2012). However, systems thinking is especially difficult for learners to comprehend and to reason about complex ecosystem relations (Eberbach et al., 2021).

Education for sustainable development goals (ESDG) can enhance systems thinking skills as a key competence of 21st century by enabling students to understand the complexity and dynamics of different domains (i.e. environmental, economic and social) across different scales (local to global) (Armenia et al., 2022; Capra & Luisi, 2014; Meadows, 2008; Schuler et al., 2018; Sleurs, 2008; Wiek et al., 2011a). In other words, acquiring systems thinking is a dominant goal for ESDG and its implementation (Benninghaus et al., 2019). Integrating SDGs into K-12 education introduces complex interactions, dynamic changes and systems thinking skills to students (Weber et al., 2021).

Understanding the world as a system involves the improvement of systems thinking because such thinking shows a holistic approach through the explanations of the dynamic interdependencies among parts in a whole, that is, for seeing a whole as a sum of its parts (Kordova et al., 2018; Sterling, 2003; Stave & Hopper, 2007; Vasconcelos & Orion, 2021). Education for sustainable development goals (ESDG) help learners understand the Earth as a system, and how numerous and complex our impacts are on the planet (Torkar et al., 2019). Understanding the interrelationship between the human social system and the environmental system is crucial in solving problems sustainable development goals (Dale & Newman, 2005). The five Pillars of Sustainable Development Goals (SDGs) provide a promising framework for acquiring systems thinking skills among students because they emphasize the links and interactions among people, prosperity, planet, peace and partnership for the survival and well-being of our world (Capra & Luisi, 2014; Torkar et al., 2019). In the 'People' pillar of SDGs, learners' thinking skills can be developed to help them think about multi-faceted issues like ending poverty and hunger, promoting good health and well being, developing quality education, ensuring gender equality and providing clean water and sanitation. In the 'Prosperity' pillar of SDGs, learners' thinking skills about achieving affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequalities, sustainable cities and communities can be developed. In the 'Planet' pillar of

SDGs, it can be developed learners' thinking skills about achieving responsible consumption and production, acting for climate action, protecting life below water and life on land. In the 'Peace' pillar, learners' thinking skills about peace, justice and strong institutions can be developed. In terms of the 'Partnership' pillar learners' can develop their thinking skills on what is necessary to build viable partnerships for achieving the goals. It is also paramount that students can acquire life-long learning skills like systems thinking skills promoted by ESDG, particularly by engaging in the links and interactions between these 5 pillars (Torkar et al., 2019). Identifying and assessing interactions between sustainable development goals is an effective way of leveraging systems thinking skills (Carlsen et al., 2023).

ESDG helps individuals contribute to achieving the SDGs by raising individuals with the knowledge and competencies they require to comprehend what the SDGs are about and to engage as conscious citizens in achieving the necessary transformation (UNESCO, 2020). ESDG aims at developing the competencies like system thinking, critical thinking, normative, anticipatory, strategic, collaboration, self-awareness, integrated problem-solving competencies that support learners to reflect on their own actions and consider their environmental, economic, social and cultural effects for the present and future from a local and global perspective (de Haan, 2010; Rieckmann, 2012, 2017; Wiek et al., 2011a,b). These key competencies represent what global citizens specifically need to master in the face of today's complex challenges like poverty, global heating, illiteracy, energy, homelessness and increasing income gaps and equality, etc. All competencies are related to the individual SDGs and also help students to link the different SDGs to each other and to grasp the big picture of the 2030 Agenda. For example, one specific learning objective for SDG 2 (Zero Hunger) described by Rieckmann (2017) is "The learner explains the causes and effects of hunger". This knowledge could be gained by conducting learning activities including case studies on hunger in some countries. Simultaneously, this learning activity can contribute to a students' system thinking skills by facilitating the understanding that many factors can affect hunger. However, system thinking skills are not limited to system thinking regarding hunger. As a key skill, it also helps the learner to grasp the complex interrelations in other SDGs as well. Interconnected sustainable

development goals to support environmental, social and economic objectives can enhance students' system thinking skills. In addition, systems thinking requires the involvement of stakeholders and the sharing of knowledge to comprehend cause-effect relationships for goals and actions (Clark et al., 2022; Michalopoulou et al., 2019; Sanneh, 2018).

STS are an innovative approach expanding students' awareness about global challenges to respond better to the circular nature of the world we live in. The 17 Sustainable Development Goals (SDGs) involves multiple interconnected and indivisible realities in our present time. Therefore, it is needed to think and act beyond one area of expertise or grasp how the actions of our work contribute to the SDGs. Systems thinking skills can help students in this effort (Stephens, Lewis & Reddy, 2018) (Figure 2.11). Therefore, there are recommendations about the development of more educational programs on various topics for students to improve their systems thinking skills and understanding about integration of earth systems in school curriculum (Lee et al., 2011).



Figure 2.11. Systems thinking skills for sustainable development goals

2.6 Ethical Reasoning in Action (ERiA)

Improving ethical reasoning abilities is extremely important so that all of us can live an ethical life and create an ethical world (Paul & Elder, 2006). Ethical reasoning is defined as decision-making process includes that individuals make

moral judgements on what is right or wrong by weighing the benefits and potential consequences of their actions (Alkhuzaee et al., 2022; Sternberg, 2012a,b). Although ethical reasoning skills are crucial and employers around the world want to work with professionals who have advanced reasoning abilities in todays' world, ethical decision-making skills have not been emphasized enough at education (Hart Research Associates, 2013; Lau, 2010). However, local and global challenges we are facing as humanity put emphasis on a critical need for developing decision making skills because ethical shortcomings are very common in our society (James Madison University, 2013; Lampe,1994; Sanchez et al., 2017; Smith et al., 2017) Sternberg (2012a) emphasized that there are no easy answers or solutions to global problems we are facing in our modern society. Therefore, ethical reasoning can and should be taught to students in K-12 curriculum all over the world. Teaching such reasoning helps students make compelling decisions wisely, including ethical considerations where the answers are far from certain. Moreover, Sternberg (2012a, 2015) stated that teaching ethical reasoning is important because teaching is mostly in vain if there is no application to life ethically (Sternberg, 2012a, 2015). Ethical reasoning can be taught to students through cases (Menzel, 2009; Sternberg, 2012a). Students require to learn how to reason about and apply ethical principles when they encounter with ethical problems in different domains. Students also need to be made aware of pressures to act unethically. James Madison University (JMU) addressed a shortcoming of effective ethical reasoning and decision-making education at colleges and universities and conceptualized ethical reasoning as a learned critical thinking strategy that includes asking Eight Key Questions (8 KQ) (Sanchez et al., 2017). By using 8KQ students can assess their ability to tackle ethical problems and change their way of thinking. The logical next step is to invest resources in educational endeavors and pedagogical approaches aimed at improving ethical decision-making skills. In this study, the framework was developed by James Madison University (2018) was used. This framework involves 8 key dimensions: fairness, outcomes, responsibilities, character, liberty, empathy, authority and rights. These dimensions were explained at below:

Fairness: First dimension of ethical reasoning is 'fairness'. Fairness refers to treating everyone honestly and justly, respecting the rules of society and the rights of others. In order to determine fairness level for ethical reasoning, JMU determined

the question of ‘How can I/we act justly, equitably, balancing legitimate interests?’ (James Madison University, 2018, p.2).

Outcomes: Second dimension of ethical reasoning is ‘outcomes’. Outcomes refers to considering the outcomes or consequences of our actions. JMU determined the question of ‘What are the short- and long-term out-comes for everyone?’ to assess outcomes dimension of ethical reasoning. (James Madison University, 2018, p.3).

Responsibilities: Third dimension of ethical reasoning is ‘responsibilities’. Responsibilities refers to the opportunity or ability to act independently and take decisions without authorization. JMU determined the question of ‘What duties and/or obligations apply?’ to assess responsibilities dimension of ethical reasoning. (James Madison University, 2018, p.4).

Character: Fourth dimension of ethical reasoning is ‘character’. Character refers to the mental and moral qualities distinctive to an individual. JMU determined the question of ‘What actions help me become my ideal self/we our ideal selves?’ to assess character dimension of ethical reasoning (James Madison University, 2018, p.5).

Liberty: Fifth dimension of ethical reasoning is ‘liberty’. Liberty refers to the state of being free within society from oppressive restrictions imposed by authority on one's way of life, behaviour, or political views. JMU determined the question of ‘How are freedom and personal autonomy best respected?’ to assess liberty dimension of ethical reasoning (James Madison University, 2018, p.6).

Empathy: Sixth dimension of ethical reasoning is ‘empathy’. Empathy refers to ‘the ability to understand and share the feelings of another. JMU determined the question of ‘How would I/we respond if I/we cared deeply about all involved?’ to assess empathy dimension of ethical reasoning (James Madison University, 2018, p.7).

Authority: Seventh dimension of ethical reasoning is ‘authority’. Authority refers to the power or right to give orders, make decisions, and enforce obedience. JMU determined the question of ‘What do legitimate authorities (e.g., experts, law) expect?’ to assess authority dimension of ethical reasoning (James Madison University, 2018, p.8).

Rights: Eighth dimension of ethical reasoning is ‘rights’. Rights refers to a moral or legal entitlement to have or do something. JMU determined the question of ‘What rights (e.g., innate, legal, social) apply? ’ to assess rights dimension of ethical reasoning (James Madison University, 2018, p.9).

2.6.1 Developing Ethical Reasoning in Action with ESDG

Although there are great challenges of incorporating ethical decision-making in science classrooms because of complexity of subjects, educational efforts aiming to enhance students ’ethical decision-making is crucial in today’s world (Yoon, 2008). The intellectual development of students in ethical reasoning is requirement to enhance comprehending of the relationship between science and society (Chowning et al., 2012; Kolarova et al., 2013; Sadler, 2004; Zeidler et al., 2005). Ethical reasoning skills provides students to critically reflect on their ethical beliefs and by this way, contributes to the improvement of their individual autonomy (Meyer, 2023). One way to bridging an ethical practice in classrooms includes analysis of real-life ethical issues which may help learners improve from beginner towards expert ethical reasoning skills (Bennett et al., 2002; Kenny et al., 2015; Lampe,1994). Bringing sustainable development goals in K-12 classrooms provides to take up ‘real life ’ethical global issues in the classroom (Andersson, 2019; Block et al., 2019; Öhman & Östman, 2019b; Rudsberg & Öhman, 2019; Sund & Pashby, 2019) because SDGs are completely interlinked with the ethics and vice versa, that is, each complement and justifes the other (Figure 2.12). For instance, society without ethics cannot achieve economic, social and gender equality (Guerra et al., 2021).

Today the Sustainable Development Goals (SDGs) are thought to be the main goal of international authorities tasked with addressing the detrimental effects linked with misleading the economic, environmental and social issues (Guerra et al., 2021). People need to achieve the sustainable development goals to balance the environmental, economic, and social spheres in an equitable and ethical manner to ensure the survival and quality of life for all living things. Therefore, SDGs can be thought as an ethical movement that supports and collaborates for the consolidation of a new global morality (Guerra et al., 2021). Ethical reasoning is not an easy skill to master (Sanchez et al.,2017). Academic courses that use discussions about ethical issues increase students' ethical reasoning abilities (Eynon et al., 1996). Education

for Sustainable Development Goals cover various ethical issues and challenges relating to social, ecological, economical as well as cultural/political dimensions (Grice & Franck, 2017). Therefore, Education for Sustainable Development Goals can have fruitful outcomes to enhance students' ethical thinking (Vesala-Varttala et al., 2021). ESDG can enhance students reason ethically on many scales (i.e environment, economic, social) rather than on one scale (i.e only environment) (Schlottmann, 2008). Through real-world learning opportunities, students' ethical competence can develop as they are placed in ethical conflict situations (Grice & Franck, 2017). Students can obtain a deeper ethical understanding of sustainability through learning activities that are experiential, collaborative, and experimental (Seager & Selinger, 2009).

In addition, developing students' ethical reasoning helps them assess their own beliefs and values, to think critically on ethical issues, and to apply an ethical reasoning process for making sound decisions about local and global issues as global citizens (Hornor, 2021; Kolarova et al., 2013). Developing students' ethical reasoning is a significant attainment of K-12 education because ethical reasoning skills are extensively accepted as an essential component of individuals' personal and professional development (Goldie, 2000).

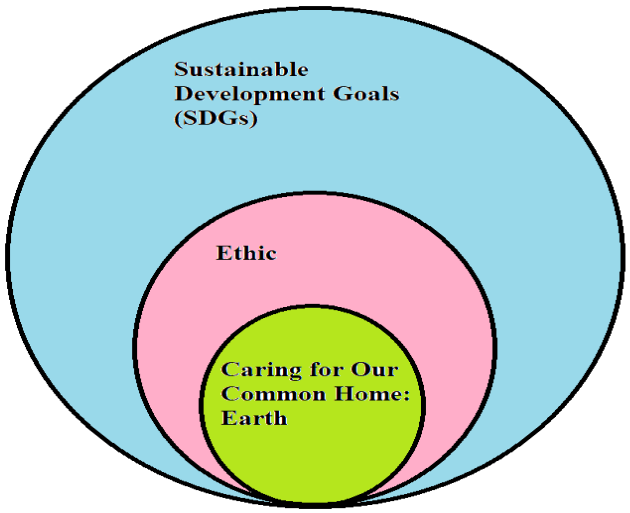


Figure 2.12 The interconnection of SDGs-Ethic

3
METHOD

3.1 Research Design

3.1.1 Educational Design Research

The main purpose of this research was to develop and implement a Sustainable Development Goals unit that can be used to enhance middle school students' (1) systems thinking skills and (2) ethical reasoning in action. In order to achieve these aims, educational design research was employed in the current study. Educational design research (EDR) was evolved by and for educators near the beginning of the 21st century and aims to increase the impact of educational research on real-life practices (Anderson & Shattuck, 2012; Bell, 2004; Brown, 1992; Collins, 1992; Mckenney & Reeves, 2014; Reimann, 2011; Wang & Hannafin, 2005) (Figure 3.1). Educational design research (EDR) is a systematic and flexible type of research involving the iterative development of solutions to complex educational problems (e.g. educational products, processes, programs) (Mckenney & Reeves, 2014). Educational Design Research includes an interdisciplinary mixed method research approach conducted in the research site that contributes to applied and theory building purposes (Reimann, 2011). In other words, educational design research mixes the theory-driven design of learning environments with empirical educational research and enables educators to comprehend when, how and why educational designs work in practice (Design-Based Research Collective, 2003). In the current study, the three research phases ((1) analysis and exploration phase, (2) the design and construction phase (3) the evaluation and reflection phase) suggested by McKenney and Reeves (2014) were followed within the scope of educational design-based empirical research (Figure 3.1).

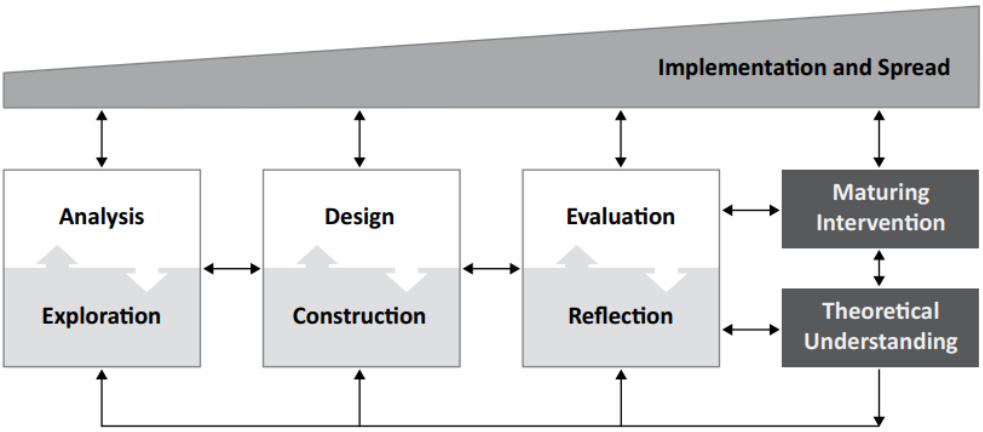


Figure 3.1 Educational design research (McKenney & Reeves, 2014)

The first research phase of educational design research is analysis and exploration. This phase includes problem identification and diagnosis (Mckenney & Reeves, 2014). The analysis part of the research involves initial orientation (i.e. problem, context, stakeholders), a literature review (i.e. scientific and practical, well-structured) and field-based investigation (i.e. planning, field work, meaning making). The exploration part of the research covers site visits, professional meetings and networking. The main outcomes of this phase are both theoretical and practical. In this phase, a descriptive and analytical understanding of the problems within a particular context are generated as a theoretical product. On the other hand, a clear understanding and specification of the problem and long-range goals and its origins are produced as practical product in this phase (Mckenney & Reeves, 2014).

In the analysis part of the present research, a literature review about education for sustainable development goals, developing students 'systems thinking skills, developing students 'ethical reasoning in action was conducted and the problem of the research was defined mainly as 'How can a SDG unit be developed to improve students 'systems thinking skills and ethical reasoning in action? Then, context analysis (about developing a SDG unit) and needs assessment (what needs for improving STS and ERiA of students) was conducted about how a SDG unit can be generated that can help enhance students 'systems thinking skills and ethical reasoning in action. Therefore, it was explored how a SDG unit can be effective for developing systems thinking skills and ethical reasoning skills of students. In the

exploration part of this study, the researcher visited the class and spent time with the science teacher and students before undertaking the research process. In addition, she collaborated with a practitioner (the science teacher) in professional meetings to gain a better understanding of the educational problem to be addressed, the context and students 'needs. Moreover, the researcher attended different workshops and conferences, such as the North American Association for Environmental Education (NAAEE) to meet with peers and learned colleagues. These explorations enabled the research to gain current insights on possible ways and solutions to the problem at hand by discussing the details of similar studies (e.g. developing systems thinking skills or reasoning) conducted by professional researchers from all over the world. These discussions enabled the researcher to conceptualize the research problem, determine requirements for the design and construct the initial principles of her design.

The second research phase of educational design research is the design and construction phase. This phase refers to a deliberative-generative cycle including purposeful and rational consideration of available knowledge, and the relationships and arrangements of internally consistent and externally useful concepts (Mckenney & Reeves, 2014). The design part of the research includes exploring solutions (involving generating, considering and checking ideas) and mapping solutions (involving requirements and propositions, skeleton design, detailed specification). The construction phase of the research covers building solutions (i.e. creating initial prototypes) and revising solutions (revising prototypes) (Mckenney & Reeves, 2014).

During the design part of this research, various design ideas for potential solutions to the problem were generated. That is, several SDG unit designs to enhance systems thinking skills and ethical reasoning in action were generated, explored and considered. The skeleton designs for a viable SDG unit were generated by considering requirements and propositions and a detailed specification for developing systems thinking skills and ethical reasoning in action. In the construction part of this research, the learn-think-act based-SDGs unit that enhances and develops the systems thinking skills and ethical reasoning of students was created and revised according to experts' opinions and the results of a pilot study.

The third research phase of educational design research is the evaluation and reflection phase which includes empirical testing of a constructed intervention or a design and active consideration of both research and development with the intent of generating theoretical understanding (Mckenney & Reeves, 2014). The results of empirical findings and critical reflection are utilized to accept, refine, or rebut the frameworks, conjectures or principles depicted in design frameworks or actual interventions (Mckenney & Reeves, 2014). In a practical aspect, ideas for conclusions about a specific intervention or redesign are constructed in this phase. In a theoretical aspect, a broader theoretical understanding regarding the type of intervention or phenomena concerning the intervention are built with the knowledge with the combined activities in this phase (Mckenney & Reeves, 2014). The evaluation part of the research includes planning (establishing focus, framing questions, selecting strategies, determining methods, documenting plan), field work (preparing instruments, engaging participants, collecting data) and meaning making (analyzing data, considering findings, reporting study) processes. On the other hand, the reflection part of the research (organic and structured) includes generating explanations for the results, new/refined ideas regarding designs.

In the evaluation part of this research, an empirical cycle (including planning, fieldwork and meaning making) was conducted. That is, first, the implementation process of the SDG unit was planned. In the fieldwork part, data collection instruments were prepared, participants were engaged with the SDG unit and the data were collected as before and after SDG unit implementation. In the meaning making process, data about systems thinking skills and ethical reasoning from students were analyzed and the results were reported. In the reflection part of this research, results about developing systems thinking skills and ethical reasoning of students were explained and discussed and new or refined ideas were generated about developing or revising the SDG unit design and the implementation process of the unit for middle school students.

Typically, researchers aim to secure two main products from educational design research: (1) maturing interventions and (2) theoretical understanding (Mckenney & Reeves, 2014). The first output enables the researcher to practice directly by addressing the problem and to acquire theoretical understanding indirectly (e.g. reifying specific, articulated, design frameworks) (Mckenney & Reeves, 2014). In

this study, as a first output (maturing intervention), the learn-think-act-based Sustainable Development Goals unit that help improve students 'systems thinking skills and ethical reasoning in action was developed.

The second output is theoretical understanding. The resulting conjectures and empirical findings enable the researcher to practice since they may be shared among professionals and utilized to build new interventions and contribute to significant building blocks for theory (Mckenney & Reeves, 2014). Developing theoretical understanding in educational design research can be achieved through the design and implementation of interventions in practice (Mckenney & Reeves, 2014). Improving students 'systems thinking skills and ethical reasoning in action through the development and implementation of learn-think-act based- SDG unit can be used to build new interventions among professionals. Moreover, the current research can contribute crucial building blocks for theory. That is, a learn-think-act based SDG unit can be an effective educational material used to improve students'systems thinking skills and ethical reasoning in another new context or interventions (e.g different grade level).

Research approaches engaging design consist of three parts: (a) a designer (i.e. researcher in this study), (b) a practitioner (i.e. science teacher in this study), and (c) an artefact (i.e. learn-think-act based Sustainable Development Goals unit in this thesis) (Juuti & Lavonen, 2006). These three parts were explained in detail at below.

3.1.1.1 Researcher's Position (Role) as a Designer

The researcher has a background in both education for sustainable development and environmental education. She received her undergraduate and graduate degree in the field of elementary science education. She took several courses on education for sustainable development, sustainable development goals, sustainability, environmental education, qualitative research in science education during her undergraduate and graduate education. She studied specifically the issues of sustainable development and environmental education in her master's thesis. She, as a research assistant, has experienced and assisted the courses related to sustainable development environmental education at public universities for 8 years. During her master's and doctoral education, she participated in several conferences about environmental education and education for sustainable development (ESD).

The basic motivation behind this research is the researcher's belief about that students need a systemic and ethical way of thinking to find sustainable solutions for local and global challenges in our lives. Researcher thinks that current education system does not include educational materials to master systems thinking skills and ethical reasoning and not train students to perceive the big picture of the complex systems. Thus, the researcher aimed to contribute to ESDG research by integrating SDGs into K-12 that enhance students' systems thinking and ethical reasoning. Researcher believes that enhancing systems thinking and ethical reasoning with ESDG can play transformative role in understanding and thinking on the local and global issues, discovering the links between these issues, and find ways to solve complex issues.

As a designer, researcher developed the learn-think-act based Sustainable Development Goals unit, data collection tools for systems thinking skills and rubrics for data analysis. In addition, she adapted data collection tools for ethical reasoning. Then, she received experts' opinions about SDGs, data collection tools and rubrics. A pilot study was conducted to assess validity, reliability and applicability of the unit, and data collection tools. Finally, experts' common views and advices on the unit and the results of pilot study were assessed and the latest version of unit, data collection tools and rubrics was designed by researcher. Moreover, researcher has observer role at the implementation process of SDGs unit.

3.1.1.2 Teacher's Position (Role) as a Practitioner

Science teachers have important key role in education for sustainable development goals because they can shape future generations' skills to build a sustainable world (UNESCO, 2014a). Science teacher as a practitioner of this research graduated from public university and she took several courses on environmental education, sustainable development, and sustainability during her bachelor's degree at teacher education program. She had a ten years of teaching experience about environmental issues and sustainable development issues at both science course and environmental education and climate change course in K-12. Before the SDGs unit implementation, the science teacher was trained about the content and implementation of SDGs unit by researcher. This training process lasted 5 week (2-3 hours per week). In the training process, researcher (designer) gave information about the theoretical knowledge about SDGs and learn-think act

approach. In addition, the researcher explained the learning objectives (cognitive, socio-emotional and behavioral), classroom activities and assessment tasks for each SDGs in detail. Moreover, the science teacher practiced by implementing some part of the SDG unit for 3 weeks (9 hours- for 9 SDGs) with 7th grade students who were not included among the main research participants in the scope of a pilot study during the fall semester of 2022-2023 academic year. As a practitioner, the science teacher implemented the learn-think-act based Sustainable Development Goals unit for 8 weeks.

3.1.1.3 Sustainable Development Goals Unit as an Artefact

In this research, a learn-think-act based Sustainable Development Goals Unit was designed to develop students' systems thinking skills and ethical reasoning. In the unit development process, the backward design (Understanding by Design) approach offered by Wiggins and McTighe (2005) was used. The backward design presents a framework for designing courses and content units. This design includes 3 main stages. (1) identifying desired results, (2) determining acceptable evidences, (3) planning learning experiences and instruction (Wiggins & McTighe, 2005).

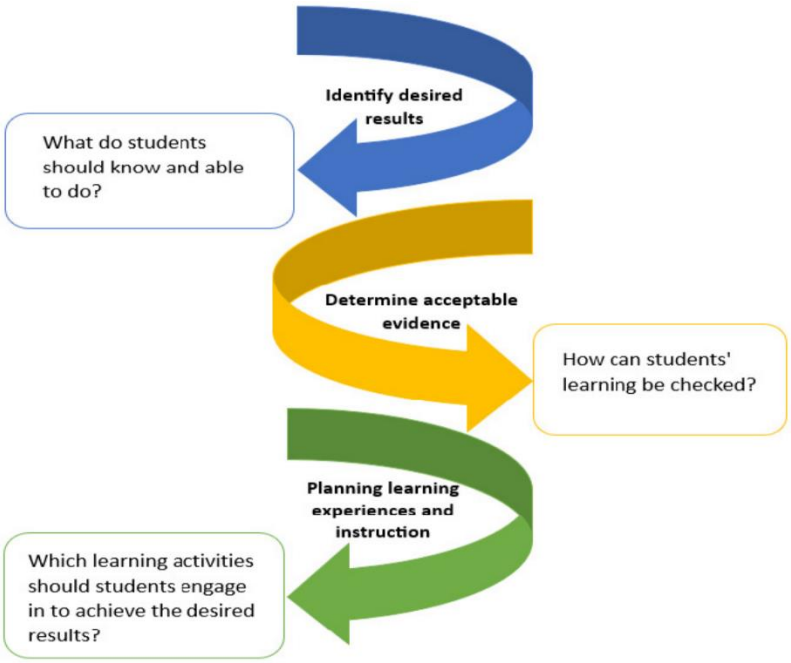


Figure 3.2 The backward design (Understanding by design) (Wiggins & McTighe, 2005)

At the first stage of backward design (identifying desired results), learning goals (objectives) of the course, the knowledge and skills students will learn, are established first. Therefore, the learning objectives about each SDG were determined in accordance with a Learn-Think-Act approach, which is a pedagogical approach enabling students to learn about issues but also think critically and find ways to use their learning themselves in meaningful and appropriate way. From these aspects, a Learn-Think-Act approach complements the global citizenship and SDGs themes in education (OXFAM, 2019). These learning objectives were identified in the cognitive, socio-emotional and behavioural domains preferred in literature for each SDGs (Rieckmann, 2017). The cognitive domain consists of knowledge and thinking skills to comprehend the SDG better and the challenges in achieving SDGs. The socio-emotional domain involves social skills enabling learners to communicate, negotiate and collaborate to promote the SDGs as well as attitudes, self-reflection skills, values, and motivations helping learners to improve themselves. The behavioural domain includes competencies for action. For example, cognitive learning objectives were determined for SDG 1 like 'Students explain the concept of poverty, distributions of poverty, causes and impacts of poverty.'. This learning objective is about understanding theoretical information about SDG 1. The socio-emotional learning objective was described like 'Students discuss their own role and responsibilities for no poverty.' This learning objective is about thinking on solutions for SDG 1 and the learning objective is about thinking critically about SDG 1. The behavioural learning objective was identified like 'Students propose local and global solutions for no poverty.' This learning objective is about taking action about SDG 1. This learning objective is about taking action about SDG 1. Similar to the learning objectives for SDG 1, all other SDGs' learning objectives were determined in line with the cognitive, socio-emotional and behavioural domains in accordance with a Learn-Think-Act approach preferred in literature for each SDGs (see Appendix A).

At the second stage (determining acceptable evidences), it was decided the assessments and performance tasks learners will complete in order to show evidence of understanding and learning. So, the performance tasks and assessments were determined to evaluate students' learning for each SDGs. For instance, in order to assess students' learning about each SDGs, activity sheets including

questions about SDGs (what SDGs are, why achieving SDGs is important, how SDGs can be achieved etc.) were given to students after teaching of each SDG (see Appendix A).

The third stage of backward design (planning learning experiences and instruction) is that instructional strategies and learning activities are created according to learning goals and assessment methods. Thus, instructional strategies and teaching procedure including key concepts and different activities about SDGs was designed. For instance, the classroom activity entitled 'The world's resources are not fairly or equally distributed!' was designed for SDG 1. A classroom activity was designed for each goal and implemented throughout the implementation of unit. The classroom activities include theoretical information about SDGs and they enable students practice theoretical knowledge about SDGs (see Appendix A). Template for SDG unit plans were given in Table 3.1.

Table 3.1 Template for SDG unit plans

Course	
Grade Level	
Unit	
Theme	
Subject	
Time	
Learning Objectives	Cognitive Learning Objective
	Socio-Emotional Learning Objective
	Behavioral Learning Objective

Table 3.1 Template for SDG unit plans (cont.)

Teaching Approach	
Teaching Procedure	Learn
	Think
	Act
Assessment	

- **Pilot Study for SDG Unit**

After the SDG unit was developed according to the steps of the backward design, experts 'opinion was received. One of the experts is an assistant professor. She has twelve years of research experience in education on sustainable development, the Sustainable Development Goals, and sustainability. Her views were received about the design of the SDG unit (learning objectives and classroom activities, teaching approach). Another expert is an experienced science teacher. She has ten years of teaching experience in sustainable development issues at the middle school level. Her views were received about the suitability and applicability of the unit for middle school levels and the readiness of students for this unit. The other expert is a curriculum developer with ten years of research experience in the development of curriculum, educational programs or materials and units at the middle school level. Her views were received about the methods of unit design and steps of the unit development process (see Table 3.2). After receiving experts 'opinions of the proposed pilot study, a part of the unit was trialed to assess its applicability in terms of learning objectives, assessments tasks, learning activities and their compatibility

with each other, and time. The pilot study was held during the fall semester of 2022-2023 academic year. The science teacher implemented a part of the SDG unit over 3 weeks (9 hours- for 9 SDGs) with 7th grade students who would not be included as participants in the main research study. Students' views about learning activities were also received. Finally, experts', the science teacher's, and students 'common views and suggestions on the unit, and the results of the pilot study were evaluated. The level and amount of information that are taught about each SDG and some of the classroom activities were rearranged and the latest version of the unit was designed (see Appendix A).

Table 3.2 Experts' information and scope of views and revisions

Experts	Title	Experience	Scope of Views	Revisions
1	Assistant professor	She has twelve years of research experience in education on sustainable development, the Sustainable Development Goals, and sustainability.	Views were received about the design of the SDG unit (learning objectives, classroom activities, assessments, teaching approach).	The level and amount of information that are taught about each SDG and some of the classroom activities were rearranged. Since time is limited and the sustainable development goals include very comprehensive topics, the amount and level of information has been reduced and made suitable for the 7th grade academic level.
2	Curriculum development specialist	She has ten years of research experience in the development of units at the middle school level.	Views were received about the methods of unit design and the steps of the unit development process.	Using the backward design as a method of unit design was decided and the steps of the backward design was conducted in the unit development process.
3	Science teacher	She has ten years of teaching experience in sustainable development issues at the middle school level.	Views were received about the suitability and applicability of the unit for middle school levels and the readiness of students for this unit.	Some of the classroom activities were rearranged to make more suitable and applicable for middle school students. For example, science teacher advised that some activities were carried out individually and some activities were carried out in groups. In addition, the difficulty level of activities was rearranged with the advise of science teacher.

3.2 Research Group

In the current educational design-based research, criterion sampling, which is one of the purposive sampling techniques, was used. This sampling method includes selecting participants based on specific predetermined criteria or characteristics (Mckenney & Reeves, 2014; Patton, 2002; Teddlie & Yu, 2007). In this research, the research group was determined based on specific predetermined criteria. The criterion is that students have not taken any course or training about sustainable development or sustainable development goals until they participated to 'Environmental Education and Climate Change' course. Therefore, the data were collected from 20 students voluntarily attended in all research process including the implementation process of SDG unit and data collection through the semester. In this manner, the research group consisted of 20 7th grade students enrolled 'Environmental Education and Climate Change' elective course in a public school in Istanbul, Türkiye during the 2022-2023 Spring semester. Ten of the students are male and ten of them are female. Their ages were at the range of 12-14 years. All participants had similar personal and low socio-economic background. That is, they grew up and lived in the same neighborhood of metropolitan city throughout their lives. All participants have similar academic background about sustainable development and sustainable development goals. That is, they had not taken any course or training about sustainable development or sustainable development goals until they participated to 'Environmental Education and Climate Change' course.

3.3 Implementation

For the implementation, the elective course titled "Environmental Education and Climate Change" was redesigned to teach Sustainable Development Goals unit in order to develop systems thinking skills and ethical reasoning of students. This course was held in two- three hours each week and lasted eight weeks. At the beginning of 'Environmental Education and Climate Change' course, students were shown a real-life scenario ('Home' documentary) including how the world's problems are interconnected. Then, the science teacher began to implement learn-think-act based SDGs unit. The content of the unit includes theoretical and practical knowledge about sustainable development and SDGs and practical activities. The classroom activities and discussion questions have been arranged so that student

can think in systems and reason ethically. Each week, SDGs were taught based on theme (people, prosperity, planet, peace, partnership). In the first week, science teacher introduced sustainable development and SDGs and gave general information about these issues. From the second week, the science teacher started to teach SDGs in detail based on learn-think-act framework. For each SDGs, students learned theoretical information about SDGs, made practices with classroom activities which stimulate to think critically, and found solutions for local and global issues or made suggestions for achieving SDGs. Every week, initially, science teacher gave theoretical information about SDGs. Secondly, students made classroom activities about each SDGs with the guidance of teacher. Thirdly, students made activities about finding solutions and making suggestions for achieving SDGs and watched videos about what their peers' actions for SDGs all over the world (see Table 3.3).

Table 3.3 Implementation process

Week	**SDG Pillars**	**Implementation**	**Teaching Approach**
Week 1 (3 lesson hours)		'Home' Documentary Data Collection (Open-ended questions)	
Week 2 (3 lesson hours)		Data Collection (Semi structured Interviews)	
Week 3 (2 lesson hours)		Introducing Sustainable Development (SD) and Sustainable Development Goals (SDGs)	**Learn:** Theoretical knowledge about SDGs were taught to students by science teacher
Week 4 (3 lesson hours)	People	SDG 1: No Poverty SDG 2: Zero Hunger SDG 3: Good Health and Well-being	
Week 5 (3 lesson hours)	People	SDG 4: Quality Education SDG 5: Gender Equality SDG 6: Clean Water and Sanitation	

Table 3.3 Implementation process (cont.)

Week	**SDG Pillars**	**Implementation**	**Teaching Approach**
Week 6 (3 lesson hours)	Prosperity	SDG 7: Affordable and Clean Energy SDG 8: Decent Work and Economic Growth SDG 9: Industry, Innovation and Infrastructure	**Think:** Students made different learning activities to think critically about SDGs **Act:** Students found ways to use their learning themselves about SDGs in meaningful and appropriate way
Week 7 (2 lesson hours)	Prosperity	SDG 10: Reducing Inequalities SDG 11: Sustainable Cities and Communities	
Week 8 (2 lesson hours)	Planet	SDG 12: Responsible Consumption and Production SDG 13: Climate Action	
Week 9 (2 lesson hours)	Planet	SDG 14: Life below Water SDG 15: Life on Land	
Week 10 (2 lesson hours)	Peace/ Partnership	SDG 16: Peace, Justice and Institutions SDG 17: Partnerships for Goals	
Weeks 11-12 (3 lesson hours)		Data Collection (Open-ended Questions- Semi structured Interviews)	

3.4 Instruments

A real-life scenario (Home documentary) and associated open-ended/interview questions were used as the instruments in this research.

3.4.1. The Real-Life Scenario ('Home' documentary)

Real-life contexts provide better understanding of the world as a system, sustainable development issues and increase the consciousness for self-actions (Tilbury, 2011). In this thesis, the 'Home' documentary was selected as real-life scenario. A 'Home' documentary is a depiction of how world's problems (related to people,planet,prosperity, peace and partnership) are all interlinked by presenting aerial footage from fifty-four countries all over the world (https://www.youtube.com/watch?v=rurtJhnEkTE). This documentary as real-life context was selected because it involves all pillars of sustainable development goals (people, planet, prosperity, peace and partnership) and implicitly it depicts the world as a system and the consequences of human decisions on this system. It points out the social issues by addressing poverty, hunger, inequality etc. It shows the environmental issues by addressing life on land, life below water, climate change, carbon emissions, environmental pollutions etc. It also demonstrates the economic issues like energy, economy, work, cities. In addition to all these issues, it provides the peace and partnership. The scenario provides systemic connections among all aspects by emphasizing how the world is changing due to human impacts.

3.4.2 Open ended/Interview Questions for STS

Open ended questions were developed by the researcher to assess students' systems thinking skills based on the eight emergent hierarchic characteristics of systems thinking skills determined by Ben-Zvi Assaraf and Orion (2005) in the context of earth systems (see Appendix B). Then experts' opinions were obtained in terms of ensuring validity and reliability of questions. Two of the experts were assistant professors. They have research experience in systems thinking skills and education on sustainable development and sustainability. They gave views and suggestions about whether the questions measure systems thinking skill or not and how they can be improved. Another expert is an experienced science teacher. She has ten years of teaching experience in science and sustainable development issues at the middle school. She offered her views about suitability and applicability of questions for 7th

grade students. Open-ended questions for systems thinking skills were rearranged according to experts' opinions and suggestions. After that, pilot study was conducted to assess and test the validity and reliability of open-ended questions about systems thinking skills. The pilot study was held during the fall semester of 2022-2023 academic year. Four students (two girl and two boy) volunteered to participate in pilot study. The students were also 7th grade level. Each participant responded open-ended questions before and after implementation of part of the SDGs unit. Responses to open-ended questions were analyzed to evaluate questions for systems thinking skills. Experts' opinions were received during the evaluation process. Finally, experts', the science teacher's, and students' common views and suggestions on the data collection tools for systems thinking skills and the results of the pilot study were evaluated. For example, in terms of gaining more clear responses from the participants, some additions and removals made into the questions for STS. For example, in order to assess students' ability to identify dynamic relationships within the system (STS 3), the question of 'Is there a human impact on the problems experienced in the world? was determined before. After pilot study, the addition of 'What do you think about whether there is a relationship between the problems experienced in the world and people's lifestyles?' was made to make the question clearer for students. The data collection tools were revised and gained their final forms for STS.

3.4.2 Open ended/Interview Questions for ERiA

The Eight Key Questions developed by James Madison University (2018) was adapted and used to assess students' ethical reasoning in action (Appendix C). The 'Eight Key Questions' developed by James Madison University (2018) are in the form of open-ended questions. The aim of these questions is to assess the strategy for making well-informed decisions. Each question addresses each dimension of ethical reasoning (fairness, outcomes, responsibilities, character, liberty, empathy, authority and rights).

The Eight Key Questions was translated and adapted to Turkish by the researcher and then experts' opinions were obtained in terms of ensuring validity and reliability of open-ended questions (see Appendix C). One of the experts checked and revised questions in terms of Turkish language. Another expert was a researcher in developing 8 key questions for ethical reasoning in action from James Madison

University (2018). She has research experience in ethical reasoning in action. She gave her views and suggestions about the adaptation of questions for middle school students, whether the questions measure ethical reasoning in action or not and how they can be improved. The third expert was an experienced science teacher with ten years of teaching experience in ethical issues in science education at the middle school level. She offered her views about suitability and applicability of questions for 7th grade students. Open-ended questions for ethical reasoning in action were rearranged according to experts' opinions and suggestions. Thereafter, the pilot study was conducted to assess, adapt and test the open-ended questions about ethical reasoning in action.

The pilot study was held during the fall semester of 2022-2023 academic year. Each participant responded to open ended questions before and after implementation of a part of the SDGs unit. Responses to open-ended questions were analyzed to evaluate the open-ended questions for ethical reasoning in action. Experts' opinions were received during the evaluation process. Finally, experts', the science teacher's, and students' common views and suggestions on the data collection tools for ethical reasoning in action and the results of the pilot study were evaluated. In terms of gaining more clear responses from the participants, some of the open-ended questions were amended to enable them to more fully reflect on their ethical reasoning in action. In addition, the analysis rubric for ethical reasoning in action was developed in the light of results of pilot study. After the pilot study, data collection tools were revised and gained their final forms and rubrics for ethical reasoning in action were formed.

3.5 Data Collection

At the beginning of the 'Environmental Education and Climate Change' course, students were shown a real-life scenario ('Home' documentary) as a part of the data collection process. After students watched the documentary, open ended questions were responded by students to assess students' initial systems thinking skills and ethical reasoning in action. In addition, semi structured interviews were conducted for the purpose of obtaining in-depth understanding about students' initial STS and ERiA prior to implementation of the SDGs unit. The interviews lasted approximately 20–30 mins for each student before the SDGs unit implementation. Then, the learn-think-act based SDG unit was implemented by the science teacher

over a period of 8 weeks. After SDGs unit implementation, data was collected again from students through open-ended questions to assess their systems thinking skills and ethical reasoning in action. Moreover, semi structured interviews were conducted again with the purpose of getting in-depth understanding about students' STS and ERiA. The interviews lasted approximately 40–50 mins for each student after SDGs unit implementation Interviews were audio recoded with the permission taken from interviewees.

3.6 Data Analysis

The open-ended questions and recorded data from semi-structured interviews were transcribed and analyzed with rubrics developed by the researcher through deductive content analysis. In this study, two researchers analyzed the data of students' systems thinking skills and ethical reasoning. 30% of the students' systems thinking skills and ethical reasoning in action were evaluated independently by two researchers (main researcher and expert in field) according to the rubrics. The results of analyses were similar to a large extent. Researchers discussed the little inconsistencies and reached full agreements at the end of process. Therefore, all remaining data was analyzed by main researcher. Inter-coder reliability by two researchers is used as a method to ensure validity for analysis of open-ended questions and interviews. This is explained in detail in section 3.7.1 Dependability.

3.6.1 Deductive Content Analysis

Deductive content analysis was used to make meaning of the data. This approach is a systematic research method that enables the researcher to analyze and make inferences about different forms of qualitative information such as that obtained from interviews, focus groups, documents, etc (Bingham & Witkowsky, 2022). In addition, this type of analysis includes an a priori design with parameters that were defined by researchers for coding information and content into categories that were classified based on a specified coding procedure (Krippendorf, 2018; McKibben et al.,2020; Neuendorf, 2018). It is known that a deductive content analysis approach enables researchers to test a previous theoretical knowledge (as the starting point) in a different situation or to compare categories at different time periods (Elo & Kyngäs, 2008; Schram, 2014). Therefore, the research questions are influenced by prior knowledge and an effort was made to understand how they could impact the

data collection process. The deductive content analysis approach utilizes an organising framework (a half-structured or structured analysis matrix) involving themes for the coding process (Azungah, 2018; Bradley et al., 2007; Braun & Clarke, 2006; Burnard et al., 2008; Miles & Huberman, 1994). The framework is used in the analysis that certain core concepts are in the data (Bradley et al., 2007; Miles & Huberman, 1994; Thomas, 2006). Reporting findings is structured according to the determined categories, themes or concepts (Kyngäs & Kaakinen, 2020; Pandey, 2019; Rimmel & Cordazzo, 2021). In this research, during the data analysis process, students' systems thinking skills and ethical reasoning in action was analyzed with rubrics such as the organising framework developed by the researcher through deductive content analysis. Rubric development and data analysis based on rubrics are explained below.

3.6.2 Rubric Development

Rubrics can be developed based on determining three elements: 1) the criteria for assessing the performance or product 2) a range of quality levels, and 3) an appropriate and relevant scoring strategy (Brookhart, 2013, 2018; Brookhart and Chen, 2015; Brookhart and Nitko, 2015; Brookhart et al.,2016). The rubrics in the present study were developed to determine the systems thinking skills and ethical reasoning levels of students in accordance with the pillars of the Sustainable Development Goals produced by the United Nations (2015), and systems thinking skills determined by Ben-Zvi Assaraf and Orion (2005, 2010a) and ethical reasoning in action developed by James Madison University (2018). During the rubric development in the current research, researcher used the steps of rubric development determined by Brookhart (2018), the relevant literature, the responses of the pilot open-ended questions and interviews, and opinions of two experts on ESDG, systems thinking skills and ethical reasoning in action.

3.6.2.1 Rubric for Systems Thinking Skills (STS)

The STS rubric was developed based on the integration of the pillars of the Sustainable Development Goals produced by the United Nations (2015) and systems thinking skills determined by Ben-Zvi Assaraf and Orion (2010a) for this study. With this rubric, it was aimed to analyze open-ended questions and semi-structured interviews based on the 8 systems thinking skills (see Appendix D). The

rubric included five levels to grade students' systems thinking skills. These levels are Insufficient (0), Marginal (1), Good (2), Excellent (3), and Extraordinary (4). Necessary criteria for assessing each level were explained explicitly and exemplified in the rubric (see Appendix D). According to these levels, students were labeled as insufficient (0) level if they could not identify systems thinking skills in terms of any pillar of sustainable development goals. Students were labeled as marginal (1) level if they could identify systems thinking skills in terms of only one pillar of sustainable development goals (e.g only people, only prosperity or only planet). Students were labeled as good (2) level if they could identify systems thinking skills in terms of two pillars of sustainable development goals (e.g people-planet, people-prosperity or prosperity-planet). Students were labeled as excellent (3) level if they could identify systems thinking skills in terms of three pillars of sustainable development goals (e.g people-prosperity-planet). Students were labeled as extraordinary (4) level if they could identify systems thinking skills in terms of all pillars of sustainable development goals (e.g. people-prosperity-planet-peace and partnership). For example, if a student could identify the components of a system and processes within the system (STS 1) by mentioning planet (environmental) components and processes like melting of glaciers, global warming, increased carbon dioxide emissions, human waste, air, soil, water pollution, this student was labeled as marginal (1) level because s/he could identify the components of a system and processes within the system in terms of only the planet pillar of sustainable development goals. On the other hand, if a student could identify the components of a system and processes within the system (STS 1) by mentioning people aspect (poverty, hunger, inequality, health problems, lack of water, education), prosperity aspect (economical problems, energy, industrialization), planet aspect (climate change, global warming, responsible consumption) peace aspect (equal rights, justice,) and partnership aspect (collaboration for goals), this student was labeled as extraordinary (4) level because s/he could identify fairness in terms of all people, prosperity, planet, peace and partnership pillars of sustainable development goals. Data analysis for all characteristics of systems thinking skills was conducted similarly.

3.6.2.2 Rubric for Ethical Reasoning in Action (ERiA)

The Ethical Reasoning rubric was developed based on the integration of the pillars of the Sustainable Development Goals produced by the United Nations (2015) and ethical reasoning in action determined by James Madison University (2018). With this rubric, it was aimed to analyze open-ended questions and interviews was based on the 8 dimensions of ethical reasoning in action that are presented in in Appendix E. The rubric included five levels to grade students' development of ethical reasoning. These levels are Insufficient (0), Marginal (1), Good (2), Excellent (3), and Extraordinary (4). Necessary criteria for assessing each level were explained explicitly in the rubric (see Appendix E). According to these levels, students were labeled as insufficient (0) level if they could not identify the dimensions of ethical reasoning in terms of any pillar of sustainable development goals. Students were labeled as marginal (1) level if they could identify the dimensions of ethical reasoning in terms of only one pillar of sustainable development goals (e.g only people, only prosperity or only planet). Students were labeled as good (2) level if they could identify the dimensions of ethical reasoning in terms of two pillars of sustainable development goals (e.g. people-planet, people-prosperity or prosperity-planet). Students were labeled as excellent (3) level if they could identify the dimensions of ethical reasoning in terms of three pillars of sustainable development goals (e.g people-prosperity-planet). Students were labeled as extraordinary (4) level if they could identify the dimensions of ethical reasoning in terms of all pillars of sustainable development goals (e.g. people-prosperity-planet-peace and partnership). For example, if a student could identify fairness, which is one of the dimensions of ethical reasoning in action, by mentioning providing same opportunities for all living, saving resources, not discriminating, this student was labeled as marginal (1) level because s/he could identify fairness in terms of only people pillar of sustainable development goals. On the other hand, if a student could identify fairness by mentioning like providing social equality, increasing the rate of girls going to school, by developing job opportunities, like cleaning and recycling garbage on land and sea, this student was labeled as excellent (3) level because s/he could identify fairness in terms of only people, prosperity and planet pillars of sustainable development goals. Data analysis for all dimensions of ethical reasoning in action was conducted similarly.

3.7 Trustworthiness of the Study

The trustworthiness of qualitative studies is often determined with the five most relevant criterias: dependability, credibility, conformability, transferability, and authenticity (Elo et al., 2014; Merriam & Tisdell, 2015). In this chapter, what each of these criteria mean and how they were applied to in the current research was explained under the seperate subheadings. In addition, ethical issues related to the study are explained in below.

3.7.1 Dependability

Dependability means the stability of data under different conditions and over time (Elo et al., 2014). This refers to that dependability indicates that the results of research are consistent and could be replicated (Kyngäs et al., 2020). The dependability of research can be provided a code-recode strategy, using an audit trail, stepwise replication, peer examination and triangulation (Ary et al., 2010; Chilisa & Preece, 2005; Krefting, 1991; Miles et al., 2014; Schwandt et al., 2007).

Code-recode strategy (also called as code agreement) includes that the same data are coded twice by researcher with one- or two-weeks break period between each coding. In order to see that the findings are the same or different, the findings from each codings are compared (Chilisa & Preece, 2005). In the current study, in order to enhance dependability of study, researcher coded the data about systems thinking skills and ethical reasoning in different times and compared them to ensure that coding is right. Coding results in different times were in the agreement.

Audit trails consists of systematic record-keeping approach that helps researchers to document and track the research process comprehensively. That is, an audit trail includes an analysis of the research process and product and researcher's explanations about all the research decisions and activities to demonstrate the method of data collection, record and analysis (Bowen, 2009; Li, 2004). It allows other researchers to follow the researcher's thinking process, evaluate the trustworthiness of findings, and potentially replicate the study. In order to conduct a thorough audit trial, some documents (raw data, interviews, observation notes, documents and records etc.) should be kept for crosschecking the research process (Guba & Lincoln, 1982). In this study, researcher recorded and kept raw data, interviews, and notes etc. During the research process, researcher observed and took

notes about the teaching process of SDG unit during and after each course every week. These notes were useful in terms of understanding the research process comprehensively.

Stepwise replication involves that two or more researchers examine and analyze the data of the research individually and compare their findings (Chilisa & Preece, 2005). In the present study, two researchers analyzed the data of students' systems thinking skills and ethical reasoning and the results of analyses were similar to a large extent. Researcher and other expert discussed the few inconsistencies and reached full agreements at the end of process. In order to guarantee validity for analysis of open-ended questions and semi-structure interviews, inter-coder reliability by two researchers is used. The coder-reliability can be calculated with the formula given at below (Miles & Huberman, 1994, p. 64; Tinsley & Brown, 2000).

$$Reliability = \frac{numberofagreements}{(totalnumberofagreements+disagreements)}$$

The inter-coder reliability must be within the range of 0.85-0.90 (Miles, Huberman & Saldana, 2014). In the current research, inter-coder reliability for the open-ended questions and semi-structured interviews were calculated and found as 0.88 for categorical level. That is, dependability of the inquiry was achieved.

Peer examination involves that researcher discusses the research process and the results of study with colleagues (e.g. experts or doctoral students) who have experience of qualitative research (Bitsch, 2005; Krefting, 1991). Moreover, peer examination contributes to researchers' deeper reflexive analysis and enable the researcher to be honest about his/her research (Bitsch, 2005; Krefting,1991). In this study, before, during and after research process, researcher and two experts in the field of ESDG, systems thinking skills and ethical reasoning discussed in the processes of SDGs unit development, the development and adaptation of data collection tools for systems thinking skills and ethical reasoning, data analysis process. Discussions were held on issues on which there was no consensus about the SDG unit, data collection tools for STS and ERiA, or data analysis. For example, classroom activities for some SDGS were revised in line with these discussions. Moreover, some open-ended questions and interview questions for STS were

changed or revised according to experts' opinions. After discussions with experts, the consensus was reached.

3.7.2 Credibility

Credibility can be explained as the confidence in how well the data address the intended focus of the study (Elo et al., 2014; Merriam & Tisdell, 2015; Polit & Beck, 2012). In qualitative research, credibility can be provided with some strategies like prolonged engagement in research site, persistent observation, use of peer debriefing, triangulation, member checking, establishing structural coherence and authority of researcher, reflexivity (field journal). Each strategy used was explained in detail at below.

In qualitative studies, prolonged engagement in research site includes that researcher get involved in the participants' world (Bitsch, 2005). This is important in terms of minimizing the deformations of information that may arise because of the researcher'presence in the research site. In addition, the researcher can acquire an insight the research' context. In order to ensure credibility of the results, the researcher spent time in the research site for approximately 3-4 weeks and she observed and communicated with science teacher and students before the research process begin. Then, the research process started, and the SDG unit implementation and data collection processes lasted approximately three months until the end of the semester. Researcher observed each lesson and took notes about the research process in detail. This enabled the researcher to build students' trust and a greater understanding of research group' context and culture.

Persistent observation is another strategy to enhance credibility because extended interaction with the context and research group enables explore participants' qualities, and essential and characteristics (Guba, 1981). In this study, researcher observed continuously students and science teacher in the setting to gain detailed understanding for in-depth study before (approximately 3-4 weeks), during (every week during the application of unit) and after (1-2 weeks for data collection) the study.

Another strategy to establish credibility is the use of peer debriefing which provides opportunity for researchers to test to expose themselves to research questions and their growing insights (Guba, 1981). In this study, before, during and after the

research process, researcher received supports from other two professionals in this field willing to provide scholarly guidance. Feedback and comments from experts about background information, data management, data collection process, data analysis procedure and research findings helped the researcher to improve the quality of the research. Two experts in the field of ESDG, systems thinking skills and ethical reasoning made suggestions and advices during the preparation of SDG unit and data collection sources. Furthermore, one expert in ESDG analyzed some parts of the data and came to agreement by discussing findings and interpretations with researcher in the data analysis process.

One of the important strategies to enhance credibility is triangulation. Triangulation includes the use of different methods, sources investigators and theories in order to get corroborating evidence (Onwuegbuzie & Leech, 2007). Triangulation cross-examines the integrity of participants' responses and enables the researcher to reduce bias. It is suggested that one or two triangulation techniques should be used in qualitative research. In this study, two triangulation techniques were used. First, investigator triangulation that utilizes several researchers to examine the same problem. This enables to strengthen the integrity of the results and brings different perceptions of the inquiry. The second triangulation technique is data triangulation that utilizes different research instruments or data sources such as open-ended questions, focus group discussion, interviews or participant observation to improve the data' quality from different sources (Denzin & Lincoln, 2005; Lincoln & Guba, 1985; Patton, 2002; Phillmore & Goodson, 2004). Choosing the most suitable method for data collection is fundamental for providing the content analysis'credibility (Graneheim & Lundman, 2004). Thus, the researcher should think long and hard how to collect the most appropriate data for content analysis. In this study, for ensuring accuracy of the findings (triangulation), data were obtained from different sources including open-ended questions, semi-structured interviews, students' activity sheets, researcher's notes and observations, or a combination of different methods and the researcher compared findings collected from different data sources. That is, students' systems thinking skills examined with data coming from open-ended questions, semi-structured interviews, students' and researcher' notes. The results from different data sources were compared and explained.

Another strategy for enhancing the quality and credibility of qualitative data is member checks. Member checks is a crucial process that qualitative researchers must experience as the heart of credibility (Lincoln & Guba, 1985; Onwuegbuzie & Leech, 2007). Member checks refers to continuously testing data and interpretations derived from members of research groups from which data are collected (Guba, 1981). The member checks strategy covers testing the data to guarantee that there is no internal conflict or inconsistencies and testing the analysis and interpretation of documents in data collection before generating the final report (Guba, 1981). In this research, researcher included the voices of students in the data analysis and the interpretation of the data to prevent researcher' bias. In other words, the interpreted and analyzed data was sent back to some students (generally students who are not clear what they mean) for them to assess the interpretation made by the researcher and to recommend changes if they had been misreported or they are unhappy with it.

In order to ensure credibility, researcher' self-awareness is necessary (Koch, 1994). Pre-interviews can enable to identify the appropriateness of the interview questions for getting rich data responding the questions of research. In order to evaluate the researcher's own actions critically, interview recordings and transcribed text must be analyzed carefully. For example, some questions like "Did I lead or manipulate the participants of the study?" and "Did I ask too structured or broad questions?" can be asked. Such assessments should be started both at the beginning of the study and be supported with continuous reflection to guarantee the content analysis' trustworthiness. In this study, in line with these questions, pilot study was conducted to obtain data about whether data collection tools developed by researcher (open-ended questions) were understandable and suitable for students Moreover, experts' opinions about the data collection tools were received to be ensure the suitability of data collection tools. The pilot study allowed the researcher to practice the research of data collection, thus, she has experienced about asking questions without manipulation or leading participants.

In addition, researcher reflexivity or position is the strategy enabling the reader to comprehend how researcher interprets the data and approaches to the study (Merriam, 2009). Researcher's position (role) for the current research was given in detail at the 3.1.1.1 (Researcher's Position (Role) as a Designer) section, Moreover, Shenton (2004) stated some suggestions for ensuring honesty in informants. The current study was conducted with volunteer students enrolled Environmental Education and Climate Change course. Before and during the data collection process, it was given information to students about that there was not right or wrong answer to the open-ended questions or semi structured interviews and they will not be graded. Thus, students responded to the question by feeling comfortable in the classroom.

3.7.3 Conformability

Conformability means the objectivity and the data accuracy by showing the interpretations of the data from the participants are not invented by the researcher. That is, there should be agreement among two or more different researchers about the data's accuracy, meaning or relevance. The results should reflect the inquiry' conditions and participants' voice, and not the perspectives, biases, or motivations of researchers (Elo et al., 2014; Lincoln & Guba, 1985; Polit & Beck, 2012; Shenton, 2004). Research recommend that conformability of qualitative inquiry can be provided with an audit trial, triangulation, and reflexive journal (Bowen, 2009; Koch, 2006; Lincoln & Guba, 1985). Shenton (2004) emphasized that triangulation provides to reduce researcher's bias in the study. Thus, in order to ensure conformability of this research, data were obtained from different data collection tools like open-ended questions, semi- structured interviews, and supportive sources like students' and researchers' notes and reports for triangulation. Furthermore, researcher explained all the research process and data collection and analysis in detail and conducted peer review to guarantee that the results are not influenced by biases.

Reflexive journal includes reflexive documents held by the researcher for the purpose of tentatively interpret, reflect on and plan data collection (Koch, 2006; Wallendorf & Belk, 1989). In the current research, investigator kept a reflexive journal including all processes in the field and her personal reflections about the research.

3.7.4 Transferability

Transferability means to what extent the findings can be generalized or transferred to other situations, settings or groups. (Koch, 1994; Lincon & Guba, 1985; Merriam, 2009; Miles & Huberman, 1994; Polit & Beck, 2012). In order to ensure transferability of the research, the researcher should describe the enquiry (thick description) in detail and select participants purposively (purposeful sampling) (Bitsch, 2005; Jensen, 2008; Merriam & Tisdell, 2015; Moretti et al., 2011).

Thick description includes that the enquirer explains all research processes like data collection, methodology and research' context and generation of the research report (Li, 2004). Thick description enables that different researchers replicate the research in other contexts or settings with similar conditions. Thus, the details of the research processes like SDG unit implementation process, the research group, the method of research, data collection and analysis process, descriptions of findings with quotes were provided in this research.

Purposive Sampling involves selection of participants in naturalistic inquiry studies based on purposes connected with responding the research questions (Teddlie & Yu, 2007). In this study, 7th grade students enrolled 'Environmental Education and Climate Change' course were determined as research group to get in-depth findings about their systems thinking skills and ethical reasoning. The detailed information about sampling and research group are given in part 3.2 (Research Group).

3.7.5 Authencity

The other criterion for trustworthiness of qualitative study is authenticity which means the degree to which researchers indicate a range of realities fairly and faithfully (Lincoln & Guba, 1985; Polit & Beck, 2012). In order to provide authenticity, researchers should have knowledge and experience to perform an accurate analysis of the study (Lincoln & Guba, 1985; Whittemore et al., 2001). In this study, the researcher has a background and experience in both education for sustainable development and qualitative research. She took several courses on education for sustainable development and qualitative research throughout undergraduate and graduate education. She studied specifically sustainable development and environmental education during her undergraduate and graduate education. She, as a research assistant, has experienced and assisted the courses

related to environmental and education for sustainable development at public universities for 8 years. Researcher also has experience and studies about qualitative research. Furthermore, researcher presented all steps of research process explicitly and revealed a range of realities fairly and faithfully by applying all process of trustworthiness for this qualitative study.

3.7.6. Ethical Issues

A series of ethical issues were considered from beginning to the end of this research. According to Miles and Huberman (1994), three important ethical issues that require attention before, during and after the qualitative research ((1) informed consent, (2) privacy, anonymity and confidentiality and (3) avoidance of harm). In this context, necessary permissions were obtained from the ethical committee of the university and Ministry of National Education of Türkiye to conduct this study before the study started. Since all research including human beings should be examined by an ethics committee to guarantee that the suitable ethical standards are being applied, permission were obtained from Ethical committee of the university for conducting this research. This provides to protect the rights, dignity and welfare of the participants of research. In addition, permission was obtained from Ministry of National Education of Türkiye to implement research process and collect data from 7th grade students enrolled in Environmental Education and Climate Change course in a public school, Türkiye. Ministry of National Education of Türkiye examined the suitability of unit implementation and data collection tools for students in terms of protecting students' privacy and rights. At the beginning of the research process, informed consent was obtained from all students involved through a "Voluntariness of subjects and informed consent form". In addition, informed consent was obtained from their parents through a "Child consent form for research purposes" before the study. Moreover, students were given information about research process (unit implementation, data collection etc.) and the course content in detail. Moreover, they were informed that this implementation was a part of the research and voluntariness was taken in basis. In addition, students were enlighted about that they had an option not to participate in the research or they could give up the study if they wanted. Furthermore, it was given information about that nobody could access the data for the privacy of the students. For the anonymity, participants' personal knowledge and names were not used and not shared in the

research and they were given numerical names (i.e, ST1, ST5). Moreover, there was not any harm, risk or disadvantage to students in this study since necessary precautions in classroom was taken by researcher and the science teacher.

4
RESULTS

In the current study, a learn–think–act approach-based Sustainable Development Goals unit was developed and the effect of this unit on middle school students' systems thinking skills and ethical reasoning was explored. The results are presented under separate headings for the three main areas of the research: (1) Sustainable Development Goals unit, (2) students' systems thinking skills and (3) students' ethical reasoning in action.

4.1 Sustainable Development Goals (SDGs) Unit

The first aim of this thesis is to develop an educational resource (a SDGs unit) for K-12 education to train students about sustainable development goals. Therefore, a learn-think-act based Sustainable Development goals unit was developed for middle school students. The aim of this unit is to develop their systems thinking skills and ethical reasoning as global citizens to achieve the Sustainable Development Goals by 2030. The SDG unit was based on a learn–think–act pedagogical approach and included cognitive, socio-emotional and behavioral learning objectives for each SDG. The cognitive learning objectives for each SDG consisted of required knowledge and thinking skills to comprehend the SDGs better and overcome the challenges to achieve them. For example, the cognitive learning objective for 'SDG 1: No Poverty' in the unit is 'Students explain the concept, distributions, causes and impacts of poverty.' The socio-emotional learning objectives for each SDG in the unit involved social skills such as attitudes, self-reflection skills, values and motivations so that learners can communicate, negotiate and collaborate for SDGs. For instance, the socio-emotional learning objective for 'SDG 2: Zero Hunger' in the unit is 'Students discuss critically their own role and responsibilities for zero hunger.' The behavioral learning objectives for each SDG in the unit included competencies for action. For example, the behavioral learning

objective for SDG 3: Good Health and Well-being' in the unit is: 'Students propose suggestions for promoting good health and well-being.'

The teaching procedure for each goal in the unit consisted of three main parts: Learn-Think-Act. The "learn" part for each SDG involved theoretical knowledge about the SDGs and different instructional videos. For instance, the learn part of 'SDG 4: Quality Education' included 2 instructional videos about SDG 4 and explanations about the concept of quality education and the important role of quality education and lifelong learning opportunities for all. The "think" part for each SDG consisted of practical educational resources such as different cases and learning activities about the 17 SDGs to make students think critically. For example, the "think" part of 'SDG 7: Affordable and Clean Energy' included the activity entitled 'Let's use renewable energy!' The "act" part for each SDG covered different videos and learning activities about action and reflection. For instance, SDG 12: Responsible Consumption and Production involved 2 videos about the examples of actions related to SDG 12 and a learning activity about the solutions, suggestions and actions for SDG 12. Table 4.1 shows a part of the Sustainable Development Goals unit (related to SDG 1: No poverty) (see Appendix A for the whole unit).

Table 4.1 A part of the Sustainable Development Goals unit (related to SDG 1: No poverty)

SDG	**Learn**	**Think**	**Act**
SDG 1-No poverty	**Cognitive Learning Objective:** Students explain the concept of poverty, distributions of poverty, causes and impacts of poverty.	**Socio-Emotional Learning** **Objective**: Students discuss their own role and responsibilities for no poverty.	**Behavioral learning objective:** Students propose local and global solutions for no poverty.
	Background V**ideos:** Understand SDG 1: No Poverty https://www.youtube.com/watch?v=A2O1HU6FMfk accessed on 20 January 2023 https://www.youtube.com/watch?v=T7qiM0quEf4&t=2s accessed on 2 February 2023	**Classroom Activity:** The world resources are not fairly and equally distributed!	**Activity:** What can you do to end poverty? **Videos:** Take Action on SDG 1: No Poverty https://www.youtube.com/watch?v=VbYXMxeRoAc accessed on 20 January 2023 https://www.youtube.com/watch?v=T66qWMHg83c accessed on 20 January 2023

4.2 Students' Systems Thinking Skills (STS)

In the scope of this research, 20 7th grade students' systems thinking skills were examined before and after SDG unit implementation. Answers by each student to the open-ended questions and semi-structured interviews were analyzed by using the rubric developed by researcher. Based on the data analysis, students' system thinking levels were determined and presented under separate headings. For each STS level, the development of students' systems thinking skills and excerpts from their answers were supplied.

4.2.1 STS 1: The ability to identify the components and processes of the system

According to Ben-Zvi Assaraf and Orion (2005, 2010a), the first systems thinking skill involves identifying the components of a system and the processes within the system. In this study, students were asked 'What are the components (problems) of the world? Please explain'. Students were expected to identify the components and processes within the system by considering each pillar of sustainable development goals (people, prosperity, planet, peace and partnership) within the real-life case of the world.

According to the results, before the SDG unit implementation, 4 of the students were placed at the insufficient (0) level, 13 at the marginal (1) level, 2 at the good (2) level, and only 1 was placed at the excellent (3) level regarding identifying the components of a system and the processes within the system by considering each pillar of sustainable development goals. This means that most students identified the components of the system and its processes by considering only one pillar of sustainable development goals (mostly planet).

After SDGs unit implementation, all students' STS 1 level developed and reached higher level systems thinking skills. 17 students were placed at the extraordinary level (4) and 3 at the excellent (3) level. All students could identify the components of the system and its processes by considering a minimum of three of the pillars of sustainable development goals. Figure 4.1 shows the results about the numbers of students according to STS 1 level before and after SDG unit implementation.

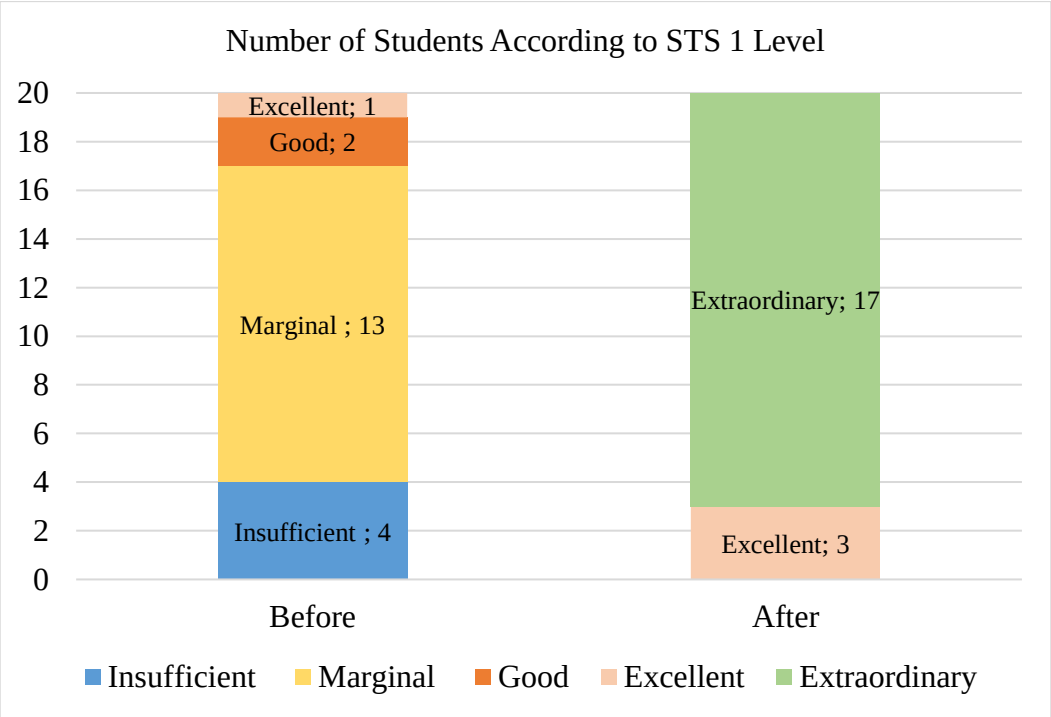


Figure 4.1 Number of students according to STS 1 level

Table 4.2 presents the results about students' skills in identifying the components of a system and the processes within the system (STS 1) before and after SDG unit implementation. Table 4.2 also shows students' levels of STS 1 and which pillars of the sustainable development goals were considered by students in identifying the components of the system and its processes (STS 1).

Table 4.2 Students' STS 1 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
STS 1: The ability to identify the components of a system and processes within the system	Insufficient (0)	No pillar	4	ST4, ST6, ST8, ST9		
	Marginal (1)	People	1	ST17		
		Planet	12	ST2, ST3, ST5, ST10, ST11, ST12, ST13, ST14, ST15, ST16, ST19, ST20		
	Good (2)	People-Planet	2	ST7, ST18		
	Excellent (3)	People-Planet-Prosperity	1	ST1	3	ST11, ST13, ST20
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			17	ST1, ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9, ST10, ST12, ST14, ST15, ST16, ST17, ST18, ST19

According to the results, most students (13) (ST 2, ST3, ST 5, ST10, ST11, ST 12, ST 13, ST 14, ST 15, ST 16, ST 17, ST 19 and ST 20) were at the marginal (1) level and identified the components and processes within the system by considering only one pillar of sustainable development goals at the beginning of SDG unit implementation. The results also indicated that most of these students (ST 2, ST3, ST 5, ST10, ST11, ST 12, ST 13, ST 14, ST 15, ST 16, ST 19 and ST 20) could identify the components and processes related to the planet pillar of sustainable development goals. They identified environmental components and processes such as the melting of glaciers, global warming, increased carbon dioxide emissions, human waste, air, soil, water pollution. Only one student (ST 17) could identify the components and processes of the system related to the 'people' pillar of sustainable development goals by mentioning lack of water, famine, poverty. On the other hand, some students (4) (ST4, ST6, ST8, ST9) were at the insufficient (0) level and could not identify the components of the system and the processes within the system by considering any of the pillars of sustainable development goals. Two students (ST7, ST18) were at the good (2) level and could identify the components and processes of a system by considering the 'people-planet' pillars of sustainable development goals. They emphasized sea level rise, melting glaciers, hunting animals, cutting trees, environmental pollution, global warming, hunger, lack of water, decrease in agriculture, lack of gender equality. At the beginning of SDG unit implementation, only one student (ST1) was at the excellent (3) level in identifying the components and processes of the system and she explained the components and processes by emphasizing the three pillars of sustainable development goals (people-prosperity, planet) such as air pollution, water pollution, soil pollution, global warming, decrease in agricultural lands, melting of glaciers, danger of flooding in some places, hunger, famine, economic crises, destruction of forests, inequality, gender inequality, industrialization, fossil fuel consumption, homelessness, political problems.

After SDG unit implementation, all students' STS 1 level developed and rose to higher levels. Most of the students' (17) (ST1, ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9, ST10, ST12, ST14, ST15, ST16, ST17, ST18, ST19) STS 1 level rose to extraordinary (4). That is, they could identify the components and processes within the system by considering all pillars of sustainable development goals (people,

prosperity, planet, peace and partnership). They could identify the components and processes of the systems by emphasizing the people aspect (poverty, hunger, inequality, health problems, lack of water, education), prosperity aspect (economical problems, energy, industrialization), planet aspect (climate change, global warming, responsible consumption) peace aspect (equal rights, justice,) and partnership aspect (collaboration for goals). On the other hand, 3 students' (ST 11, ST 13 and ST 20) STS 1 levels rose to the excellent (3) level and they could identify the components of the system and processes within the system by considering the 'people-prosperity-planet' pillars of sustainable development goals. They mentioned climate change, energy resources, unemployment, inequality and injustice between men and women, sustainable cities and buildings, responsible consumption and production, healthy life.

To summarize, students mostly could identify the components and processes within the system related to the 'planet' pillar of sustainable development goals before the SDG unit implementation. Their STS 1 developed and rose to higher levels with the implementation of the SDG unit. They could identify the components of the system and its processes related to the 'people, prosperity, planet, peace and partnership' pillars of sustainable development goals. Table 4.3 shows sample excerpts from students at different levels before and after the SDG unit implementation.

Table 4.3 Sample excerpts showing students' STS 1 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
STS 1: The ability to identify the components of a system and processes within the system	Insufficient (0)	No pillar	ST 4: Every year in the world, people are destroying the world, living things are losing their lives and become extinct because of many factors like factory fumes.	
	Marginal (1)	People	ST 17: The problems are famine, hunger, lack of clean water.	
		Planet	ST 11: There are problems like unplanned urbanization, melting of glaciers, global warming, climate change, excess carbon emissions, human waste gases, exhaust fumes, extinction of animals, reduction of plants, continuous cutting of trees, air, soil and water pollution, rise of water, rising temperatures, drought, lack of agriculture	
	Good (2)	People-Planet	ST 18: <u>People:</u> poverty, hunger, lack of water, lack of gender equality in some countries, population density <u>Planet:</u> unplanned urbanization, polluted water due to toxic wastes, hunting of animals, climate change, global warming, decrease in agriculture, factories emitting toxic gas and waste, sea level rise, glaciers melting, cutting trees.	

Table 4.3 Sample excerpts showing students' STS 1 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 1: The ability to identify the components of a system and processes within the system	Excellent (3)	People-Planet-Prosperity	ST 1: People: hunger, famine, poverty, inequality, gender inequality. Prosperity: economic crises, industrialization, fossil fuel consumption, political problems. While there is mechanization in agriculture in some places, agriculture is still done with human power in some places. Some people have houses, while others stay in tents. Planet: Air pollution, water pollution, soil pollution, global warming, decrease in agricultural lands, melting of glaciers, danger of flooding in some places, destruction of forests.	ST 11: People: There are problems like poverty, hunger, inequality, health problems,. People are the cause of these problems. Humans made the world this way. People cannot meet their basic needs. They cannot meet their needs such as food and water. People should be able to live in a healthy and comfortable way. Wars, thirst, hunger, cause poverty, hunger and addictive substances cause unhealthy life. Education should be good quality, and everyone should be able to benefit equally. The inequality between men and women, which has existed for a long time and continues. Discrimination between men and women should be prevented. The idea that men are superior to women should be destroyed and women should be equal to men. must come to an end. Especially in countries like Africa, people do not have access to clean water. Every person has the right to access clean water. Prosperity: It is necessary to design cities so that people can live in beautiful and sustainable cities, now and in the future. It is important to use renewable energy.

Table 4.3 Sample excerpts showing students' STS 1 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 1: The ability to identify the components of a system and processes within the system	Excellent (3)	People-Planet-Prosperity		ST 11: Planet: There are problems like global warming, pollution, famine, drought. We need to consume or product responsibly, without wasting, with the future in mind. It is important that people in the future have the resources we have today and live comfortably. Temperatures are rising due to human misuse of natural resources. Action is urgently needed to tackle climate change and its effects, to stop global warming and fix the world's climate. People pollute the seas and harm fish. In order for aquatic life to improve, measures must be taken to keep the waters clean. We need to protect terrestrial life, which is also the habitat of people. We must preserve the cycle of nature.
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 4: Planet: We should consume as much as we need. We must consume the resources that others have the right to in a controlled and responsible manner. For example, excessive use of plastic bottles pollutes our water resources. The unconscious behaviors of people cause global warming and harm humanity. It causes climate change. Seasons are not experienced as they should be, the number of natural disasters is increasing. As humanity, when we throw our waste into the seas and lakes, we harm the creatures living in the waters. We are also hurting ourselves. We cannot enter the sea. When we eat seafood, we are more likely to get sick. Every living thing needs water and we must protect it. As humanity, we unconsciously pollute our environment and the nature we live in by throwing garbage. Therefore, as time passes, the world unfortunately becomes uninhabitable.

Table 4.3 Sample excerpts showing students' STS 1 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 1: The ability to identify the components of a system and processes within the system	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 4: <u>People:</u> There is poverty in some parts of the world like African countries. It's not about getting something when you want it. People cannot find food, water, food, drink, shelter. Millions of people die of hunger every year. Natural disasters, wars, job opportunities, low wages or climate change cause them. Something must be done to end hunger, so that not too many people go hungry. The places where these people live are not suitable for agriculture, and there are economic crises in some countries due to the war. Due to poverty, people cannot take care of their health. Can't access healthcare. People should be able to meet their health needs and lead a quality life. Education should be given in a good and quality way. In order to become a professional, we must receive adequate training. Everyone should benefit from education equally. The quality of education varies in each country. Girls are discriminated against, they cannot get a good education. If girls can get quality education, they will have a job. There is gender inequality. They do not have equal rights. Women cannot do the job they want because of discrimination. We must protect resources and not waste food and water unnecessarily. For people who do not have access to water, we must purify the water and make it drinkable and usable.

Table 4.3 Sample excerpts showing students' STS 1 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 1: The ability to identify the components of a system and processes within the system	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 4: Prosperity: In some parts of the world, people have difficulty accessing energy, some people do not even have the energy resources to cook. It is very important that everyone in the world has access to clean energy, including in poor countries. If every person has a job that suits him, the unemployment rate falls and contributes to economic growth. For example, they work in inhumane conditions in some factories (darkness, etc.). Men and women do not receive equal salaries. It is important for the world to develop the industry, to be open to innovations, and to have a solid infrastructure. this is important in every field. For example, the country's health infrastructure should be good and robust against infectious diseases. Inequalities between people or between countries need to be reduced. There should be no distinction between rich and poor, men and women. Women should have rights and be aware of their rights. It is necessary to protect our resources, to think of future generations, to build houses and cities accordingly. For example, future-proof houses should be built with sustainable materials that are resistant to natural disasters. Peace: It is very important for people to live in peace and to have well-functioning just institutions and to make efforts for people to live in peace. Partnership: For a beautiful world, it is important to make agreements between countries that will last for many years, and to act together by institutions and countries, taking into account all sustainable development goals.

4.2.2 STS 2: The ability to identify simple relationships among the system's components

According to Ben-Zvi Assaraf and Orion (2005, 2010a), the second systems thinking skill includes identifying simple relationships among the system's components. In this study, students were asked 'What are the relationships between the components (problems) of the world? Explain by giving an example.' Students were expected to identify simple relationships between the system's components by considering each pillar of sustainable development goals (people, prosperity, planet, peace and partnership) within the real-life case of world.

According to results, before the SDG unit implementation, 9 of the students were placed at the insufficient (0) level, 8 at the marginal (1) level and 3 at the good (2) level in identifying simple relationships among the system's components by considering each pillar of sustainable development goals. This means that nearly half of the students could not identify simple relationships among the system's components or the other half of the students identified simple relationships among the system's components by considering only one pillar of sustainable development goals.

After SDGs unit implementation, most of the students' STS 2 level developed and reached higher level systems thinking skills. 10 of the students' level was extraordinary, 7 of the students' level was excellent, 2 of the students' level was good, and 1 student's level was marginal. After the SDG unit implementation, most of the students could identify simple relationships among the system's components by considering a minimum of 3 pillars of sustainable development goals. Figure 4.2 shows the numbers of students according to their STS 2 level before and after the SDG unit implementation.

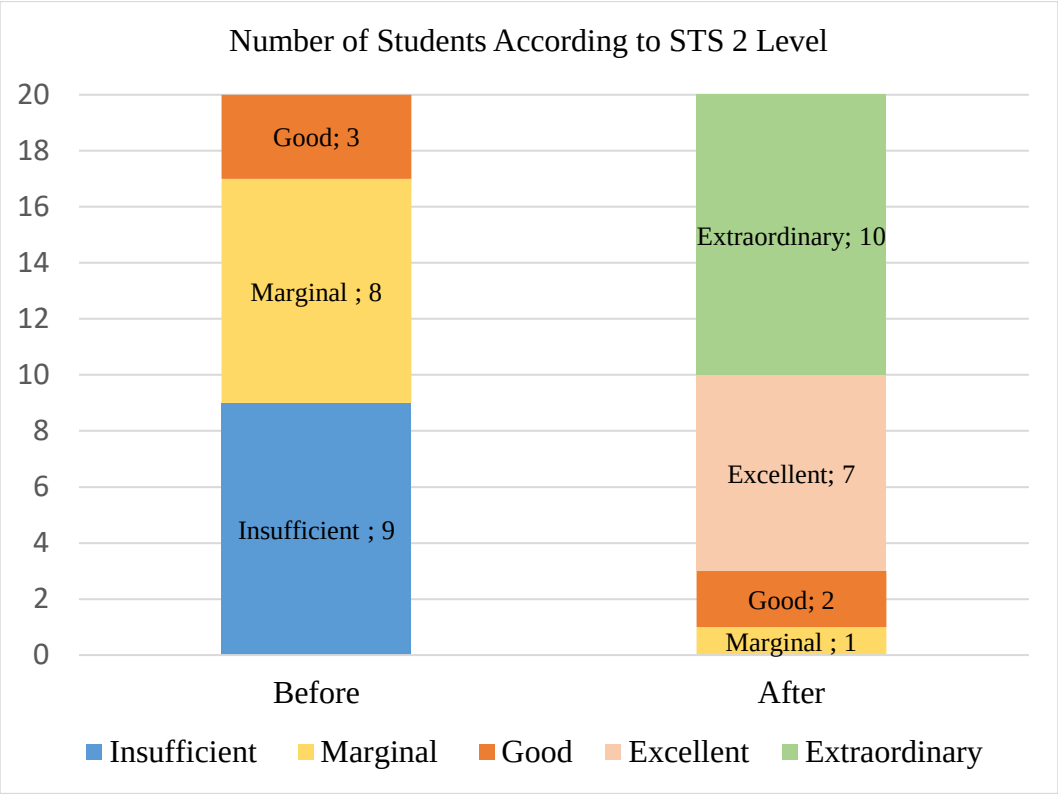


Figure 4.2 Number of students according to STS 2 level

Table 4.4 presents the results about students 'skills in identifying simple relationships among the system's components (STS 2) before and after the SDG unit implementation. Table 4.4 shows students' levels of STS 2 and which pillars of the sustainable development goals were considered by students in identifying simple relationships among the system's components (STS 2).

Table 4.4 Students' STS 2 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
STS 2: The ability to identify simple relationships among the system's components	Insufficient (0)	No pillar	9	ST4, ST7, ST8, ST10, ST15, ST17, ST18, ST19, ST20		
	Marginal (1)	Planet	8	ST1, ST2, ST3, ST5, ST6, ST11, ST13, ST14	1	ST8
	Good (2)	People-Planet	2	ST12, ST16	2	ST15, ST18
		People-Prosperity	1	ST9		
	Excellent (3)	People-Planet-Prosperity			7	ST 6, ST10, ST13, ST14, ST17, ST19, ST20
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			10	ST1, ST2, ST3, ST4, ST5, ST7, ST9, ST11, ST12, ST16

According to the results, at the beginning of the SDG unit implementation, nearly half of the students (9) (ST 4, ST7, ST 8, ST10, ST15, ST17, ST18, ST19, ST 20) were placed at the insufficient (0) level and could not identify simple relationships between the system's components by considering any pillar of sustainable development goals. 8 of the students (ST1, ST2, ST3, ST5, ST6, ST11, ST13, ST14) were at the marginal (1) level and could identify simple relationships between the system's components by considering only one pillar of sustainable development goals (the planet). They identified simple relationship between the system's components in terms of the planet such as the relationship between air pollution-toxic and exhaust gases, the relationship between greenhouse gases-global warming, the relationship between water pollution-waste of factories, the relationship between global warming-climate change-melting glaciers- extinction of animals and plants, the relationship between environmental pollution-garbage disposal. On the other hand, 3 students (ST9, ST12 and ST16) were at the good (2) level and could identify simple relationships among the system's components by considering two of the pillars of sustainable development goals. ST12 and ST 16 identified simple relationships among the system's components by considering the 'people-planet' pillars of sustainable development goals. For example, they emphasized the relationship between global warming-lack of agriculture-hunger, the relationship between lack of education-environmental pollution. ST 9 identified simple relationships among the system's components by considering the 'people-prosperity' pillars of sustainable development goals. She identified the relationship between economic crises-famine-starving.

After the SDG unit implementation, most students were placed at higher levels (excellent or extraordinary) in identifying simple relationships among the system's components by considering three or more pillars of sustainable development goals (people, planet, prosperity, peace and partnership). 10 students (ST1, ST2, ST3, ST4, ST5, ST7, ST9, ST11, ST12, ST16) rose to the extraordinary (4) level. They emphasized that there are relationships among all of the systems' components, such as the relationship between clean water and sanitation-life in water, the relationship between climate action and terrestrial life, the relationship between drought-hunger, the relationship between pollution-good health and well-being, the relationship between poverty- decent work and economic growth, the relationship between

quality education-responsible consumption and production, the relationship between peace, justice and strong institutions- reducing inequalities, the relationship between affordable and clean energy- sustainable cities. 7 of the students (ST 6, ST10, ST13, ST14, ST17, ST19, ST20) rose to the excellent (3) level. On the other hand, some students (2) (ST15, ST18) were placed at the good level and could identify simple relationships between the system's components by considering two of the pillars of sustainable development goals (people, planet). They mentioned the relationships between good health-air pollution, climate change-poverty, water shortage-responsible consumption. After the SDG unit implementation, only 1 student (ST8) was at the marginal (1) level and could identify simple relationships among the system's components by considering only one pillar of sustainable development goals (the planet). She only explained the simple relationship between global warming-melting glaciers, water pollution-waste disposal. There was no student who was at the insufficient level after the SDG unit implementation.

To sum up, students either could not identify relationships among systems' components or could identify simple relationships among the system's planet components before the SDG unit implementation. After the implementation, their STS 2 level improved and was enhanced to higher levels. Thus, they could identify simple relationships among systems' components in a minimum of three of the main pillars (people, prosperity, planet) of sustainable development goals. Table 4.5 presents quotes from students at different levels before and after the SDG implementation.

Table 4.5 Sample excerpts showing students' STS 2 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
STS 2: The ability to identify simple relationships among the system's components	Insufficient (0)	No pillar	ST 7: There is a relationship. Things that cause air pollution: cigarette smoke, factory smoke, garbage smells, forest pollution, fire fumes.	
	Marginal (1)	Planet	ST 6: Planet: Air pollution occurs due to toxic gases, factory fumes, greenhouse gases. Water pollution occurs due to garbage and chemicals thrown into seas, oceans, rivers etc.. Soil pollution occurs due to wastes. I think there is a lot of correlation and relationship between these problems. Because all of the problems I mentioned cause global warming, so the glaciers are melting. For example, there is a relationship between global warming and rural-urban migration. they may have moved from the village to the city because of the climate. Due to global warming, the climate is changing and the animals living in the glaciers are dying. They're going extinct. There are such relationships. There is a relationship between the problems in the world.	ST 8: Planet: Water pollution occurs due to people throwing waste into the water. Global warming due to factories. Air pollution is caused by harmful gases from the exhausts of cars. The reason is that people are unconscious.

Table 4.5 Sample excerpts showing students' STS 2 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 2: The ability to identify simple relationships among the system's components	Good (2)	People-Planet	ST 16: People-Planet: Lack of water, hunger, poverty, lack of education, lack of oxygen due to cutting trees, air pollution, lack of agriculture, extinction of animals. There is relationship among all of them. All events trigger each other. The fact that girls are not sent to school is due to undeveloped, unconscious people. Many people die every day from drinking contaminated water. For example, global warming causes melting glaciers. It's not raining because of the climate change. For example, methane gas cause global warming and affects our entire world and our environment. People may have difficulty breathing due to air pollution.	ST 15: People-Planet: There is a relationship between all problems. For example, as the temperature rises, people's need for water may increase. More water is consumed and this cause lack of water. When the glaciers melt, the sun's rays cannot be reflected and the temperature of the earth increases. Trees are cut down, used for house building, paper making, campfires harms nature. The polluted air may cause being sick
		People-Prosperity	ST 9: People-Prosperity: I think that the problems are interrelated. Economic problems create social problems. For example, there is famine as an economic crisis, which causes people to starve as a social problem.	

Table 4.5 Sample excerpts showing students' STS 2 levels before and after the SDGs unit implementation (cont.)

STS 2: The ability to identify simple relationships among the system's components	**Level**	**Pillars of SDG**	**Before**	**After**
	Excellent (3)	People-Planet-Prosperity		ST 6: <u>People-Prosperity-Planet:</u> There is a relationship between all components. There are many problems like people's waste, urbanization, pollutions due to irresponsible behavior of people. Factories often release harmful gases to the nature. That's why humans are slowly destroying the world. There is a relationship between climate change and aquatic life and terrestrial life. There is a relationship between all inequalities, poverty and hunger, decent work and economic growth and industry, infrastructure and innovation. They're all interrelated.

Table 4.5 Sample excerpts showing students' STS 2 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 2: The ability to identify simple relationships among the system's components	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 7: <u>People-Prosperity-Planet-Peace-Partnership:</u> People because they are connected to every event. The world is disappearing day by day because of humans. Many of them influence each other. For example, poverty and hunger are related. A poor person suffers from hunger. People who are poor may be unhealthy and may not have access to healthcare. They cannot access qualified education either. In a poor and underdeveloped country, people may not have some rights such as gender equality. In poor countries, there is no or no access to clean water and sanitation. For example, in some places, while trying to find water, people can reach dirty and muddy water. They try to clean this water, but they do not have the opportunity to purify and sanitize this water to drink or use it due to their economy. In my opinion, economic growth and industrial development should be ensured so that everyone can access clean energy. These goals are also interrelated. There is also a close relationship between economic growth, industry and decent work. If a person has a job with good conditions, economic growth is also achieved. There may be entrepreneurial opportunities for innovation. They're all interrelated.

Table 4.5 Sample excerpts showing students' STS 2 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 2: The ability to identify simple relationships among the system's components	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 7: <u>People-Prosperity-Planet-Peace-Partnership:</u> Inequality exists everywhere. But in places where there is a lot of it, for example in South American countries such as Colombia, Mexico and Venezuela, crime rates are very high. There are many cases of drugs, violence, kidnapping and murder. Security forces sometimes cannot solve these problems. Unfortunately, there are no laws, penalties or equality that will ensure social peace. Migration events may occur for these reasons. People living here can migrate to other countries where they can get their rights. Concepts such as rights, law and justice should be developed in these regions. There is already a sustainable development goal. To protect aquatic life, we must protect water, garbage, bags, all kinds of waste thrown away harm water and aquatic life (fish and other aquatic creatures). When the climate changes, the ice in the poles and Antarctica melts and the water rises, creating a harmful situation for the penguins living there and the aquatic creatures. It also affects terrestrial life. When the seasons change, for example, if a cold place becomes hot and a hot place becomes cold, the creatures living there may be harmed. All problems are interrelated and can be solved with collaboration of people and countries.

4.2.3 STS 3: The ability to identify dynamic relationships within the systems

According to Ben-Zvi Assaraf and Orion (2005,2010a), the third systems thinking skill involves identifying dynamic relationships within the systems. In this study, students were asked **'**Is there a human impact on the problems experienced in the world? What do you think about whether there is a relationship between the problems experienced in the world and people's lifestyles? Please explain'. Students were expected to identify dynamic relationships within the systems by considering each pillar of sustainable development goals (people, prosperity, planet, peace and partnership) within the real-life case of the world.

According to the results, before the SDG unit implementation, 10 of the students were placed at the insufficient (0) level, 8 of the students at the marginal (1) level and 2 at the good (2) level in identifying dynamic relationships within the systems by considering each pillar of sustainable development goals. This means that half of students could not identify dynamic relationships within the systems.

After the SDGs unit implementation, most of the students' STS 3 level developed and reached higher level systems thinking skills. 8 of the students' level was extraordinary (4), 7 of the students' level was excellent (3), 3 of the students 'level was good (2), and 2 of the students' level was marginal (1). After the SDG unit implementation, most of the students could identify dynamic relationships within the systems by considering a minimum of three pillars of sustainable development goals. Figure 4.3 shows the numbers of students according to their STS 3 level before and after the SDG unit implementation.

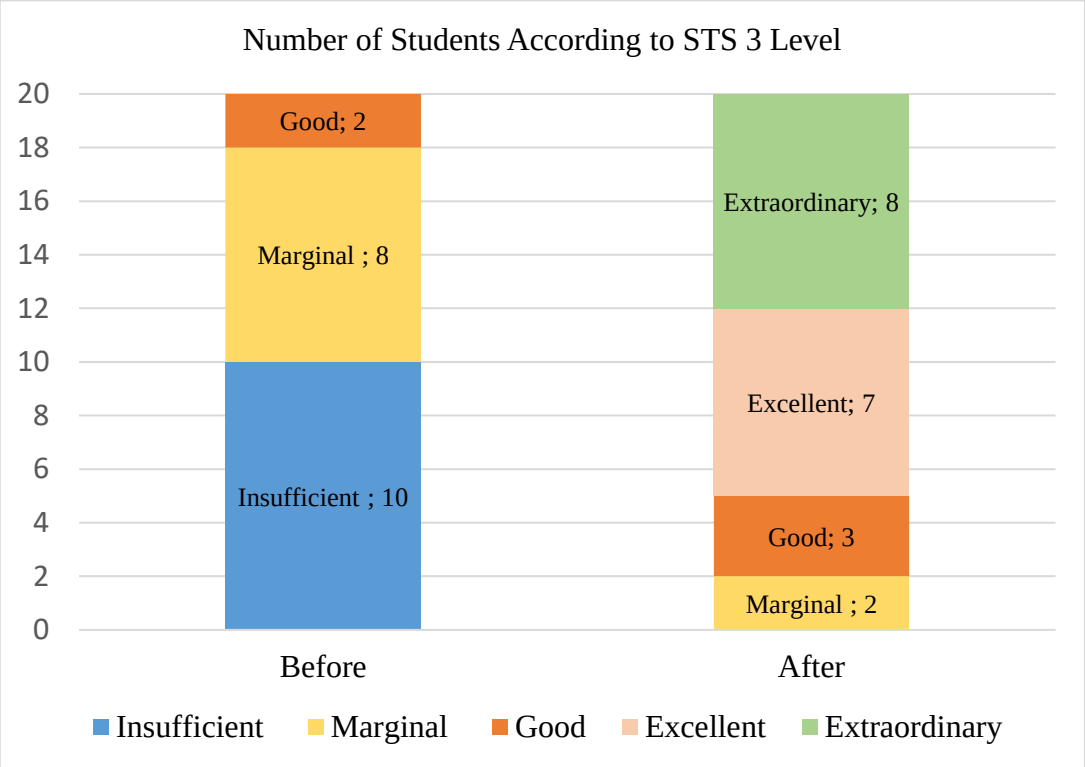


Figure 4.3 Number of students according to STS 3 level

Table 4.6 presents the results about students' skills to identify dynamic relationships within the systems (STS 3) before and after the SDG unit implementation. Table 4.6 shows students' levels of STS 3 and the pillars of the sustainable development goals that were considered by students in identifying dynamic relationships within the systems (STS 3).

Table 4.6 Students' STS 3 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
STS 3: The ability to identify dynamic relationships within the systems	Insufficient (0)	No pillar	10	ST4, ST8, ST10, ST12, ST13, ST15, ST16, ST17, ST18, ST19		
	Marginal (1)	Planet	8	ST1, ST2, ST3, ST5, ST6, ST7, ST9, ST20	2	ST8, ST18
	Good (2)	People-Planet	1	ST14	3	ST15, ST19, ST20
		Planet-Prosperity	1	ST11		
	Excellent (3)	People-Planet-Prosperity			7	ST2, ST3, ST4, ST6, ST10, ST12, ST16
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			8	ST1, ST5, ST7, ST9, ST11, ST13, ST14, ST17

According to the results of study, at the beginning of the SDG unit implementation, half of the students (10) (ST4, ST8, ST10, ST12, ST13, ST15, ST16, ST17, ST18, ST19) were placed at the insufficient (0) level and could not identify dynamic relationships within the systems by considering any pillar of sustainable development goals. On the other hand, 8 of the students (ST1, ST2, ST3, ST5, ST6, ST7, ST9, ST20) were at the marginal (1) level and could identify dynamic relationships within the systems by considering only one pillar of sustainable development goals (the planet). They especially emphasized dynamic relationships between human- environmental pollution (air, water, soil), human-lack of water (use too much water). 2 of the students (ST 11 and ST 14) were at the good (2) level and could identify dynamic relationships within the systems by considering two pillars of sustainable development goals. ST 11 could identify dynamic relationships within the systems by considering the planet and prosperity pillars of sustainable development goals while ST 14 could identify dynamic relationships within the systems by considering the people and planet pillars of sustainable development goals. For example, ST 11 mentioned the relationship between human-depletion of non-renewable energy sources-air pollution while ST 14 explained the dynamic relationship between humans using excessive water and deodorants-global warming.

After the SDG unit implementation, most of the students' (15) (ST1, ST5, ST7, ST9, ST11, ST13, ST14, ST17, ST2, ST3, ST4, ST6, ST10, ST12, ST16) levels developed and rose to higher levels (excellent (3) or extraordinary (4)). That is, they could identify dynamic relationships within the systems by considering three or more pillars of sustainable development goals. They could identify dynamic relationships within the systems such as the dynamic relationship between human-environmental pollution (air, water, soil)-global warming-climate change, the dynamic relationship between human-poverty-responsible consumption and production, the dynamic relationship between human-gender equality, human-decent work and economic conditions, the dynamic relationship between human-quality education, human-hunger-health and well-being, human-clean water and sanitation, human-life on land and life under water. In addition, students who were at the extraordinary level explained the dynamic relationship between human-peace and justice and human-being partnership for goals. On the other hand, 3 of the

students (ST15, ST19, ST20) were at the good level and could identify dynamic relationships among the system's components by considering the 'people-planet' pillars of sustainable development goals. They emphasized that there are dynamic relationships with their lifestyle and air, water, soil and noise pollution. In addition, they defined the relationship between treating all people equally without discrimination-quality education, the relationship between famine-climate change-extinction of plants and animals. After the SDGs unit implementation, 2 of the students (ST8, ST18) were at the marginal level in identifying the dynamic relationships within the systems by considering only the 'planet' pillar of sustainable development goals. These students thought that there is a relationship between human and planet pillars of SDGs and while they can contribute to the planet aspect of SDGs, they cannot do anything for the 'people' pillar (e.g. poverty, good health and well-being, quality education), for prosperity pillar (e.g. industry, industrialization, innovation, sustainable cities and communities), for 'peace' and 'partnership' pillars of SDGs. They mentioned the relationship between human and environmental concerns.

To summarize, students generally could not identify dynamic relationships among the systems' components before the SDG unit implementation. After the SDG unit implementation, their STS 3 level improved and reached higher levels. Thus, more than half of them could identify dynamic relationship among systems' components in terms of three or more pillars of sustainable development goals. Table 4.7 presents students' statements from each level before and after the SDG unit implementation.

Table 4.7 Sample excerpts showing students' STS 3 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
STS 3: The ability to identify dynamic relationships within the systems	Insufficient (0)	No pillar	ST 19: I think that there is a relationship between human actions and problems.	
	Marginal (1)	Planet	ST 5: Planet: There is a dynamic relationship, I think. When we cause air, water and soil pollution, we are harmed. For these reasons, I do not throw garbage on the ground, I recycle. It has to do with my lifestyle. As humanity, we all pollute, knowingly or unknowingly. For example, we do not recycle enough, we do not pay attention. the world is polluted. Everyone does not think what would happen if I did not do it, and one person becomes millions, and the world becomes polluted.	ST 18: Planet: We cause problems in the world with our way of life. Problems in the world negatively affect our way of life. Problems in the world affect everyone, people and other living things. I did not have such detailed information until I learned in this lesson. That's why I'm thinking of adding behaviors that will cause less environmental problems to my lifestyle. Of course, they are related with my lifestyle. My actions cause it, we all use natural resources like energy, water, etc. and we use a lot unfortunately. We are harming nature by doing this. (After-planet)

Table 4.7 Sample excerpts showing students' STS 3 levels before and after the SDGs implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 3: The ability to identify dynamic relationships within the systems	Good (2)	People-Planet	ST 14: People-Planet: I think there is a great relationship between our way of life and the problems in our world. For example, we use excessive water, we cause lack of water for some parts of the world. We cause a lot of damage to nature. However, people don't take responsibility. We litter the environment; we don't follow most rules. For example, we should not spray perfume for global warming, we do too. Our lifestyle causes these problems. Although I pay attention to some of my behaviors, unfortunately people generally do not pay attention and harms nature.	ST 19: People-Planet: There is relationship with my lifestyle. As humanity, we cause sir pollution, water pollution, soil pollution, noise pollution and they affect us. There is a relationship between these problems and my lifestyle. For example, I recycle at home to protect the environment. I throw paper and plastic into separate boxes. While the staff collects them, I give them to them separately. I don't leave the water on while brushing my teeth. People cause different kinds of inequalities. We should treat all people equally and not evaluate them based on their gender, race or religion.
		Planet-Prosperity	ST 11: Planet-Prosperity: Of course there is relationship. For example, the documentary talked about air pollution. As the air becomes polluted, we breathe the polluted air. Yes, it's related to my lifestyle. It's not just me, but all people have contributed to it. People are doing something, let's say the weather is cold, they turn on the natural gas all the way. Those who don't care about their money open it all the way. Natural gas is a non-renewable energy and may run out one day. Instead of doing this, people can have their houses insulated. They can reduce the use of natural gas. For example, sometimes we throw the packages of the food we eat while walking on the beach into the sea. We must not throw. We should not pollute the seas.	

Table 4.7 Sample excerpts showing students' STS 3 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 3: The ability to identify dynamic relationships within the systems	Excellent (3)	People-Planet-Prosperity		ST 6: <u>People-Planet-Prosperity:</u> There is relationship with my lifestyle, everyone's lifestyle. For example, someone throw garbage into the environment, this harms nature and people. For example, exhaust fumes harm the air and the environment and people's health. People use water too much and this cause lack of water in some part of the world. Economy affects many issues like accessing resources, energy, industry. In addition, the problems experienced in any country may affect other countries. People use non-renewable energy sources to meet enery need. They who drive cars with exhaust pollute the world by consuming too much fuel.

Table 4.7 Sample excerpts showing students' STS 3 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 3: The ability to identify dynamic relationships within the systems	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 5: <u>People-Prosperity-Planet-Peace-Partnership:</u> Of course, there is a relationship between our lifestyle and these problems. For example, throwing garbage and polluting the environment causes many problems. The reason for global warming and climate change is that we, as humans, pollute nature. For example, humans harm life below water and life on land, and the air is affected by pollution. Countries are not making investments in terms of decent work and economic growth. Countries in Africa, for example, do not invest in this field. In this case, the economy does not develop and people cannot earn money themselves. Poverty and hunger occur because these countries cannot invest and produce policies. Water may not be available in other regions, because there is too much water use and waste especially in rich countries. They are all interconnected; health, prosperity, living, quality education. Gender inequality occurs. The lack of investment in education and schools in war-torn regions cause the ignorance of people who cannot receive education. Being partnership for achieving sustainable development goals contribute to solve all problems experienced.

4.2.4 STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships

According to Ben-Zvi Assaraf and Orion (2005, 2010a), the fourth systems thinking skill includes organizing the systems' components, processes, and their interactions within a framework of relationships. In this study, students were asked 'How can you organize/ classify/ categorize the components (problems) experienced in the world? Explain by giving an example.' Students were expected to organize the systems' components, processes, and their interactions, within a framework of relationships by considering each pillar of sustainable development goals (people, prosperity, planet, peace and partnership) within the real-life case of world.

According to the results, before the SDG unit implementation, 11 of the students were at the insufficient (0) level, 8 were at the marginal (1) level, and 1 was at the good (2) level in organizing the systems' components, processes, and their interactions within a framework of relationships by considering each pillar of sustainable development goals. This means that more than half of the students could not organize the systems' components, processes, and their interactions within a framework of relationships by considering any pillar of sustainable development goals.

After the SDGs unit implementation, most of the students' STS 4 level developed and reached higher level systems thinking skills. 7 of the students' level was extraordinary (4), 6 of the students' level was excellent (3), 4 of the students' level was good (2) and 3 of the students' level was marginal (1) in organizing the systems' components, processes, and their interactions within a framework of relationships. After the SDG unit implementation, most of the students could organize the systems' components, processes, and their interactions within a framework of relationships by considering a minimum of 3 pillars of sustainable development goals. Figure 4.4 shows the numbers of students according to their STS 4 level before and after the SDG unit implementation.

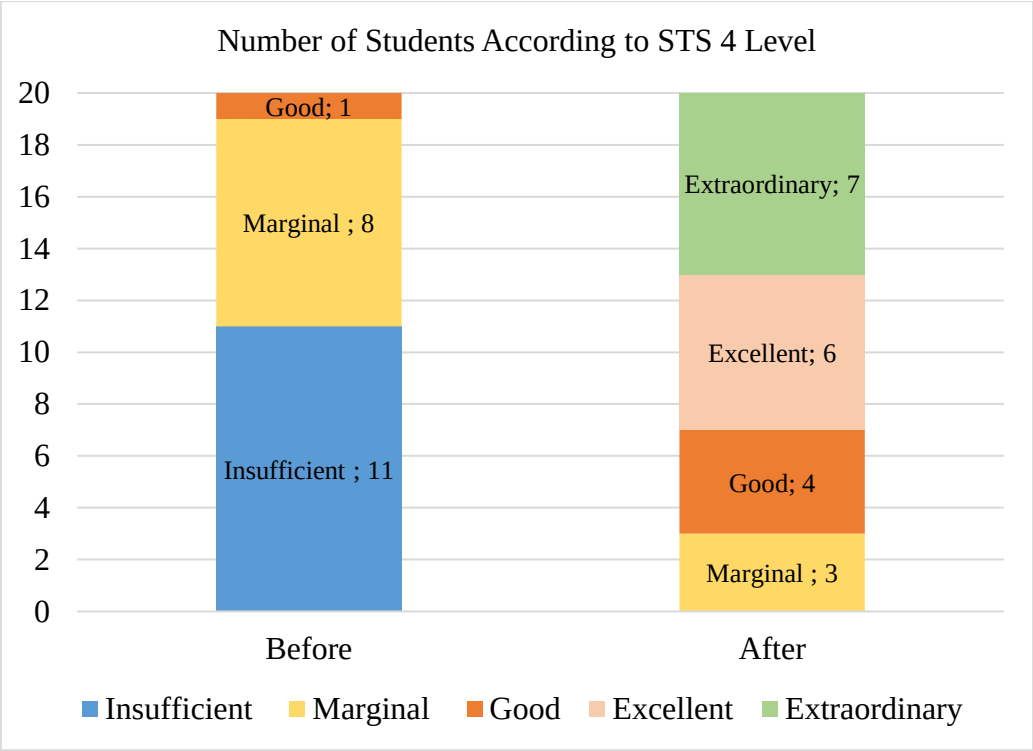


Figure 4.4 Number of students according to STS 4 level

Table 4.8 presents the results about students' skills in organizing the systems' components, processes, and their interactions within a framework of relationships (STS 4) before and after the SDG unit implementation. Table 4.8 shows students' levels of STS 4 and the pillars of the sustainable development goals that were considered by students in organizing the systems 'components, processes, and their interactions, within a framework of relationships (STS 4).

Table 4.8 Students' STS 4 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	Insufficient (0)	No pillar	11	ST2, ST5, ST8, ST9, ST10, ST13, ST15, ST17, ST18, ST19, ST20		
	Marginal (1)	Planet	8	ST3, ST4, ST6, ST7, ST11, ST12, ST14, ST16	3	ST8, ST13, ST19
	Good (2)	People-Planet	1	ST 1	4	ST10, ST17, ST18, ST20
		People-Prosperity				
	Excellent (3)	People-Planet-Prosperity			6	ST3, ST9, ST12, ST14, ST15, ST16
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			7	ST1, ST2, ST4, ST5, ST6, ST7, ST11

The results showed that at the beginning of the SDG unit implementation, students (11) (ST2, ST5, ST8, ST9, ST10, ST13, ST15, ST17, ST18, ST19, ST20) mostly were at the insufficient (0) level and could not organize the systems' components, processes, and their interactions within a framework of relationships in terms of any pillar of the sustainable development goals. 8 of the students (ST3, ST4, ST6, ST7, ST11, ST12, ST14, ST16) were at the marginal (1) level and could organize the systems' components, processes, and their interactions within a framework of relationships in terms of planet pillar of sustainable development goals. These students organized/classified the planet (environmental) components and processes such as climate action, air, water, soil pollutions, global warming, disrupting ecological balance. Only one of the students (ST 1) was at the good (2) level. That is, she could organize the systems' components as people (social components) and planet (environmental components) such as famine, hunger, inequality between men and women, different kinds of pollution (air pollution, water pollution, soil pollution), global warming, reduction of agricultural lands, inundation of certain places, destruction of forests, fossil fuel consumption.

After the SDG unit implementation, most of the students' (13 students) STS 4 levels developed and reached higher levels (excellent or extraordinary). 7 students (ST1, ST2, ST4, ST5, ST6, ST7, ST11) could organize the systems' components, processes, and their interactions within a framework of relationships in terms of all pillars (people, prosperity, planet, peace and partnership) of sustainable development goals. For instance, they categorized poverty, hunger, lack of water, health and well-being, education, inequality under the 'people' pillar of SDGs. In addition, they categorized affordable energy, industrialization, innovation, working in good conditions, economic growth and building sustainable cities under the 'prosperity' pillar of SDGs. Moreover, they organized climate action, life on land, life under water and responsible consumption and production of resources under the 'planet' pillar of SDGs. With these classifications, they could organize the peace and partnership pillars of SDGs. 6 of the students (ST3, ST9, ST12, ST14, ST15, ST16) were at the excellent (3) level and could organize the systems' components, processes, and their interactions within a framework of relationships in terms of three pillars (people, prosperity, planet) of sustainable development goals. They could categorize environmental pollution, cutting trees, rising sea levels, global

warming, deterioration of nature under the ‘planet’ pillar of SDGs, they could organize unemployment, inflation, economic crises under the ‘prosperity’ pillar of SDGs, and they could classify the inequality between women and men, slavery, forced labor of children under the ‘people’ pillar of SDGs. 4 of the students (ST10, ST17, ST18, ST20) were at the good level and could organize the systems’ components, processes, and their interactions within a framework of relationships in terms of two pillars (people and planet) of sustainable development goals. On the other hand, 3 students’ (ST8, ST13, ST19) STS 4 level remained at the marginal level and they could organize the systems’ components, processes, and their interactions within a framework of relationships in terms of only one pillar (planet) of sustainable development goals.

To sum up, students generally were at the insufficient level and could not organize the systems ’components, processes, and their interactions within a framework of relationships in terms of any pillar of sustainable development goals before the SDG unit implementation. After the implementation, their STS 4 level improved and reached higher levels. Thus, more than half of them could organize the systems ’components, processes, and their interactions within a framework of relationships in terms of three or more pillars of sustainable development goals. Table 4.9 presents statements from students at different levels before and after the SDG unit implementation.

Table 4.9 Sample excerpts showing students' STS 4 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	Insufficient (0)	No pillar	ST 15: environmental pollution, high prices, global warming	
	Marginal (1)	Planet	ST 4: Planet: There are environmental problems like global warming, climate change, environmental pollution, glaciers melting, the temperature rises.	ST 13: Planet: There are generally environmental problems in the world global warming, garbage, polluted water, environmental pollution, air pollution due to factory fumes.
	Good (2)	People-Planet	ST 1: People: There are social problems like poverty, hunger, homelesness gender inequality, lack of education. Planet: There are problems related to environment such as global warming, climate change, disappearance of trees, environmental pollutions (air, water, soil etc.)	ST 10: There are many problems in the world. Humans are creatures that think only of themselves, they act as if there is no other living thing but themselves. People: There are social problems. For example, most people cannot meet their basic needs (food, drink, clothing, shoes, etc.) economically because of poverty. There are children who suffer the food and water. The reason for this may be that the resources are scarce or unevenly distributed in the world. Some countries live in great wealth, while others live in poverty. Rich countries also use the resources of poor countries. Due to the damage done by rich countries to nature, in poor countries, for example, agricultural lands may be unsuitable and there are no job opportunities. Moreover, there is distinction between men and women. For example, they see men as superior to women. Some families do not send girls to school, they have them do work, heavy work.

Table 4.9 Sample excerpts showing students' STS 4 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	Good (2)	People-Planet		ST 10: Planet: There are environmental problems like throwing garbage on the ground, those who cook too much food and throw away half of it (irresponsible consumption), those who pollute the water in some places, those who cut trees in vain, those who waste papers, those who break pencils. Plastic, garbage, cover etc. and they damage the soil, it takes a long time for them to disappear in nature. There is air pollution.
	Excellent (3)	People-Planet-Prosperity		ST 15: Planet: environmental problems: environmental pollution (air,water,soil), cutting of trees, pollution of forests, pollution of seas, melting of glaciers, death of animals, harming and death of people from environmental pollution, methane gas can be toxic for people and other living. There are environmental problems in the world like air pollution, water pollution, soil pollution, global warming, reduction of agricultural lands, inundation of some places, destruction of forests, industrialization, fossil fuel consumption.

Table 4.9 Sample excerpts showing students' STS 4 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	Excellent (3)	People-Planet-Prosperity		ST 15: People: social: hunger, poverty, inequality, gender inequality, not sending girls to school. Clean waters may run out in the future due to excessive use. There may be no drinking water left for future generations. Prosperity: economic: items are expensive everything is expensive, high prices of necessities such as food and drink, poor economy in some part of the world, decrease in financial situation cause not being able to eat healthy. Some people live at well-equipped sustainable houses, while others stay in tents. While there is mechanization in agriculture in some places, agriculture is done by hand in some places. There are economic problems: low wages, low income, famine, people cannot see their families because they work hard, basic needs are too expensive. Some people have high incomes, and some people have low incomes. The world is full of inequalities.

Table 4.9 Sample excerpts showing students' STS 4 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 1: People: poverty is social problem. Because it affects our social life. For example, because some people are poor and their clothes are old, these people can be excluded by society. In addition, poverty may produce crime and other social problems that affect people across the socioeconomic ladder. Hunger can be social problems. If I don't have money, I can't buy food. Hunger may be caused by many things, such as poverty, poor soil, changes in climate, lack of access to water, economy, and so on. I think health and quality life are social. In some places, it is very difficult to access health services because they are paid. Some analyzes are performed for a fee. medicines are too expensive, hospital and doctor facilities are expensive. All people should have access to health services. Quality education is social because education is the right of every individual and it is important in terms of dissemination of accurate knowledge. Gender equality is social, men can discriminate against women and use violence because they are weak at some parts of world. If equality and justice are not ensured, chaos will occur. Clean water and sanitation are social because if clean water is not drunk, it may cause harm, people may get sick. Clean water and sanitation are important for healthy life. If the water is not clean, people and living may be harmed, die and become extinct.

Table 4.9 Sample excerpts showing students' STS 4 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 1: Prosperity: Accessible and clean energy is economical, some electrical appliances do not work without energy. At home, appliances such as lamps, televisions, dishwashers and washing machines do not work without energy. If energy is consumed in excess, non-renewable energies will be depleted. Therefore, renewable energy sources should be used, such as solar energy. If non-renewable energy resources such as coal, lignite and oil are used excessively, it will cause global warming. Electric vehicles should be used. Decent work and economic growth are economic. Industry, industrialization and innovation is economic, for example, because the construction of buildings and where they will be built are important, green areas should be protected, buildings should be built on hard ground. Reducing inequalities is economical. For example, in countries like Africa, there are people who earn less than $2 a day, but there are people in other parts of the world who earn more. There is unequal distribution. Sustainable cities and communities is economical because sustainable and durable cities is important. For example, multi-storey buildings collapse in an earthquake, but if single-storey buildings are built, they will be earthquake resistant. While such sustainable cities are being established in some parts of the world, unfortunately, no attention is paid to them in other parts. If the buildings are solid, it will contribute to the country's economy because, for example, if the buildings collapse every time there is an earthquake and we rebuild them again, the economy will be damaged.

Table 4.9 Sample excerpts showing students' STS 4 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 1: Planet: Responsible consumption and production is environmental. For example, when we bought an extra product, meat, the expiration date was close and we could not eat it, this meat spoils and becomes waste, so we must buy enough. We should consume responsibly. Climate action is environmental. Global warming is increasing, seasons are changing. Life below water is environmental. For aquatic creatures, for example, if people catch too much fish, they may become extinct. As aquatic creatures become extinct and there are fewer of those creatures, they can become economically expensive to consume. Life on land is environmental. When we throw garbage into the environment, a lot of people are affected. People throw garbage all the time because they think that one piece of garbage won't do anything. There are cleaning staff, but they cannot reach everywhere. These places become piles of garbage and are blown away by the wind, to other places, to houses and to water. When animals are hungry, they eat food from this garbage or chemical plastic, become poisoned and die. Since humans consume some of these creatures, these plastics pass to humans, harming people's health.

Table 4.9 Sample excerpts showing students' STS 4 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 1: Peace: Equality means that two things are equal in every way. Justice can be defined as giving everyone their due and punishing those who are unfair. For example, let me give an example about equality and justice. There was a visual. 3 people will watch the match behind a wall. One of those three people is short, one is medium height, and one is tall. If these 3 people are given a safe of equal height so that they can watch the match over the wall, this will be equality, but this does not mean that all of them can watch the match because the shorter person cannot get over the wall. The one of medium height has a hard time seeing the match. But tall people can watch the match easily. Here, justice will be achieved if the short person is given the highest size safe, the medium height person is given the medium size safe, and the tall person is given the shortest one so that all 3 people can watch the match. This should also be the case in terms of the distribution of world resources. Partnership: environmental, social, economic. Country leaders and people who are disturbed by environmental pollution can work together to raise people's awareness on this issue and keep the world clean. shelters can be established for animals, dog houses etc. Aid can be provided to poor and hungry people living in difficult situations in Africa.

4.2.5 STS 5: The ability to identify the cyclic nature of system

According to Ben-Zvi Assaraf and Orion (2005, 2010a), the fifth systems thinking skill includes identifying the cyclic nature of the system. In this study, students were asked 'Is the world cyclical? How? Explain. Does a problem occurring **any**where in the world affect only that region or the whole world? How? Explain by giving an example.' Students were expected to identify the cyclic nature of the system by considering each pillar of the sustainable development goals (people, prosperity, planet, peace and partnership) within the real-life case of our world.

According to the results, before the SDG unit implementation, 13 of the students were at the insufficient (0) level, 6 were at the marginal (1) level, and 1 was at the good (2) level in identifying the cyclic nature of system by considering each pillar of the sustainable development goals. This means that more than half of the students could not identify the cyclic nature of the system.

After the SDGs unit implementation, most of the students' STS 5 level developed and reached higher level systems thinking skills. The level of 7 of the students was extraordinary (4), that of 5 was excellent (3), 3 was good (2), 3 was marginal (1) and 2 was insufficient (0). After the SDG unit implementation, more than half of the students could identify the cyclic nature of the system by considering a minimum of 3 pillars of sustainable development goals. Figure 4.5 shows the numbers of students according to STS 5 level before and after the SDG unit implementation.

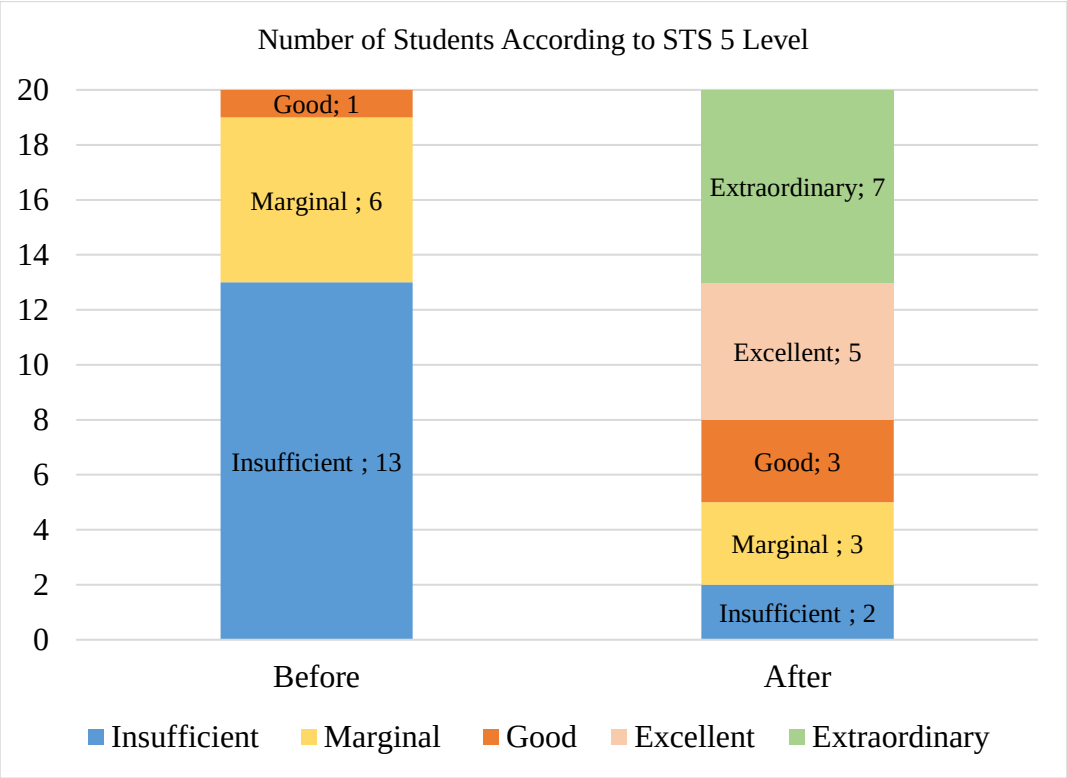


Figure 4.5. Number of students according to STS 5 level

Table 4.10 presents the results about students' skills in identifying the cyclic nature of the system (STS 5) before and after the SDG unit implementation. Table 4.10 shows students' levels of STS 5 and the pillar of the sustainable development goals that were considered by students in identifying the cyclic nature of the system (STS 5).

Table 4.10 Students' STS 5 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
STS 5: The ability to identify the cyclic nature of system	Insufficient (0)	No pillar	13	ST3, ST7, ST8, ST9, ST10, ST12, ST13, ST14, ST15, ST17, ST18, ST19, ST20	2	ST19, ST20
	Marginal (1)	Planet	6	ST1, ST2, ST5, ST6, ST11, ST16	3	ST8, ST9, ST15
	Good (2)	People-Planet	1	ST4	3	ST10, ST13, ST18
		People-Prosperity				
	Excellent (3)	People-Planet-Prosperity			5	ST11, ST12, ST14, ST16, ST17
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			7	ST1, ST2, ST3, ST4, ST5, ST6, ST7

The results revealed that at the beginning of the SDG unit implementation, more than half of the students (13) (ST3, ST7, ST8, ST9, ST10, ST12, ST13, ST14, ST15, ST17, ST18, ST19, ST20) were at the insufficient (0) level and could not identify the cyclic nature of the system by considering any pillar of sustainable development goals. On the other hand, 6 students (ST1, ST2, ST5, ST6, ST11, ST16) were at the marginal level and could identify the cyclic nature of the system by considering only one pillar of sustainable development goals (the planet). They emphasized environmental cycles like water cycle, carbon cycle, animal life cycles (butterfly, frog etc.), plant life cycles. Only one of the students (ST 4) was at the good (2) level and he could identify the cyclic nature of the system in terms of 'people-planet' pillars of sustainable development goals such as the effect of human lifestyles with environmental cycles.

After the SDG unit implementation, more than half of the students (12) (ST11, ST12, ST14, ST16, ST17, ST1, ST2, ST3, ST4, ST5, ST6, ST7) were at the excellent (3) or extraordinary (4) levels and they could identify the cyclic nature of the system by considering three or more pillar of sustainable development goals. They emphasized the cyclic relations between components in terms of people-prosperity-planet-peace-partnership. For example, they mentioned the environmental cycles like water, carbon, nitrogen, photsphorus cycles, animal life cycles, food chain, ecological balance, recycling. In addition, they mentioned social cycles like human relationship, equality between man and woman and economic cycles like using renewable energy and sustainable cities, economic growth. Moreover, students who were at the extraordinary level emphasized the importance of peace and partnership on environmental, social and economic cycles. 3 of the students (ST10, ST13, ST18) were at the good level and could identify the cyclic nature of the system by considering the 'people-planet' pillars of sustainable development goals. They emphasized environmental and social cycles. 3 of the students (ST8, ST9, ST15) were at the marginal level and could identify the cyclic nature of the system by considering only the 'planet' pillar of sustainable development goals. They only emphasized environmental cycles: water, carbon etc. 2 of the students (ST19, ST20) remained at the insufficient (0) level and could not identify the cyclic nature of the system by considering any pillar of sustainable development goals after the SDGs unit implementation.

To sum up, most of the students could not identify the cyclic nature of the system before the SDG unit implementation. After the implementation, their STS 5 level improved and reached higher levels. Thus, more than half of them (12 students) could identify the cyclic nature of the system in terms of three or more pillars of sustainable development goals. Table 4.11 indicates quotes from students at different levels before and after the SDG unit implementation.

Table 4.11 Sample excerpts showing students' STS 5 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
STS 5: The ability to identify the cyclic nature of system	Insufficient (0)	No pillar	ST 20: Yes. it could be.	ST 20: Our world has a cyclical nature.
	Marginal (1)	Planet	ST 16: Planet: it is cyclical. water cycle, flower cycle. It has a cyclical nature. The water in the seas evaporates with the effect of heat, and the clouds are loaded and descend to the earth as water as rain again. This is the water cycle. There is the food chain cycle. One Animal eats another animal, another animal eats another. If we think about global warming, the water evaporates more, causing the water to decrease. Due to global warming, the glaciers will melt, the water level will increase and some countries will be flooded. There is such a cycle.	ST 8: Planet: There is a great cycle. Many examples of this can be given. E.g. rainfall, water cycle, food chain (animals). The trees produce oxygen, it rains, the flowers grow, the flowers produce fruit, then we plant the seeds of the fruit and the same cycle continues.
	Good (2)	People-Planet	ST 4: I think it has a cyclic nature. People: human life cycle, Planet: water cycle, animal cycle, plant cycle	ST 13: I think it's circular. There are many cycles in nature. People: A problem affects the whole world. It is cyclical. The damage we do to the world harms us again. Planet: There are cycles in many living things such as plants, living things, water.

Table 4.11 Sample excerpts showing students' STS 5 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 5: The ability to identify the cyclic nature of system	Excellent (3)	People-Planet-Prosperity		ST 16: Yes, whatever we do will be in the future, so you reap what you do. There are many cycle in nature like water cycle, recycling etc.. Because of the mistakes people make, our cycle is broken, and it affects us badly, and I'm sure most people don't want to deal with a disturbed cycle. People: When people do not have decent jobs, they cannot afford their basic needs like food, water etc. Or they cannot get education and cannot access health services. Prosperity: Actually, there are relationship among all components in nature. For example, agriculture is harmed and decreased due to climate change. This case causes some people (e.g farmers) to lose their jobs and also income. Planet: The garbage we throw away mixes with the air and water and harms us. I think it's a beautiful cycle. If we treat the world badly, we will be harmed, but if we behave well, the world will be a good host to us. As humans pollute nature, it will never be a cyclical nature.

Table 4.11 Sample excerpts showing students' STS 5 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 5: The ability to identify the cyclic nature of system	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 4: Yes, everything is connected. For example, when something happens, they are also affected because it depends on other things. What happens in one country affects everywhere. Nature can renew itself. The world is cyclical, everything is interconnected, but this is gradually breaking down. We can save our world if people strive to fix it, if we strive to achieve sustainable development goals. There is a great relationship between humans and nature/world. Since the world began, humanity has been in constant development. Technology has advanced and globalization occured. People: There is a cycle among poverty, hunger, lack of water, being healthy, getting quality education, gender equality. For example, when people are poor, they go hungry, and they do not have access to clean water, and they can be unhealthy. In addition, they may not be able to receive health care and getting quality education because of poverty. Prosperity: There is cycle among sustainable cities and using clean energy, or cycle among the development of industry and economic growth etc. Planet: If we throw garbage in the sea, the living creatures (fish) living there get sick and those diseased fish come to our table after being caught and we are harmed because we eat them.

Table 4.11 Sample excerpts showing students' STS 5 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 5: The ability to identify the cyclic nature of system	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 4: Peace: For example, when there is war in one region, it affects the whole world. This affects environmental, social and economic cycles. Partnership: Partnership includes cycle among individuals, communities and countries. That is, all cycles of sustainable development goals (people, prosperity, planet,peace) are related and achiving them is related to achieve all cycle. For example, if the goal of ending poverty is achieved, other goals can also be largely achieved. This is the case for all goals.

4.2.6 STS 6: The ability to recognize hidden dimensions of the system

According to Ben-Zvi Assaraf and Orion (2005, 2010a), the sixth systems thinking skill includes recognizing hidden dimensions of the system. In this study, students were asked 'What are the hidden components (problems) of the world? Please explain.' Students were expected to recognize hidden dimensions of the system by considering each pillar of sustainable development goals (people, prosperity, planet, peace and partnership) within the real-life case of our world.

According to the results, before the SDG unit implementation, 15 of the students were at the insufficient (0) level and 5 were at the marginal (1) level in recognizing hidden dimensions of the system by considering each pillar of sustainable development goals. This means that most of the students could not recognize hidden dimensions of the system by considering any pillar of sustainable development goals.

After the SDGs unit implementation, most of the students' STS 6 level developed and reached higher level systems thinking skills. 5 of the students' level was extraordinary (4), 6 of the students' level was excellent (3), 3 of the students' level was good (2), 3 of their level was marginal (1) and 3 students were at the insufficient (0) level. After the SDG unit implementation, more than half of the students could recognize hidden dimensions of the system by considering a minimum of three pillars of sustainable development goals. Figure 4.6 shows the numbers of students according to STS 6 level before and after SDG unit implementation.

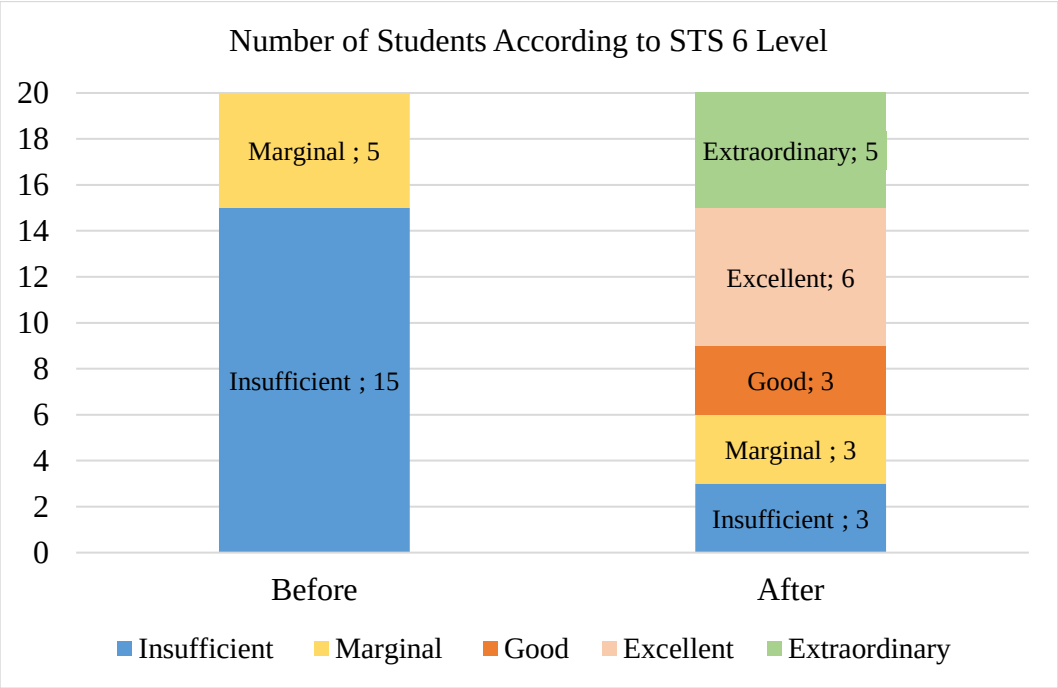


Figure 4.6 Number of students according to STS 6 level

Table 4.12 presents the results about students' skills in recognizing hidden dimensions of the system (STS 6) before and after the SDG unit implementation. Table 4.12 shows students' levels of STS 6 and the pillar of the sustainable development goals that were considered by students in recognizing hidden dimensions of the system (STS 6).

Table 4.12 Students' STS 6 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
STS 6: The ability to recognize hidden dimensions of the system	Insufficient (0)	No pillar	15	ST3, ST4, ST6, ST7, ST8, ST9, ST10, ST12, ST13, ST15, ST16, ST17, ST18, ST19, ST20	3	ST18, ST19, ST20
	Marginal (1)	Planet	5	ST1, ST2, ST5, ST11, ST14	3	ST12, ST13, ST15
	Good (2)	People-Planet			3	ST8, ST9, ST14
		Prosperity-planet				
	Excellent (3)	People-Planet-Prosperity			6	ST2, ST6, ST7, ST10, ST11, ST17
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			5	ST1, ST3, ST4, ST5, ST16

According to the results, at the beginning of the SDG unit implementation, 15 of the students (ST3, ST4, ST6, ST7, ST8, ST9, ST10, ST12, ST13, ST15, ST16, ST17, ST18, ST19, ST20) were at the insufficient (0) level and could not recognize hidden dimensions of the system by considering any pillar of sustainable development goals. 5 of the students (ST1, ST2, ST5, ST11, ST14) were at the marginal (1) level and could recognize hidden dimensions of the system by considering one pillar of sustainable development goals (the planet). They emphasized hidden dimensions of the system like pesticides used in agriculture, or the death of fish due to plastics.

After the SDG unit implementation, most of the students' levels (11) in recognizing hidden dimensions of the system developed and reached excellent (3) or extraordinary (4) levels. 5 students (ST1, ST3, ST4, ST5, ST16) were at the extraordinary level and they could recognize hidden dimensions such as environmental, social, economic issues like human population, migration, urbanization, usage of chemicals and pesticides in agriculture, fertilizers, water consumption to produce meat, rice, potatoes etc., unconsciousness of people. In addition, they emphasized the hidden dimensions for peace and partnership. 6 of the students (ST2, ST6, ST7, ST10, ST11, ST17) were at the excellent (3) level and they could identify hidden dimensions like human population, migration, urbanization, usage of chemicals and pesticides in agriculture, and unawareness of people. 3 students (ST8, ST9, ST14) were at the good (2) level and they could recognize hidden dimensions of systems in term of 'people-planet' pillars of sustainable development goals. On the other hand, 3 of the students (ST12, ST13, ST15) were at the marginal level after the SDG unit implementation and they recoginized the hidden dimensions of systems by considering only one pillar of sustainable development goals (planet). 3 of the students (ST18, ST19, ST20) remained at the insufficient (0) level and could not recognize any hidden dimensions of the system.

To sum up, students mostly could not recognize hidden dimensions of the system before the SDG unit implementation. After the implementation, their STS 6 level improved and reached higher levels. Thus, more than half of them (11 students) could recognize hidden dimensions of the system in terms of three or more pillars

of sustainable development goals. Table 4.13 indicates sample statements from students placed at different level before and after the SDG unit implementation.

Table 4.13 Sample excerpts showing students' STS 6 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
STS 6: The ability to recognize hidden dimensions of the system	Insufficient (0)	No pillar	ST 3: increase in water level	ST 18: pollution of water and land by factory wastes
	Marginal (1)	Planet	ST 2: Planet: For example, we throw waste (pet bottles, bags) into the sea, the sea becomes polluted, this water flows away and mixes with the oceans, which will harm the living creatures here and perhaps cause their death. Plastics thrown into the sea are eaten by fish and when we eat fish, they also harm us. Polluted wastes thrown into the sea can mix with the soil and the air. It also harms agriculture. Or pesticides used in agriculture also harm humans. These are the hidden components. There are many hidden components like this.	ST 13: Planet: Factory fumes, exhaust fumes, garbage thrown into the environment mix and pollute our waters. This is a hidden component. For example, we throw garbage in the sea and the animals die, they have a bag on their neck and the animal cannot breathe.
	Good (2)	People-Planet		ST 14: Yes there are hidden dimensions. People: For example, when we use or consume natural resources more than necessary, there may not be enough resources left for other living things elsewhere. Everyone should use enough for themselves. This is how we can solve poverty and hunger. People should also set an example to each other in this regard. We should have enough food on our plate, we should not buy too much and throw it away.

Table 4.13 Sample excerpts showing students' STS 6 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 6: The ability to recognize hidden dimensions of the system	Good (2)	People-Planet		ST 14: Planet: Because the world is in cycles, when something is damaged it affects other things. A living creature, such as a lion, harms another creature in order to feed, but this is necessary for natural balance. Or, for example, an animal's feces can be used as fertilizer. It can play a role in the growth of plants. Plants perform photosynthesis, use carbon dioxide and produce oxygen. But humans cause irreversible damage to the world with their behavior. For example, due to global warming and climate change, glaciers are melting, water levels are rising, in which case some regions may be flooded, and houses may be destroyed. If precautions are not taken, the world will go to a worse place, but if attention is paid, we can improve the world.

Table 4.13 Sample excerpts showing students' STS 6 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 6: The ability to recognize hidden dimensions of the system	Excellent (3)	People-Planet-Prosperity		ST 2: People. because humans destroy everything. Planet: People harm animals. Waste from the air, from the exhausts or from the waste of the tree, the waste of water. all of them are hidden reasons. When people throw garbage into waters, it directly causes pollution. People also cause pollution indirectly, for example, the waste from the factories they establish mixes with water and causes pollution. They cut down the tree just for money. People: For example, in some countries there is poverty due to economic problems. Some people use too much resources, eat too much, or waste too much. In this case, it indirectly causes other people to go hungry. If we do not waste money and help these people, they will not go hungry either. People cause inequalities by behaving racist. Prosperity: For example, in Africa, people try to travel long distances to work by walking or cycling because they do not have access to a car. They can build stone houses, but they can barely meet their food needs. Food distribution takes place at certain times of the year, in remote places. If people have the opportunity to go there, they go and buy it, but if they don't, they still can't reach them and they don't bring the food to their homes.

Table 4.13 Sample excerpts showing students' STS 6 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 6: The ability to recognize hidden dimensions of the system	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 3: Yes there are a lot of hidden dimensions. Planet: For example, we throw garbage here. The garbage thrown here causes negativity elsewhere in the world. This is infringing on that person's rights. The gases coming out of the chimneys pollute the air. The factory indirectly causes damage. For example, vehicles emit carbondioksit and contribute to climate change. In addition, when we throw garbage into the environment, we affect the freedom of other people. For example, when we pollute the seas, we prevent people from moving on rafts to fishing in the waters in Africa. It takes 100 liters of water to produce 1 kilogram of potatoes, 4000 liters of water to produce 1 kilogram of rice, and 13000 liters of water to produce 1 kilogram of beef. Agriculture is now dominated by oil, and although it has the power to feed twice the world population, it has lost its diversity. All of our lives depend on oil. People: Or, for example, we may be causing poverty. We throw away the food we don't eat, but people can't find food in other places. We can deliver these meals to people in need instead of throwing them away. The human population is the hidden component. For example, even if quality education is provided in a country, if the family does not send their girl child to school, that child cannot receive education, and in my opinion, families are the hidden factor here, hindering their children's education.

Table 4.13 Sample excerpts showing students' STS 6 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 6: The ability to recognize hidden dimensions of the system	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 3: Prosperity: Urbanization is happening. This causes many problems. There will be drought, energy will run out, food and water resources will decrease, poverty and hunger will increase. There may be very difficult situations for people. Peace: Maintaining peace depends on many hidden dimensions such as strong institutions and the implementation of laws. In addition, if resources are distributed equally and fairly, people can live in peace. Partnership: There are different stakeholders like institutions, people, teachers etc. to achieve sustainable development goals. For example, they will help people, save them from poverty, end hunger, increase use of renewable energy, and emphasis towards life on land and life in water.

4.2.7 STS 7: The ability to make generalizations

According to Ben-Zvi Assaraf and Orion (2005, 2010a), the seventh systems thinking skill includes making generalizations to solve problems based on understanding systems' mechanisms. In this study, students were asked 'What do you think what the system is? Is the world a system? Is there a relationship between humans and what happens in the world? Are humans part of the world? Explain'. Students were expected to make generalizations by considering each pillar of sustainable development goals (people, prosperity, planet, peace and partnership) within the real-life case of the world.

According to the results, before the SDG unit implementation, 16 of the students were at the insufficient (0) level and 4 of the students were at the marginal (1) level in making generalizations to solve problems based on understanding systems' mechanisms by considering each pillar of sustainable development goals. This means that most students could not make generalizations.

After the SDGs unit implementation, most of the students' STS 7 level developed and reached higher level systems thinking skills. 5 of the students were at the extraordinary (4) level, 6 were at the excellent (3) level, 2 were at the good (2) level, 3 were at the marginal (1) level and 4 were at the insufficient (0) level. After the SDG unit implementation, more than half of the students could make generalizations to solve problems based on understanding systems' mechanisms by considering a minimum of three pillars of sustainable development goals. Figure 4.7 shows the numbers of students according to their STS 7 Level before and after the SDG unit implementation.

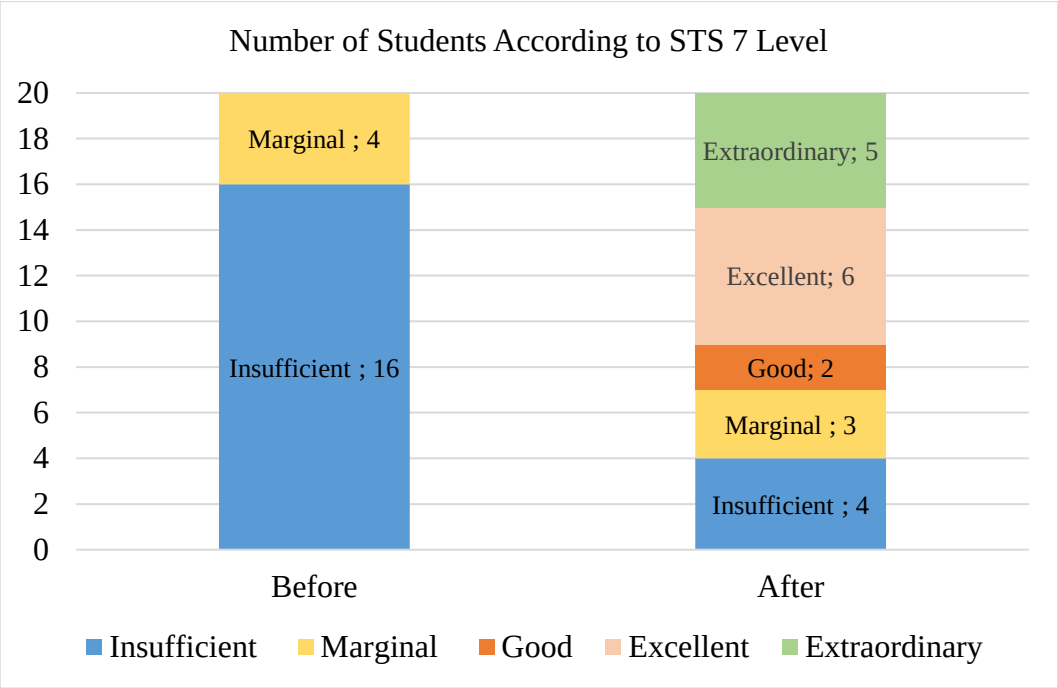


Figure 4.7 Number of students according to STS 7 level

Table 4.14 presents the results about students' skills in making generalizations (STS 7) before and after the SDG unit implementation. Table 4.14 shows students' levels of STS 7 and the pillars of the sustainable development goals that were considered by students in making generalizations (STS 7).

Table 4.14 Students' STS 7 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
STS 7: The ability to make generalizations	Insufficient (0)	No pillar	16	ST2, ST3, ST4, ST8, ST9, ST10, ST11, ST12, ST13, ST14, ST15, ST16, ST17, ST18, ST19, ST20	4	ST9, ST18, ST19, ST20
	Marginal (1)	Planet	4	ST1, ST5, ST6, ST7	3	ST8, ST10, ST13
	Good (2)	People-Planet			2	ST12, ST15
		Prosperity-planet				
	Excellent (3)	People-Planet-Prosperity			6	ST3, ST4, ST11, ST14, ST16, ST17
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			5	ST 1, ST2, ST5, ST6, ST7

The results showed that at the beginning of the SDG unit implementation, most of the students (16) (ST2, ST3, ST4, ST8, ST9, ST10, ST11, ST12, ST13, ST14, ST15, ST16, ST17, ST18, ST19, ST20) were at the insufficient level and they could not make generalizations by considering any pillar of sustainable development goals. On the other hand, 4 of the students (ST1, ST5, ST6, ST7) were at the marginal (1) level and they could make generalizations by considering only one pillar of sustainable development goals (the planet). They could make generalizations to solve problems based on understanding systems' mechanisms about providing ecological balance, solving environmental issues like climate change, protecting biodiversity of animals and plants.

After the SDG unit implementation, most of the students' skills in making generalizations (STS 7) reached excellent (3) or extraordinary (4) levels. 5 students (ST 1, ST2, ST5, ST6, ST7,) were at the extraordinary level and they could make generalizations by considering all pillars of SDGs (people, prosperity, planet, peace, partnership). They could make generalizations that the world is a system because everything is interconnected and ordered. They emphasized several pieces (environmental, social and economical issues) coming together and becoming a whole. They emphasized that environmental, social and economic problems as well as problems about peace and justice experienced in any part of the world affect the whole world. In addition, they mentioned the importance of partnership for solving problems all over the world. 6 students (ST3, ST4, ST11, ST14, ST16, ST17) were at the excellent level and they could make generalizations by thinking the 'people-prosperity-planet' pillars of SDGs. 2 students (ST12, ST15) were at the good (2) level and they could make generalizations by considering the 'people- planet' pillars of SDGs. 3 of the students (ST8, ST10, ST13) were at **t**he marginal level and they could make generalizations by considering only the 'planet' pillar of sustainable development goals. 4 students (ST9, ST18, ST19, ST20) were at the insufficient level and they could not make generalizations in terms of pillars of sustainable development goals.

To sum up, most of the students could not make generalizations by considering any pillar of sustainable development goals before the SDG unit implementation. After the implementation, their STS 7 level developed and reached higher levels. Thus, more than half of them could make generalizations in terms of three or more pillars

of sustainable development goals. Table 4.15 reveals sample quotes from students at different levels before and after the SDG unit implementation.

Table 4.15 Sample excerpts showing students' STS **7** levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
STS 7: The ability to make generalizations	Insufficient (0)	No pillar	ST 11: system is the working principles of something. The world is a system. For example, trees are like lungs. There is a relationship between the world and nature. Man is part of the world.	ST 19: system, working with all the beings of the world. The world is a system. There is a relationship between man and the world. Man is part of the world. The world is meaningless without humans.
	Marginal (1)	Planet	ST 7: Planet: It's like an ecological system. Yes, the world is the system. Yes, there is a relationship. While the world completes man, man completes nature. Man is a part of nature-world. Ecological system = things that happen in nature. It can be water, air, soil, green spaces. system, such as biodiversity. It's within the rules for something to work. Like day and night. The world is the system. There is a reciprocal relationship between man and the world. When we pollute the world, it affects everyone. Human is part of the world system.	ST 10: Planet: Earth-nature is the system. Nature has a cycle. There is a relationship. Man is a part of nature because man lives in nature. ecological system, solar panel system. yes, all animals and humans live in nature. Nature should not be polluted.

Table 4.15 Sample excerpts showing students' STS **7** levels before and after the SDGs unit implementation (cont.)

	Level	**Pillars of SDG**	**Before**	**After**
STS 7: The ability to make generalizations	Good (2)	People-Planet		ST 12: People: there is a relationship between people and the world. Man is part of the world system. Man can save the world, but he can also do harm. He influences the world by his actions. Planet: System, I think. All this space is earth and universe. And man is a part of this system. If there were no people in this world or if they disappeared, the whole system would be shut down and even meaningless. Our world is a system that includes all resources. The entire unıverse, space, earth ıs the system.
	Excellent (3)	People-Planet-Prosperity		ST 11: People: It is the system. It has regular cycles. There is a relationship between man and the world-nature. Man is a part of nature-world. I think the system is a regular cycle. It is a system in the world. There is a close relationship between humans and the world. Part of the human world system. The world is our home. We need to protect him. We need to take good care. Humanity's living system is connected to the earth.

Table 4.15 Sample excerpts showing students' STS **7** levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 7: The ability to make generalizations	Excellent (3)	People-Planet-Prosperity		ST 11: Prosperity: There is a very important relationship between humans and the world. For example, environmentally friendly energies compatible with nature should be preferred. Electric cars should be used for protecting nature. Planet: I think if people pollute the earth and do not take good care of it, it may eventually lead to the end of humanity. For example, there is a type of plastic bottle. This plastic bottle could easily disappear in nature, and they placed seeds inside this plastic bottle. When the plastic bottle disappeared, trees were growing there. We should implement such environmentally friendly practices.
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 7: The system is a complex structure. The world is a system. It is a living system. There is a strong relationship between human-world. Unfortunately, we, as humanity, are disrupting this system. Planet: Climate is changing. Global warming is increasing. The causes of this problems are environmental pollutions. Environmental pollutions affect all living such as both life on land and life below water. These problems may cause some animals to become extinct. This cause the decrease of biodiversity. These problems affect all parts of the world.

Table 4.15 Sample excerpts showing students' STS **7** levels before and after the SDGs unit implementation (cont.)

	Level	**Pillars of SDG**	**Before**	**After**
STS 7: The ability to make generalizations	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 7: People: When we put more food on our plate than necessary, we throw the rest away, and this can cause people to go hungry in other places. Or when we pollute the environment (for example, the air), this polluted air reaches other places and can affect the health of people there. Good and quality education also affects the whole world. For example, if we provide quality education, people will become more conscious and find solutions to many problems in the world, and inequalities will decrease. Prosperity: Using non-renewable energy affects whole world. I mean, for example, when we use fossil fuels, they release harmful greenhouse gases into the atmosphere, creating the greenhouse effect which causes global warming. Non-renewable energy sources are also harmful pollutants and lead to habitat destruction. We should use renewable energy sources. Moreover, Peace: When there is war in one region, it affects the whole world. Because war causes polarization among countries and the whole world' peace is affected by this. Or colloboration between countries to solve global problems may break down. Partnership: Achiving sustainable development needs partnerships between individuals, communities and countries. This means that we need to achieve all over ther world, not in only region.

4.2.8 STS 8: The ability to think temporally: retrospection and prediction

According to Ben-Zvi Assaraf and Orion (2005, 2010a), the eighth systems thinking skill includes thinking temporally (retrospection and prediction). In this study, students were asked 'Have the actions of people in the past affected the world today? Will the human activities done today affect the world of the future? Do you think there is a relationship between the past, present and future in terms of the problems experienced in the world? If so, what do you think the world will be like in the future? Explain.' Students were expected to think temporally by considering each pillar of the sustainable development goals (people, prosperity, planet, peace and partnership) within the real-life case of the world.

According to the results, before the SDG unit implementation, 17 of the students were at the insufficient (0) level and 3 of the students were at the marginal (1) level in thinking temporally by considering each pillar of sustainable development goals. This means that most of the students could not think temporally (retrospection and prediction).

After the SDGs unit implementation, most of the students' STS 8 level increased and reached higher level systems thinking skills. 4 of the students were at the extraordinary (4) level, 7 at the excellent (3) level, 3 at the good (2) level, 2 at the marginal (1) level and 4 at the insufficient (0) level. After the SDG unit implementation, half of the students could think temporally by considering three or more pillars of sustainable development goals. Figure 4.8 shows the numbers of students according to their STS 8 level before and after the SDG unit implementation.

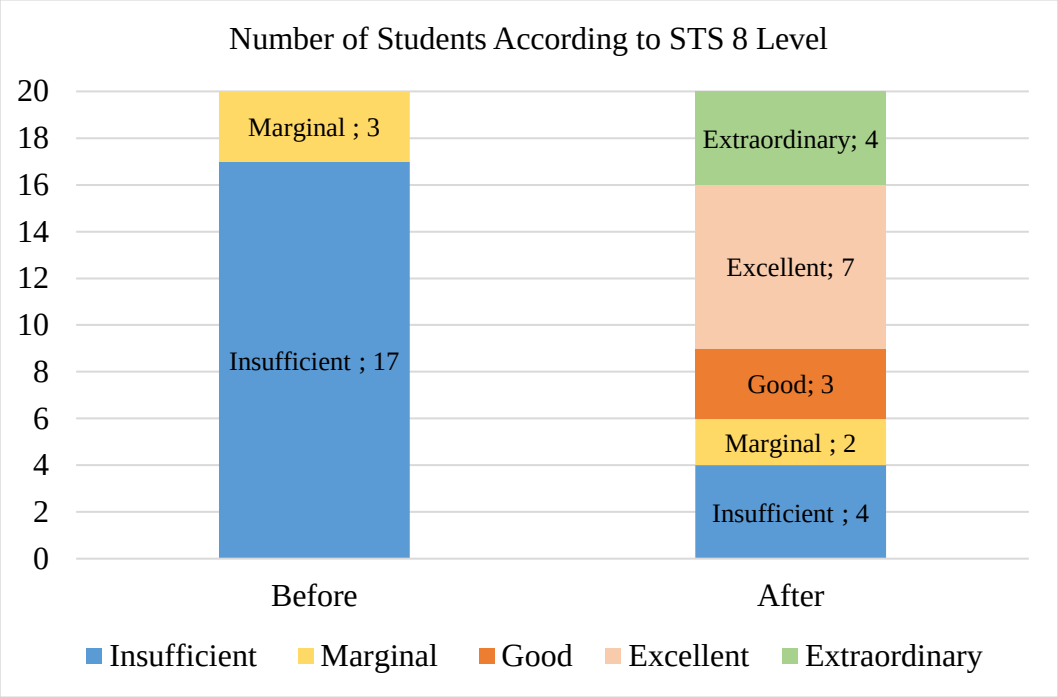


Figure 4.8 Number of students according to STS 8 level

Table 4.16 presents the results about students' skills of thinking temporally: retrospection and prediction (STS 8) before and after the SDG unit implementation. Table 4.16 shows students' levels of STS 8 and the pillar of the sustainable development goals that were considered by students in thinking temporally: retrospection and prediction (STS 8).

Table 4.16 Students' STS 8 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
STS 8: Thinking temporally: retrospection and prediction	Insufficient (0)	No pillar	17	ST2, ST3, ST4, ST5, ST7, ST8, ST9, ST10, ST11, ST12, ST13, ST14, ST15, ST17, ST18, ST19, ST20	4	ST13, ST18, ST19, ST20
	Marginal (1)	Planet	3	ST1, ST6, ST16	2	ST8, ST10
	Good (2)	People-Planet			2	ST3, ST12
		Prosperity-Planet			1	ST11
	Excellent (3)	People-Planet-Prosperity			7	ST2, ST4, ST5, ST9, ST14, ST15, ST17
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			4	ST1, ST6, ST7, ST16

The results showed that most of the students (17) (ST2, ST3, ST4, ST5, ST7, ST8, ST9, ST10, ST11, ST12, ST13, ST14, ST15, ST17, ST18, ST19, ST20) were at the insufficient (0) level and could not think temporally (retrospection and prediction) by considering any pillar of sustainable development goals before the SDG unit intervention. They generally could not establish a relationship between past and present events. They think that actions in the past do not affect the present situation of the world or have little impact on the current state of the world. On the other hand, 3 of the students (ST1, ST6, ST16) were at the marginal (1) level and could think temporally by considering only one pillar of the sustainable development goals (the planet). They could think temporally by emphasizing the effects of past human actions on the environment and nature such as pollution.

After the SDGs unit implementation, most of the students (11) reached either excellent (3) or extraordinary (4) levels and could think temporally by considering three or more pillars of sustainable development goals. 7 students (ST2, ST4, ST5, ST9, ST14, ST15, ST17) were at the excellent (3) level and they could think temporally in terms of the people-planet-prosperity pillars of sustainable development goals. For instance, they mentioned the importance of conscious usage of natural resources like food, water, energy, and protecting environment, life below water and life on land for present and future generations. Moreover, they emphasized the importance of innovations in terms of past-present-future. 4 students (ST1, ST6, ST7, ST16) were at the extraordinary level and they could emphasize that there are strong relationships among the past, present and future and thought the effects of problems in terms of people, prosperity, planet, peace and partnership. 3 of the students (ST3, ST11, ST12) were at the good (2) level and they could think temporally in terms of the two pillars of SDGs by mentioning the effects on the environment and society. 2 of the students (ST3 and ST 12) could think temporally in terms of 'people-planet' pillars of sustainable development goals and mentioned the effects of famine, hunger and harming the environment. ST 11 could think temporally in terms of 'prosperity-planet' pillars of sustainable development goals and emphasized the effects of pollution and unplanned urbanization and buildings. 2 of the students (ST8, ST10) remained at the marginal (1) level and they could think temporally in terms of the 'planet' pillar of sustainable

development goals. 4 of the students (ST13, ST18, ST19, ST20) remained at the insufficient level and they could not think temporally.

To summarize, most of the students could not think temporally by considering any pillar of sustainable development goals before the SDG unit implementation. After the implementation, their STS 8 level improved and reached higher levels. Therefore, in the end, more than half of them could think temporally in terms of three or more pillars of sustainable development goals. Table 4.17 shows sample quotes from students at different levels before and after the SDG unit implementation.

Table 4.17 Sample excerpts showing students' STS 8 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
STS 8: Thinking temporally: retrospection and prediction	Insufficient (0)	No pillar	ST 14: In the past, there was no mechanization in agriculture as there is now. People work by hand. It effects. There is progress today. Robots may replace humans in the future. The world in the future is where there is a lot of development where humans no longer have a function, robots.	ST 13: No relationship because things that happened in the past are different from things that happen today. For example, the pollution was less in the past, it is more today.
	Marginal (1)	Planet	ST 6: Planet: yes, there is relationship. People are causing trouble in the world. The activities that people do affect us all. In my opinion, in the future, everything in the world will be robots. Now, people in this world do sometimes bad and sometimes good actions for world. People generally forget their past, their day, their future by acting towards nature. If people keep the forests and their environment clean, we and future generations will live in healthy and clean environment all over the world.	ST 10: Planet: Yes, there is strong relationship. In the past, people polluted nature, and this still continues. Yes, there is a relationship, the world will be a garbage-filled planet in the future. I think the actions taken in the past affected the present, and the actions we take today will affect the future. Because the effects of people polluting nature in the past have come to the present day. Pollution remains in nature and affects it. The actions we take now, the garbage we throw will affect the future, and we will pollute the world even more. There is a very close relationship between the past-present-future. As far as I watched in the 'Home' documentary, the first times of the world were very beautiful. The population density is low. Even until now, the world has been pretty much destroyed. it will get worse in the future. In the future, perhaps the majority of people will die from air pollution, water pollution and soil pollution. The world will change for the worse.

Table 4.17 Sample excerpts showing students' STS 8 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 8: Thinking temporally: retrospection and prediction	Good (2)	People-Planet	.	ST 3: <u>People:</u> There is a relationship among past, present and future. They affect because air pollution always remains. For example, fire in the past, exhaust and factory fumes pollute the air today. The world will be a very bad place for people in the future. Yes it does because the bad fumes from the factory affect the air, the oxygen is decreasing, it is getting less and less as the years go by, this may be very bad for future people, future people will breathe unhealthy air that contains more polluted less oxygen. Actions taken in the past have affected the present. I think it will affect our future even more. We are in 2023, if it continues like this, there may be famine, hunger, fights, water and food wars among people in 2040. The reason is people. <u>Planet:</u> There is a relationship between past, present and future. Actions taken in the past affect our present and our future. The world will be a bad place with many problems in the future, the waters will decrease, the land will be unproductive, there will always be artificial things, natural resources will decrease, trees will decrease, oxygen will decrease, there will be more factories, there will be a lot of air pollution. Some animals may perish because of the garbage thrown into the seas. We won't be able to find some food. For example, some animals that lived in the past became extinct. Dodo bird, dinosaurs etc. For example, I think koala, panda, cheetah will go extinct in the future. Whales may go extinct.

Table 4.17 Sample excerpts showing students' STS 8 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 8: Thinking temporally: retrospection and prediction	Good (2)	Prosperity-Planet		ST 11: Prosperity: I think, it affects. There is a relationship. If we save, maybe we can be the same as before. In our past, there were many forested and green areas, but now there are unplanned urbanization and buildings. But we can prevent this. We have to build enough buildings, not much. Planet: We should plant trees in other areas, we should make green areas. If not prevented, there may be water and air pollution in the future, and people may be harmed and killed due to them. There is a strong relationship between past, present and future.

Table 4.17 Sample excerpts showing students' STS 8 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 8: Thinking temporally: retrospection and prediction	Excellent (3)	People-Planet-Prosperity		ST 14: People: If people spend a lot of water and electricity in the present, there will be no water or electricity for future people. There will be famine/drought. That is, in the future there may be almost no water. Food will be scarce. Poverty and hunger will increase. Most people will be poor. Prosperity: Inventions made in the past have made our lives easier now. We can save the future by inventing now. I think the world will be a very different place in the future. Everywhere will change. Planet: Because if people continue their harmful actions on the environment like throwing garbage, our world will get worse and maybe there will be no such place as the world. It affects our future and in the coming years, the world may get worse and there may not be a place to live, a place to breathe, or even a country/place we can go to, and I think this will lead to the death of many people in the world. If people do not protect this world well, our world will become unlivable in the future and we will cause many harms and deaths. That's why we need to take good care of our world and improve our future.

Table 4.17 Sample excerpts showing students' STS 8 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 8: Thinking temporally: retrospection and prediction	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 6: People: Yes, there is strong relationship. There will be many problems in the world in the future. For example, hunger and poverty will increase, violence against women will increase, lack of education will increase, wars will increase, health problems, energy problems, climate problems will increase. Prosperity: In the past, the invention of the printing press, a lot of trees are cut down. The invention of weapons influenced world wars. Non-renewable energy resources like coal, oil, fuel etc. were used and continue to be used. This affected our present and will affect the future. There are many relationships between past-present-future. Planet: Yes it does because people in the past had invented steam engines. Now, technology has developed and the world has become more polluted and because technology will develop more in the future, the world will become an uninhabitable place and people will pollute other planets as well. Factories cause global warming. I think that if humanity exists in the future, they will go to other planets, such as Mars, where they will pollute a lot. I don't think there will be trees, greenery and clean water here in the world if humanity does not become conscious. For example, there are very few trees in Istanbul already. I don't think the world will be a good place in the future.

Table 4.17 Sample excerpts showing students' STS 8 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
STS 8: Thinking temporally: retrospection and prediction	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 6: Peace: As humanity, we will affect the future. Because there were many wars in the past, it has affected our day, but in the past, the human population was low, it suddenly increased, this affected the peace and justice, I think. Partnership: We must achieve the sustainable development goals by 2030. If we fail, the problems in the world will increase.

4.2.9 Summary of the results about students' systems thinking skills

The results indicated that before SDG unit implementation, most of the students' STS levels were either insufficient (0) or marginal (1) in eight characteristics of systems thinking skills (STS 1-8). After the SDG unit implementation, most students' STS levels developed and reached either excellent (3) or extraordinary (4) (see Figure 4.9).

The results of the study revealed that there could be a hierarchy and complexity among the skills highlighted by Assaraf and Orion (2005,2010a) because the number of students who have low or high STS were directly proportional to the complexity of the skills. That is, the results showed that the number of students with low STS levels increased from STS 1 to STS 8 before the SDG unit implementation. In other words, the lowest number of students with low STS levels was in STS 1 while the highest number of students with low systems thinking skills was in STS 8. After the SDG unit implementation, most of the students' STS level developed in a compatible way to the hierarchy and complexity level of the skills. For example, there were more students whose STS 1 level improved, as compared to the number of students whose STS 8 level improved at the end of the SDGs unit implementation. That is, students' STS levels developed on the basis of the development of the next level's skills (see Figure 4.9). The results showed that the simplest skills are identified as STS-1, STS-2 and STS-3 which could be developed easily while the hardest skills are identified as STS-6, STS-7 and STS-8 which could be harder to develop. However, it is not evident that there is a certain hierarchical level among these skills. For example, even though one may not identify the cycling nature of the system (STS-5), he/she may still be able to make generalizations (STS 7).

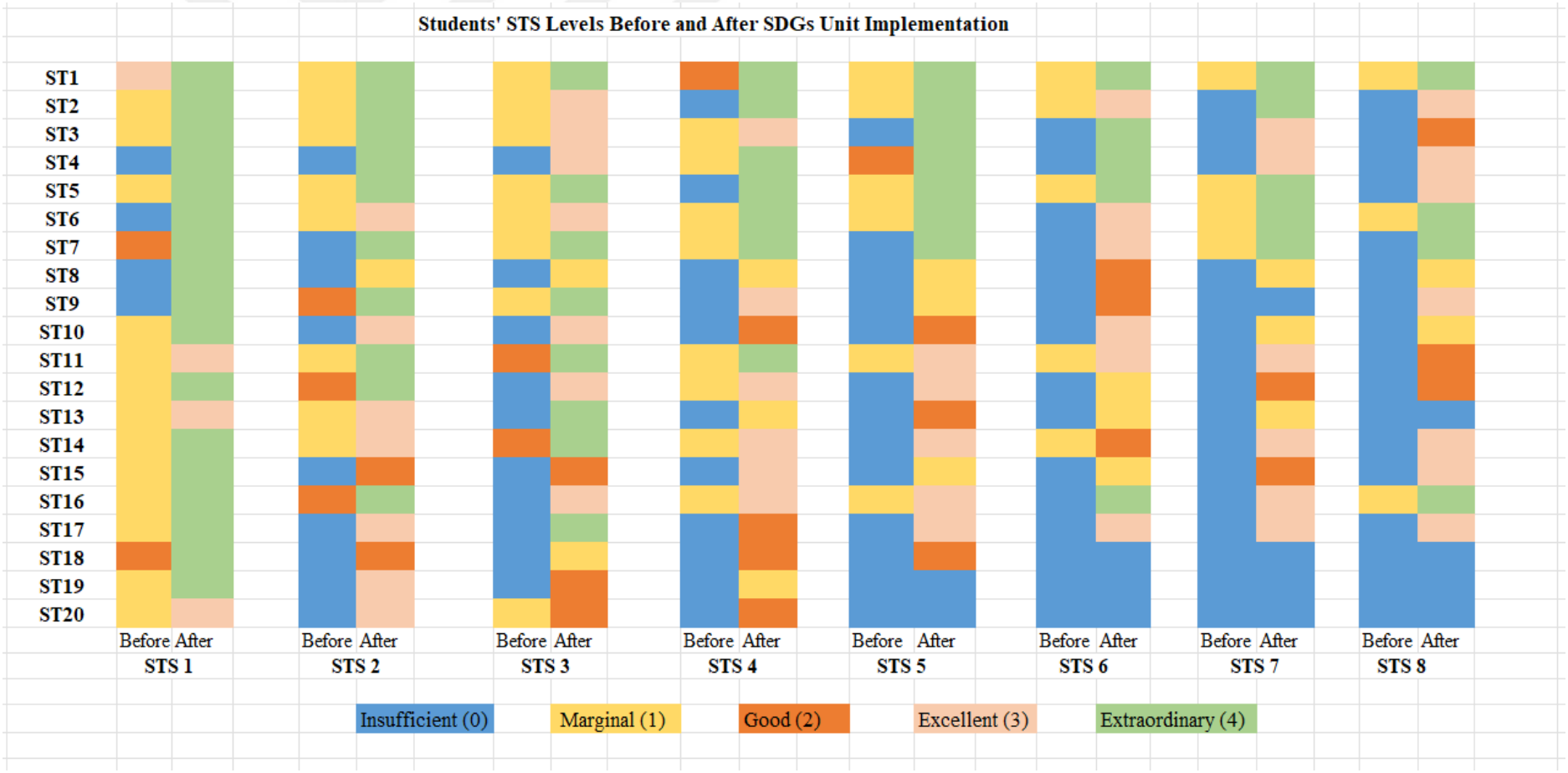


Figure 4.9 Students' STS levels before and after SDGs unit implementation

4.3 Students' Ethical Reasoning in Action (ERiA)

In the scope of this research, 20 7th grade students' ethical reasoning of this study was examined before and after the SDG unit implementation. For each student, open-ended questions and semi-structured interviews were analyzed by using the rubric developed by researcher. Based on the data analysis, students' eight dimensions of ethical reasoning levels were determined and presented under separate headings. For each ethical reasoning level, the development of students' ethical reasoning is given and necessary quotes from the students are presented.

4.3.1 ERiA 1: Fairness

According to James Madison University (2018), the fairness dimension of ethical reasoning includes being able to identify the characteristic of treating people equally or in a way that is right or reasonable. In order to determine the fairness levels of students, the question 'How can you treat people and living in different parts of the world fairly and equally? Explain' was asked before and after the implementation. In this research, students were expected to identify fairness considering pillars of sustainable development goals. Students' abilities of identifying fairness considering pillars of sustainable development goals were determined before and after the SDG unit implementation.

According to the results, before the unit implementation, one of the students was at the insufficient (0) level, 12 students were at the marginal (1) level, 4 students were at the good (2) level, 2 students were at the excellent (3) level, and 1 was at the extraordinary (4) level in identifying fairness considering pillars of sustainable development goals. This means that most of the students identified fairness considering only one pillar of sustainable development goals. That is, they can identify fairness considering only one aspect of sustainable development goals, which is generally the planet (environmental) aspect.

After the SDGs unit implementation, most students' fairness level developed and reached higher level reasoning skills. Nine students' levels were extraordinary (4), six students' levels were excellent (3), four students' levels were good (2) and only one student was at the marginal (1) level. Most students could generally define fairness considering 3 or more aspects of sustainable development goals. Figure

4.10 shows the numbers of students according to fairness level before and after the implementation.

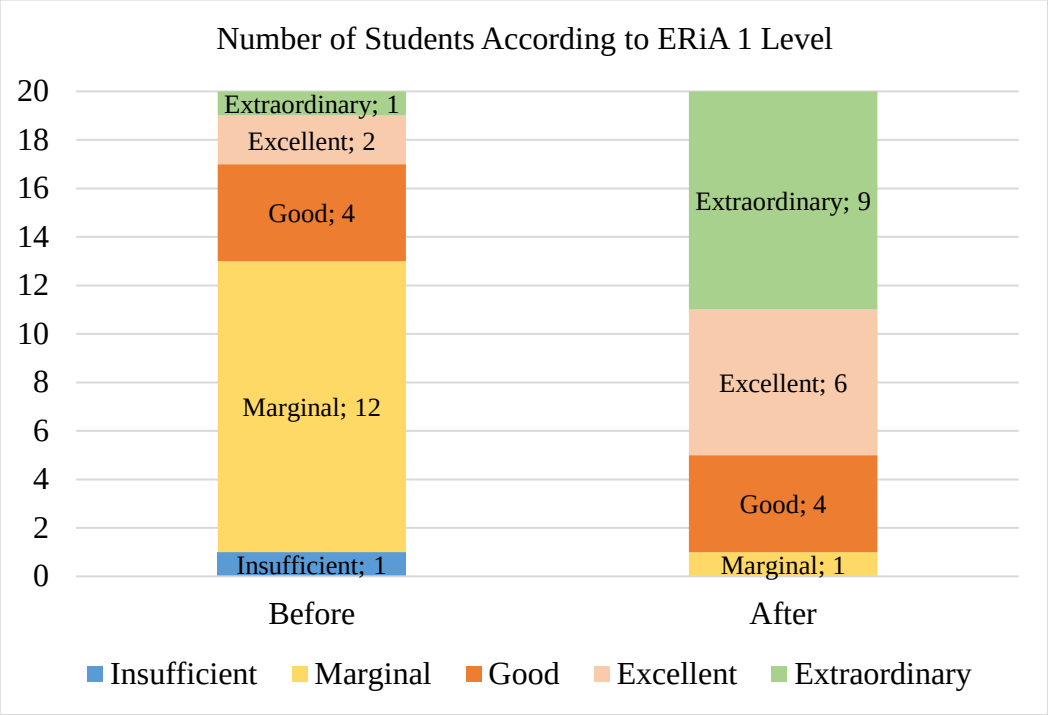


Figure 4.10 Number of students according to ERiA 1 level

Table 4.18 presents the results considering students' ethical reasoning (fairness) (ERiA 1) before and after the SDG unit implementation. Table 4.18 shows students' levels of ERiA 1 and the pillars of the sustainable development goals considered by students in identifying fairness (ERiA 1).

Table 4.18 Students' ERiA 1 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
ERiA 1: Fairness	Insufficient (0)	No pillar	1	ST 19		
	Marginal (1)	People	8	ST7, ST9, ST10, ST13, ST16, ST17, ST18, ST20	1	ST 13
		Planet	4	ST4, ST6, ST8, ST15		
	Good (2)	People-Planet	4	ST1, ST11, ST12, ST14	3	ST12, ST18, ST19
		People-Prosperity			1	ST17
	Excellent (3)	People- Prosperity-Planet	2	ST2, ST3	6	ST1, ST4, ST6, ST9, ST14, ST20
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership	1	ST 5	9	ST2, ST3, ST5, ST7, ST8, ST10, ST11, ST15, ST16

According to the results, at the beginning of the SDG unit implementation, most of the students (12 students) were at the marginal (1) level and could identify fairness by considering only one pillar of sustainable development goals. Most of them (8) (ST7, ST9, ST10, ST13, ST16, ST17, ST18, ST20) could identify fairness by considering the 'people' pillar of sustainable development goals. They explained fairness as providing the same opportunities for all people, saving resources, not discriminating between people. Some students (4) (ST4, ST6, ST8, ST15) could identify fairness by considering the 'planet' pillar of sustainable development goals. They identified fairness with treating animals equally and fairly by giving them their natural habitats, not hunting illegally, protecting and not destroying their natural balance, using resources responsibly. On the other hand, before the SDG unit implementation, some of students (4) were at the good (2) level and could identify fairness by considering two pillars of sustainable development goals (Table 4.18). ST1, ST11, ST12 and ST 14 could identify fairness by considering the people and planet pillars of sustainable development goals. Two of the students were at the excellent (3) level and could identify fairness by considering three pillars of sustainable development goals. ST2 and ST3 could identify fairness by considering the 'people, prosperity, planet' pillars of sustainable development goals. One student was at the extraordinary (4) level and could identify fairness by considering all pillars of sustainable development goals (people, prosperity, planet, peace, partnership). Moreover, one of the students was at the insufficient (0) level and she could not identify fairness by considering any pillar of sustainable development goals.

After the SDG unit implementation, most of the students (15) reached excellent (3) or extraordinary (4) levels. They could identify fairness by considering three or more pillars of sustainable development goals. They could identify fairness by considering the people pillar of sustainable development goals such as providing social equality, increasing the rate of girls attending school, meeting people's needs by helping them, ending poverty, solving people's hunger problems and water problems, distributing resources fairly. Moreover, they could identify fairness in terms of the prosperity pillars of sustainable development goals such as using solar energy, using electric cars, contributing to decent work and economic growth, developing job opportunities, industry, innovation and infrastructure, building

sustainable houses for people. Students also could identify fairness in terms of the planet pillar of sustainable development goals such as cleaning and recycling garbage on land and sea. In addition, students who were extraordinary level could identify fairness in terms of peace and partnership. 4 students (ST12, ST 17, ST18, ST19) were at good level and they could identify fairness by considering two pillar of sustainable development goals. Only 1 student were at marginal level after SDGs unit implementation.

To summarize, most of the students could identify fairness by considering one pillar of sustainable development goals (people mostly) before the SDG unit implementation. After the implementation, their ERiA 1 level improved and reached higher levels. Therefore, more than half of them could identify fairness in terms of three or more pillars of sustainable development goals. Table 4.19 shows sample quotes from students at different levels before and after the SDG unit implementation.

Table 4.19 Sample excerpts showing students' ERiA 1 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
ERiA 1: Fairness	Insufficient (0)	No pillar	ST 19: We can help people or countries which need to act fairly.	
	Marginal (1)	People	ST 16: People: Empathy is necessary in order to treat all people fairly and equally. People on the other side of the world are suffering from water shortages, food shortages. For example, they cannot farm. I don't think there is much we can do to treat them fairly. We can empathize. We can put ourselves in their shoes. We saw their lives in the documentary. We can understand them. We can provide financial aid to places like Africa. We can send packages of supplies. We can drill a water well. (Before-People)	ST 13: People: We can act fairly and equally by ensuring gender equality and reducing inequalities. For example, I empathize with them and I treat all people and living things equally, I do not discriminate.
		Planet	ST 6: Planet: I think, by not polluting the nature, not throwing garbage on the ground, not throwing garbage on the seas and beaches, not cutting trees, not wasting, by saving, we can treat all people equally and fairly. We can act fairly and equally by giving the excess food that we do not eat to the animals instead of throwing it away, not taking the habitats of other living things, by feeding them, by behaving well.	

Table 4.19 Sample excerpts showing students' ERiA 1 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
ERiA 1: Fairness	Good (2)	People-Planet	ST 12: People: In order to treat people fairly and equally, we should not use all the resources in the world as if they were ours alone. For example, there are people who cannot find water, if we waste this water, we will cause inequality and injustice. We should not use all natural resources (water etc.) as our own. There are many poor countries in Africa that cannot find water. We should not use the world's resources as if they were our own. We must realize our responsibilities. We do not treat people fairly and equally because we overuse natural resources. We should use as much as we need. For example, in some countries there is still gender inequality. Boys go to school, girls stay at home and do housework. Such injustices exist. We can try to avoid them. Planet: We should not throw garbage into the environment and the sea. To act fairly to all people and other living, we can plant trees, clean the garbage from the waters, clean the picnic areas in the forests.	ST 12: People: We can act fairly by helping people who need with our unused and clean clothes. As we see in the Sustainable Development Goals, we can be fair and equal by ending poverty and hunger for people, by supporting them to have a healthy and quality life, and by ensuring gender equality. In addition, we must use the water carefully to ensure that all living things have access to clean water. Planet: We can act fairly by not polluting the forests and nature, which are the living spaces of living things, and feeding them. As we see in the Sustainable Development Goals, we can be fair and equal by protecting terrestrial and aquatic creatures.
		People-Prosperity		ST 17: People: As in the 5th goal, we can work for equality of women and men. As stated in Goal 5, we can act equally and fairly by not discriminating or being racist. Food and aid should be given to people and living in need, then we can put an end to hunger and poverty. Prosperity: As in stated the 10th goals, we can work reduce all kinds of inequalities in all fields. We can act equally and fairly by providing equal conditions (jobs, income, resources) for all.

Table 4.19 Sample excerpts showing students' ERiA 1 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
ERiA 1: Fairness	Excellent (3)	People-Planet-Prosperity	ST 2: People: sending aid to different countries in the world, raising people's awareness. In this way, it can be fairer to people survived with hunger and poverty in Africa. Prosperity: We can use renewable energy to not pollute the world. Countries with good economy can help countries wıth bad economy. Everyone can help. Thus, fairness can be achieved. Planet: By keeping the world clean and collecting garbage, we can act fairly.	ST 6: People: To be fair to all people, we must be able to meet their needs. If we can drink clean water, eat food, and receive quality education, all people in the world should also be able to benefit from these. People all over the world should be able to have the opportunities we have. Everyone should be given food, water, house, etc. equally. Prosperity: There should be job opportunities for everyone. We should use solar energy which is one of the renewable energies. We try to reduce all inequalities according to the goal 10. Planet: For example, we must feed living things and protect their habitats. We should protect our environment and natural habitats for animals. Responsible production and consumption according to the 12th goal, we should not overuse the resources that others also have a right to.

Table 4.19 Sample excerpts showing students' ERiA 1 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
ERiA 1: Fairness	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership	ST 5: People: We can be fair by ending poverty and achieving gender equality. We can establish global institutions and help different parts of the world, all different places like Africa, Russia, America, Canada. For example, if there is inequality between men and women in some countries, awareness can be raised on this issue and equality can be achieved through conscious managers. The world will be fairer and more equal if rich states provide healthy nutrition and life services (hospitals, etc.), clothing and food aids to poor countries such as Africa. Prosperity: We can act fairly and equally by by contributing to decent work and economic growth, by developing industry, innovation and infrastructure. Planet: We can save natural resources by throwing garbage in the trash and recycling. For example, if we recycle plastic waste instead of throwing it in the trash, we do not harm the environment and instead of producing new plastics in vain, we can reuse this plastic, resources can be allocated to people who need it elsewhere. When we throw something into the environment, the wind drags that waste into the ocean, that waste reaches other people's living spaces. We are harming their environment, water and transportation routes. If we pay attention to these, we can be fair to those people.	ST 16: People: Gender equality is unfortunately not implemented. Equality between men and women is not implemented. Women can be subjected to violence. Some girls are not sent to school. They cannot receive quality education. They cannot gain knowledge because they cannot go to school. Women also need to enjoy their rights, the right to education, the right to work, etc. It is very important for girls to receive quality education. I think it is important to explain these to their families for a fairer and more equal world. In some parts of the world, due to many reasons (poverty, migration etc.) people without ID card cannot go to hospitals or even benefit from the right to health. If we can end poverty and present health services or hospitals for all people, the world become fairer. Planet: By protecting the environment, protecting trees, we can be fair and equitable because trees produce oxygen and this oxygen belongs to all people all over the world. In order to treat all people fairly and equally, we must not pollute the environment. We should not throw away waste that will cause forest fires, especially glasses, as sun rays can cause fires. We should not pollute the forests. We should not pollute the waters, we should care about nature. We must not cause harm. We need to planting trees. We can grow enough fruits and vegetables to sustain us. We must protect living creatures.

Table 4.19 Sample excerpts showing students' ERiA 1 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
ERiA 1: Fairness	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership	ST 5: Peace: We can unite and establish an institution, take resources from the rich and deliver them to the poor, and ensure equality and justice. Partnership: All countries in the world can act together and establish institutions that ensure justice and equality.	ST 16: Prosperity: By treating all living things equally, we strive to reduce inequalities as in Goal 10. Accessible and clean energy, economic growth, industry, innovation and infrastructure are crucial to build fairer world for humanity. Peace: For example, in developed countries such as Japan, there is justice and good practices for protecting the rights of people. Partnership: People should come and work together to achieve fairer and more equal world.

4.3.2 ERiA 2: Outcomes

According to James Madison University (2018), the outcomes dimension of ethical reasoning includes being able to consider the outcomes or consequences of our actions for our world. In order to determine students' ability levels of considering outcomes, the question 'What are some possible actions to achieve the best short- and long-term outcomes for you and others around the world?' was asked before and after the implementation. In this research, students were expected to identify outcomes considering pillars of sustainable development goals. Students' abilities to predict the short- and long-term outcomes (results, consequences, or effects) of their actions on our world considering pillars of sustainable development goals were determined before and after the unit implementation.

According to the results, before the unit implementation, one of the students (1) was at the insufficient (0) level, 15 students were at the marginal (1) level, and 4 students were at the good (2) level in identifying outcomes considering the pillars of sustainable development goals. This means that most of the students identified outcomes considering only one pillar of sustainable development goals. That is, they can identify the outcomes considering only one aspect of sustainable development goals, which is gener**a**lly the planet (environmental) aspect.

After the SDGs unit implementation, most students' outcome levels improved and reached higher level reasoning skills. 15 students' levels were extraordinary (4), 1 student's level was excellent (3), 4 students' level was good (2) and there were no students who were insufficient or marginal. Most students could generally define outcomes considering all aspects of sustainable development goals. Figure 4.11 shows the number of students according to outcomes levels before and after the SDGs unit implementation.

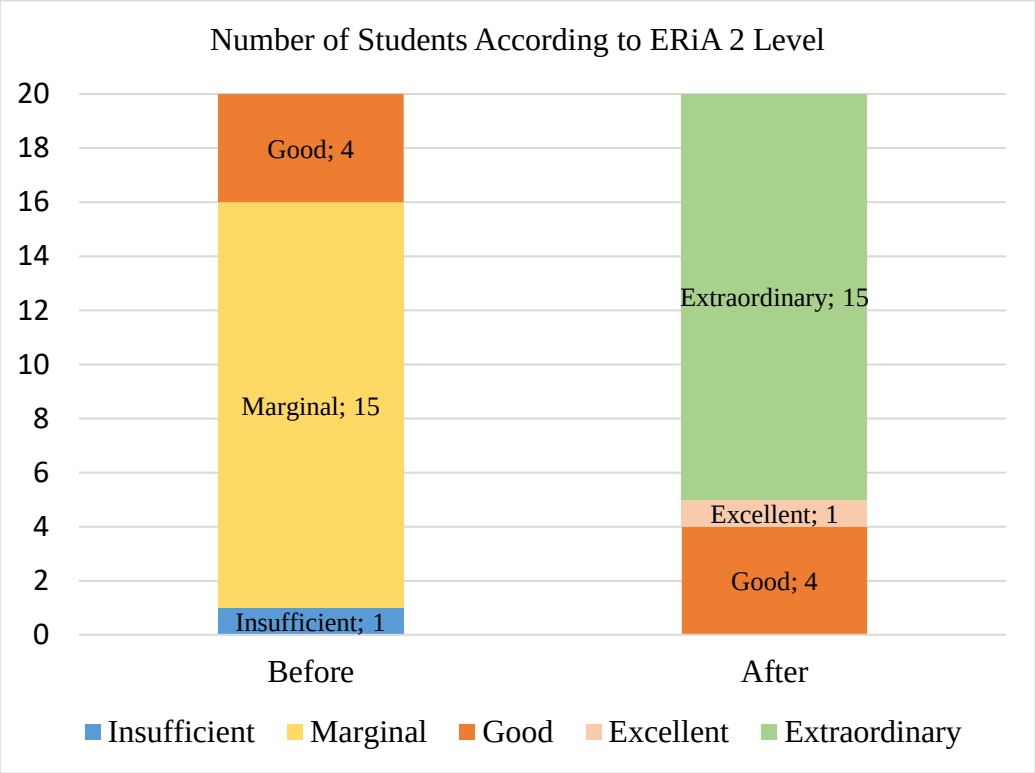


Figure 4.11 Number of students according to ERiA 2 level

Table 4.20 presents the results on students' ethical reasoning (outcomes) (ERiA 2) before and after the SDG unit implementation. Table 4.20 shows students' levels of ERiA 2 and the pillars of the sustainable development goals considered by students in identifying outcomes (ERiA 2).

Table 4.20 Students' ERiA 2 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
ERiA 2: Outcomes	Insufficient (0)	No pillar	1	ST16		
	Marginal (1)	People	5	ST4, ST7, ST12, ST17, ST19		
		Planet	10	ST1, ST3, ST8, ST9, ST10, ST11, ST13, ST14, ST15, ST18		
	Good (2)	People-Planet	2	ST6, ST20	2	ST8, ST16
		Prosperity-Planet	2	ST2, ST5	1	ST 15
		People-Prosperity			1	ST 10
	Excellent (3)	People-Prosperity-Planet			1	ST 19
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			15	ST1, ST2, ST3, ST4, ST5, ST6, ST7, ST9, ST11, ST12, ST13, ST14, ST17, ST18, ST20

The results revealed that at the beginning of the SDG unit implementation, most of the students (15) were at the marginal (1) level and could identify outcomes by considering only one pillar of sustainable development goals (see Table 4.20). Most of these students (10) could identify possible actions related to the planet for best short- and long-term outcomes for everyone living around the world. They emphasized actions such as not littering the environment, not polluting the air and seas, protecting the environment, recycling, protecting forests. Some of these students (5) could identify outcomes by considering the 'people' pillar of sustainable development goals (Table 4.20). They could identify actions like developing sustainable agriculture to end poverty, using resources without wasting them to end hunger, providing aid to alleviate hunger and lack of water, and treating everyone equally. Before the SDG unit implementation, some of the students (4) were at the good (1) level and could identify outcomes by considering two pillars of sustainable development goals (Table 4. 20). Half of these students could identify possible actions related to the 'people-planet' aspects for best short- and long-term outcomes for everyone around the world. They emphasized actions like treating people equally, helping people in need, stopping illegal hunting, planting trees, not littering the nature. The other half of the students could identify possible actions related to 'prosperity-planet' for best short- and long-term outcomes for everyone around the world. They emphasized actions like using renewable energy sources, responsible production of plastics, recycling, and environmental protection. One student (ST16) was at the insufficient (0) level and could not identify outcomes by considering any pillar of sustainable development goals.

After the SDG unit implementation, most students (15) (ST1, ST2, ST3, ST4, ST5, ST6, ST7, ST9, ST11, ST12, ST13, ST14, ST17, ST18, ST20) reached the extraordinary level (4) and could identify outcomes by considering all pillars of sustainable development goals (Table 4.20). Students could identify possible actions related to people, prosperity, planet, peace and partnership for best short- and long-term outcomes for everyone around the world. They emphasized actions like developing sustainable agriculture to end poverty, using resources without wasting them to end hunger, providing aid to alleviate hunger and lack of water, and treating everyone equally. They identified actions for prosperity such as using renewable energy, contributing to promoting decent work and economic growth,

industry, innovation, infrastructure, building sustainable cities and communities. They identified actions for the planet such as not littering the environment, not polluting the air and seas, protecting the environment, recycling, protecting forests, consuming responsibly, reducing climate change, protecting terrestrial and aquatic life. They identified actions for peace such as acting for peace. They identified actions for partnership such as working together for goals. 1 student (ST 19) was at excellent level and could identify outcomes by considering three pillars of sustainable development goals. 4 students (ST8, ST10, ST15, ST16) were at good level and they could identify outcomes by considering two pillars of sustainable development goals after the SDGs unit implementation.

To summarize, most students could identify outcomes by considering one pillar of sustainable development goals (planet mostly) before the SDG unit implementation. After the implementation, their ERiA 2 levels improved and reached higher levels. Therefore, more than half of the students could identify outcomes in terms of all pillars of sustainable development goals. Table 4.21 shows sample excerpts from students at different levels before and after the SDG unit implementation.

Table 4.21 Sample excerpts showing students' ERiA 2 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
ERiA 1: Outcomes	Insufficient (0)	No pillar	ST 16: Acting sensitively to world.	
	Marginal (1)	People	ST 19: <u>People:</u> We can help people who are in financial difficulties and cannot reach food. We should put cat-dog food and a bowl of water in front of our house for living things. Instead of thinking about what we will contribute, what is important is that we contribute, no matter how little or how much. If people realize problems (but I don't think so), we can prevent it in the long run, even to some extent. We can't do much in a short time because there are so many problems. We can take action individually or together and do something.	
		Planet	ST 15: <u>Planet:</u> We should throw our garbage in the trash, recyclables, and materials in the recycling bin. We should not throw garbage into the waters, seas and oceans. We should install filters in the chimneys of houses and workplaces, exhaust pipes for preventing air pollution. We should not light fires in forests. When we picnic in the forests, we should leave it clean. We should not throw rubbish into the waters and there may be developed a mechanism for collecting garbage in the waters. Recycling bins can be increased for soil pollution, for battery waste. Trash cans can be increased.	

Table 4.21 Sample excerpts showing students' ERiA 2 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
ERiA 1: Outcomes	Good (2)	People-Planet	ST 20: People: We should give food to those in need. We have to help. In the long run, we must warn all people. We must treat people equally, not mistreating other living things. Planet: We should not pollute the nature and the environment; we should not cut down trees. We must keep our nature clean, collect the garbage. We should not throw garbage or waste into the seas or on the land. In the short term, keeping our environment clean, throwing the garbage in the trash, recycling.	ST 16: People: In the short and long term, social media can be used to ensure gender equality and to raise awareness on this issue. In addition, those who do not follow the rules can be punished. Planet: In the short term, we can announce it to many people on social media about not polluting the environment. We need to plant trees in terms of oxygen, in terms of living things. We should not pollute the waters.
		Prosperity-Planet	ST 5: Prosperity: For example, using renewable energy sources that do not harm the environment we can remain a better world for future generations in the long term. Planet: As a whole humanity, we can clean the world in the short and long term by giving importance to environmental pollution and recycling, and cleaning plastics from the oceans. We must stop the production of plastic. We don't produce any more plastic if we recycle, and we can prolong the life of the world. We can do something to clean the oceans, the seas. As an alternative to plastic, we can use materials, items, plates made from mud. It is in harmony with nature and does not harm.	ST 15: Prosperity: Using electric vehicles instead of gasoline-powered cars that cause air pollution. By acting sparingly, we get results in the short and long term. Planet: By not polluting the world, not throwing garbage and polluting in the seas, not hunting animals, not cutting trees, protecting terrestrial life,

Table 4.21 Sample excerpts showing students' ERiA 2 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
ERiA 1: Outcomes	Good (2)	People-Prosperity		ST 10: People: Treating all people equally and caring for animals. The 5th goal of sustainable development goals is to ensure gender equality. We need to achieve this goal. We can use water sparingly, using it only when necessary, for a long time. Prosperity: We can achieve long-term results by using renewable energy sources.
	Excellent (3)	People-Planet-Prosperity		ST19: People: I think possible actions is to try to solve the social problems like poverty, hunger, lack of clean water, equality between women and men specified in the goals. Prosperity: I think possible actions is to solve the economic problems like unemployment, income, lack of affordable and clean energy by achieving sustainable development goals Planet: I think possible actions for best outcomes is to solve the environmental problems such as environmental pollutions, climate change, damaging of biodiversity, endangered animals and plants by achieving sustainable development goals.

Table 4.21 Sample excerpts showing students' ERiA 2 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
ERiA 1: Outcomes	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 1: Things that depend on us. It depends on our behavior. The 17 development goals we learned in the lesson are actions that will deliver the best short- and long-term results for all people and living things. People: We should end poverty, hunger, inequalities, ensure good health and well being, quality education, gender equality, clean water and sanitatation. We should not pollute our waters and use them cleanly. As stated in the clean water and sanitation goal. For example, in some places, hunger and poverty are high. Aid can be provided to the people there, food areas can be created. Thus, we can end hunger in the short term. Prosperity: We should use affordable and clean energy, promote decent work and economic growth, industry, innovation, infrastructure, build sustainable cities and communities. Planet: We should protect our climate for long-term, life below water and on land, and consume and product responsively. Climate action, for example. To reduce climate change, filters should be used, exhausts, factory chimneys, etc. We must protect aquatic life. If we do not throw garbage into the waters, animals will continue to live and we will protect them. As humans, we must protect terrestrial life, which is our living space, reduce our garbage, and increase tree planting. We must consume responsibly, use everything as much as necessary, not more than necessary.

Table 4.21 Sample excerpts showing students' ERiA 2 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
ERiA 1: Outcomes	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 1: Peace: To do all of this, we must act jointly with peace, justice and strong institutions for these purposes. Partnership: Being partner with countries for goals provide short and long-term results. If we achieve the 17 goals of sustainable development, we can leave a better world to future generations environmentally, economically and socially.

4.3.3 EriA 3: Responsibilities

According to James Madison University (2018), the responsibilities dimension of ethical reasoning includes being able to identify our duties and obligations to the world/nature. In order to determine students' ability levels of considering responsibilities, the question 'What duties and/or obligations apply?'was asked to them before and after the implementation. In this research, students were expected to identify responsibilities by considering pillars of sustainable development goals. Students' abilities to identify the duties and obligations to our world/nature considering pillars of sustainable development goals were determined before and after the unit implementation.

According to the results, before the unit implementation, 19 students were at the marginal (1) level and only one student was at the good (2) level in identifying responsibilities considering pillars of sustainable development goals. This means that most of the students identified responsibilities considering only one pillar of sustainable development goals. That is, they can identify the responsibilities considering only one aspect of sustainable development goals, which is generally the planet (environmental) aspect.

After the SDGs unit implementation, most students' responsibilities levels improved and reached higher level reasoning skills. 6 students reached the extraordinary (4) level, 6 students reached the excellent (3) level, 2 students were at the good (2) level and 6 students were at the marginal (1) level. Most students could generally define responsibilities considering a minimum of 3 aspects of sustainable development goals. Figure 4.12 shows the number of students according to responsibilities levels before and after the implementation.

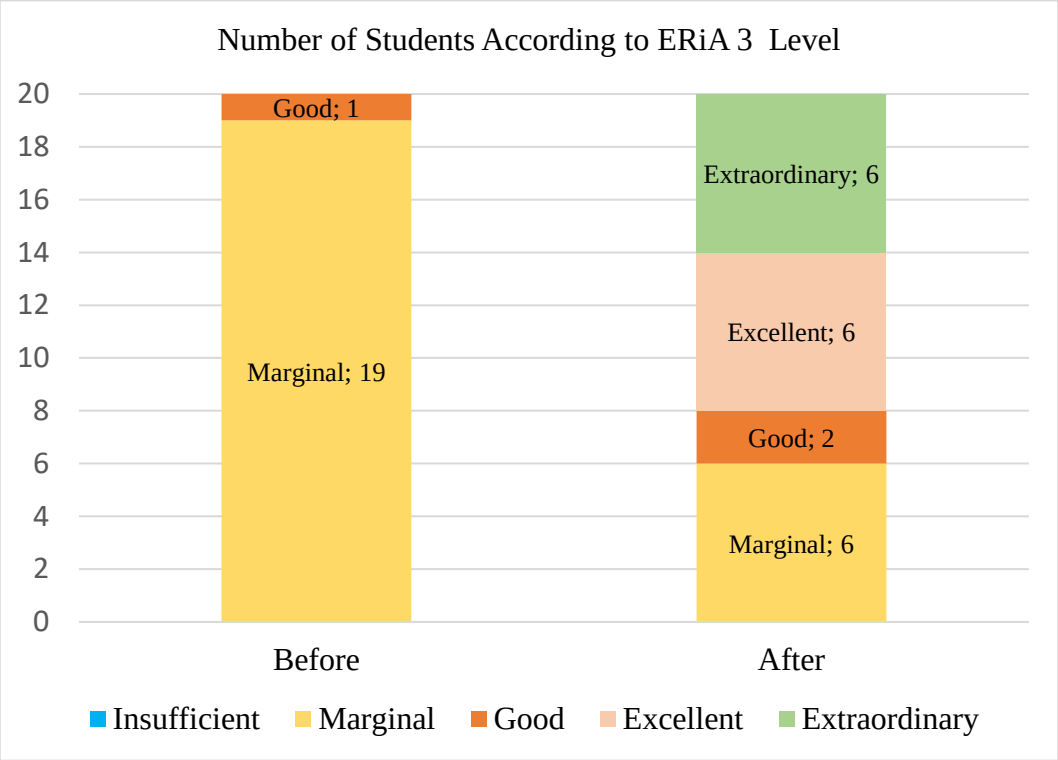


Figure 4.12 Number of students according to ERiA 3 level

Table 4.22 presents the results concerning students' ethical reasoning (responsibilities) (ERiA 3) before and after the SDG unit implementation. Table 4.22 shows students' levels of ERiA 3 and the pillars of the sustainable development goals considered by students in identifying responsibilities (ERiA 3).

Table 4.22 Students' ERiA 3 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
EriA 3: Responsibilities	Insufficient (0)	No pillar				
	Marginal (1)	Planet	19	ST1, ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST10, ST11, ST12, ST13, ST14, ST15, ST16, ST17, ST18, ST19, ST20	6	ST10, ST15, ST16, ST18, ST19, ST20
	Good (2)	People-Planet	1	ST 9	2	ST3, ST11
		Prosperity- Planet				
		People-Prosperity				
	Excellent (3)	People- Prosperity- Planet			6	ST2, ST4, ST6, ST8, ST12, ST17
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			6	ST 1, ST5, ST7, ST9, ST13, ST14

According to the findings, at the beginning of the SDG unit implementation, 19 students (ST 1, ST2, ST3, ST 4, ST5, ST6, ST7, ST8, ST10, ST11, ST12, ST 13, ST14, ST15, ST 16, ST17, ST18, ST19 and ST20) were at the marginal (1) level and could identify responsibilities by considering only one pillar of sustainable development goals (the planet). They identified their responsibilities as not throwing garbage to the environment, recycling, planting trees, protecting natural sources, taking public transport, not polluting the oceans and seas, not polluting our atmosphere, not harming living things/animals, waste sorting. One student (ST 9) was at the good level and she could identify responsibilities by considering two pillars of sustainable development goals (people-planet). She identified her responsibility as helping people who suffer from hunger as wells as protecting the environment.

After the SDG unit implementation, more than half of the students' (12) reasoning about responsibilities developed and rose to extraordinary (4) and excellent (3) levels. That is, they could identify responsibilities by considering a minimum of three pillars of sustainable development goals. They listed their responsibilities towards the planet as not wasting water, not polluting our environment, protecting animals, not using resources unnecessarily, planting trees. Moreover, they stated their responsibilities about people as helping those who suffer from poverty and hunger, using water without wasting, not discriminating between boys and girls. In addition, they explained their responsibilities about prosperity as using renewable and environmentally-friendly energy, working for economic growth and innovations, striving for reducing all kinds of inequalities like wage inequality, etc. Furthermore, they stated their responsibilities about peace and partnership as working together for peace and justice, achi**e**ving all goals with collaboration. 2 of the students (ST3, ST11) were at the good level and they could identify their responsibilities in terms of the 'people-planet' pillars of sustainable development goals. They emphasized responsibilities such as keeping the environment clean, protecting terrestrial and aquatic life, helping people in need (like poor, hunger etc.), not using water unnecessarily, reducing water use. 6 of the students (ST10, ST15, ST16, ST18, ST19, ST20) were at the marginal (1) level and could identify responsibilities by considering the 'planet' pillar of sustainable development goals

(not polluting the environment, recycling, consuming and producing resources responsibly, protecting the climate and living things).

To sum up, most students could identify responsibilities by considering one pillar of sustainable development goals (planet mostly) before the SDG unit implementation. After the implementation, their ERiA 3 levels improved and reached higher levels. More than half of the students were able to identify responsibilities in terms of three pillars of sustainable development goals. Table 4.23 shows sample quotes from students at different levels before and after the SDG unit implementation.

Table 4.23 Sample excerpts showing students' ERiA 3 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
EriA 3: Responsibilities	Insufficient (0)	No pillar		
	Marginal (1)	Planet	ST 8: <u>Planet:</u> Our responsibilities towards the world and our nature are not throwing the garbage on the ground, throwing the garbage in the garbage bins determined according to each waste. (for example, papers in the paper waste bin, batteries in the battery waste bin, etc.), keeping the environment clean, preferring recyclable products.	ST 16: <u>Planet:</u> As responsibilities, every human can contribute to nature but certainly not harm it. I can give an example of terrestrial life, we should plant more trees, we should plant trees, we can turn our world into a more beautiful and oxygen-rich environment. For example, let me give an example from school; there is a trash can in every classroom. We should not pollute our classrooms. We should throw our garbage in the trash bin. In nature, we should throw our garbage into garbage bins, not into the environment, the beach or the sea. Garbage bins should be placed everywhere. Since they collect garbage at certain hours, we should not leave our garbage on the streets after these hours. For example, when we go to nature with my family, we do not leave our garbage behind, we collect it and leave. I think my family and I know our duties and responsibilities and we protect nature.

Table 4.23 Sample excerpts showing students' ERiA 3 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 3: Responsibilities	Good (2)	People-Planet	ST 9: People: We should help people who are starving in another country. For example, we should help people who are experiencing natural disasters (such as earthquakes). Planet: I think, priority is to protect the environment and nature. The duty of all living things is to protect nature. It's actually very easy. It will be enough if we leave it clean. Keeping my environment clean, protecting animals, planting trees, helping are my responsibility against the world. This should be done not only in our own country, but all over the world.	ST 11: People: Moreover, I have a responsibility to help people who need (like poor, hunger etc.) I should not use water unnecessarily, to reduce water use, so we can prevent water scarcity Planet: I have a duties and responsibilities to keep nature clean, not to pollute, to warn those who pollute. To be a person worthy of nature. We should warn people, protect aquatic life, feed fish, not hunt them when they are young, not take them away from their natural habitats or imprison them, not lock birds in cages, for example, and let them live in their natural habitats.

Table 4.23 Sample excerpts showing students' ERiA 3 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 3: Responsibilities	Excellent (3)	People-Planet-Prosperity		ST 8: <u>People:</u> We should protect the world, we should not use resources unnecessarily. We can help people socially. We should not discriminate between boys and girls, racism or gender discrimination. <u>Planet:</u> We should keep the air, water and soil clean, not polluting the environment. We need to plant a lot of trees and make them green. We should not pollute the air, water, soil with wastes. We can recycle. We must protect our life on land and life below water. <u>Prosperity:</u> We should increase green areas instead of buildings. Or we can make solar panels that will benefit our economy. We can contribute economy and we can use resources such as electricity instead of exhaust gases, factory gases. We can use the energy of water. We can generate electricity from water. We can take advantage of waves and dams.

Table 4.23 Sample excerpts showing students' ERiA 3 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 3: Responsibilities	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 9: People: We should not waste our food, supporting campaigns (to fight poverty and hunger). We should recycle, reuse and reduce. We should think of other people and living things who need food and clean water. Planet: Before this lesson, I thought that we could not do much. There was a few thing we can do like not throwing garbage in our nature, not polluting the waters. At the end of the lesson, my thoughts changed. I realized that I actually have more duties and responsibilities towards the world. Before the lesson, I couldn't think globally, I couldn't think about the welfare level. But now I'm more aware. recycling, using electric cars, not throwing garbage as much as possible, collecting garbage on land and in water, not harming and protecting animals, and using environmentally friendly products. We must not throw garbage, we must not pollute the seas, otherwise the fish will be harmed. Prosperity: For example, if we are going to build a house for ourselves, we should make it from nature-friendly materials and build a green house. To achieve the goal of sustainable cities and communities, we can make buildings strong and we do not need to build constantly, even if there are disasters such as earthquakes. We should use renewable energy sources suc as solar energy to protect our world. Peace: Moreover, we should work for spread of peace, justice all over the world. We must obey the laws. Partnership: As humanity, all of us have important responsibilities. We can work and achieve all together.

4.3.4 ERiA 4: Character

According to James Madison University (2018), the character dimension of ethical reasoning includes being able to identify actions reflecting who you are and who you want to be for the world. In order to determine students' level of character, the question 'What action best reflects who you are and the person you want to become?' was asked to students before and after the implementation. In this research, students were expected to identify character by considering pillars of sustainable development goals. Students' abilities in reflecting who they are and who they want to be for the world considering pillars of sustainable development goals were determined before and after the unit implementation.

According to the results, before the unit implementation, 2 students were at the insufficient (0) level and 18 students were at the marginal (1) level in identifying character considering pillars of sustainable development goals. This means that most of the students identified character considering only one pillar of sustainable development goals. That is, they could identify the character considering only one aspect of sustainable development goals, which is generally the planet (environmental) aspect.

After the SDGs unit implementation, most students' character level improved and reached higher level reasoning skills. 4 students reached the extraordinary (4) level, 6 students reached the excellent (3) level, 5 students reached the good (2) level and 5 students remained at the marginal (1) level. Half of students could generally define character considering a minimum of 3 aspects of sustainable development goals. Figure 4.13 shows the number of students according to character level before and after the implementation.

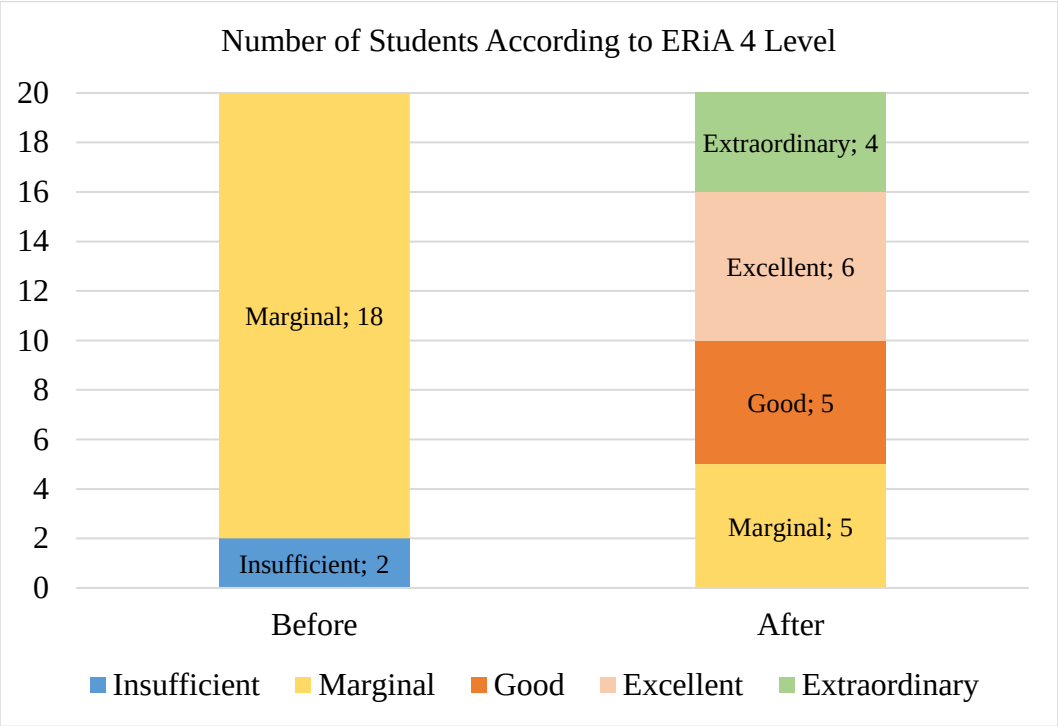


Figure 4.13 Number of students according to ERiA 4 level

Table 4.24 presents the results about students' ethical reasoning (character) (ERiA 4) before and after the SDG unit implementation. Table 4.24 shows students' levels of ERiA 4 and the pillars of the sustainable development goals considered by students in identifying character (ERiA 4).

Table 4.24 Students' ERiA 4 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
ERiA 4: Character	Insufficient (0)	No pillar	2	ST16, ST18		
	Marginal (1)	Planet	18	ST1, ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9, ST10, ST11, ST12, ST13, ST14, ST15, ST17, ST19, ST20	5	ST10, ST15, ST16, ST17, ST18
	Good (2)	People-Planet			5	ST1, ST3, ST4, ST6, ST19
		Planet-Prosperity				
		People-Prosperity				
	Excellent (3)	People-Planet-Prosperity			6	ST2, ST7, ST8, ST9, ST13, ST14
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			4	ST5, ST11, ST12, ST20

According to the results, at the beginning of the SDG unit implementation, most of the students (18) (ST1, ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9, ST10, ST11, ST12, ST13, ST14, ST15, ST17, ST19, ST20) were at the marginal level in identifying character by considering only one pillar of sustainable development goals. They identified character in terms of the planet pillar, such as being someone who does not pollute the nature, does not contribute to air, water and soil pollution, recycles, saves resources, plants trees, prioritizes nature in every action. In addition, they emphasized that they wanted to be environmentally-friendly by warning people who damage the environment and by protecting other living things besides humans. 2 students (ST16, ST18) were at the insufficient level and they could not identify character by considering any pillar of sustainable development goals.

After the SDG unit implementation, half of the students' (10) levels were at excellent (3) or extraordinary (4) levels. They could identify character by considering three or more pillars of sustainable development goals. They defined their character as responsible world-citizens who try to achieve all sustainable development goals. For example, they stated that they wanted to be person who make efforts for ending poverty, hunger, inequalities, contributing to economic growth, innovations, sustainable cities and communities as well as protecting our environment, terrestrial and aquatic life. Moreover, they stated that they wanted to be someone who constructs peace, justice and strong institutions. 5 students (ST1, ST3, ST4, ST6, ST19) were at the good level and they could identify character by considering the 'people and planet' pillars of sustainable development goals. They mentioned being someone who protects the environment (not throwing garbage etc.) and takes action to end poverty and hunger and to contribute to gender equality. 5 of the students (ST10, ST15, ST16, ST17, ST18) remained at the marginal level and they could identify character by considering the 'planet' pillar of sustainable development goals. They emphasized being someone who keeps the world clean, protects the environment and engages in responsible consumption.

To sum up, most of the students could identify character by considering one pillar of sustainable development goals (planet mostly) before the SDG unit implementation. After the implementation, their ERiA 4 levels improved and reached higher levels. Therefore, half of the students could identify character in terms of three pillars of sustainable development goals at least. Table 4.25 shows

sample excerpts from students at different levels before and after the SDG unit implementation.

Table 4.25 Sample excerpts showing students' ERiA 4 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
EriA 4: Character	Insufficient (0)	No pillar	ST 18: I think I am good person and I want to be good person against the world.	
	Marginal (1)	Planet	ST 12: Planet: I am a person with responsibilities towards nature, I do not pollute nature and do not harm trees. In the future, I want to be someone who has responsibilities towards nature, does not pollute nature, does not cause air, water and soil pollution. I have responsibilities towards nature. I want to be someone who recycles, saves, helps nature, and prioritizes nature in everything. I want to be an environmentally conscious person.	ST 18: Planet: Being someone who strives for the 13th, 14th and 15th goals of sustainable development, does not throw garbage, does not pollute the nature, and takes precautions against global warming. I would like to be an environmentally conscious person, plant trees and protect the green.
	Good (2)	People-Planet		ST 4: People: I want to be someone who takes action to end poverty and hunger and contribute to gender equality. I want to be a person who uses the world's resources as much as I need, helps people. I want to be someone who uses our waters sparingly. I'm trying not to pollute the water or something.

Table 4.25 Sample excerpts showing students' ERiA 4 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 4: Character	Good (2)	People-Planet		ST 4: Planet: I want to be someone who protects the environment, I am already. I want to be someone who protects the environment, protects animals, builds shelter for them, and gives them food, does not throw garbage in the world, I want to be a person who plants trees and prevents fires.I want to be a good environmentally friendly person. If no one is sensitive to the environment, all natural resources will be damaged, forests, air, water, soil etc. I want to be an environmentalist because I also think about future people. I try not to pollute the air. I'm planting trees.
	Excellent (3)	People-Planet-Prosperity		ST 13: People: I am a person who strives for the 1st and 2nd goals of the sustainable development goals and attaches importance to reducing inequalities as in the 5th and 10th goals. I provide financial aid to people in need as much as I can. Prosperity: I would like to strive for decent work and economic growth, the 8th goal of the sustainable development goals, and sustainable cities and communities, the 11th goal of the sustainable development goals.

Table 4.25 Sample excerpts showing students' ERiA 4 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 4: Character	Excellent (3)	People-Planet-Prosperity		ST 13: Planet: Before this lesson, I was not an environmentally protective person. For example, when I bought something from the market, I would throw the garbage on the ground. After this lesson, I realized that it was wrong and harmful. I thought that I was becoming a sensitive person who protects my environment after learning about sustainable development goals in this course. I want to be a person who strives to make the world/nature a better place I want to be a person who keeps my environment clean and sensitive to the problems in the world.
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 12: People: I want to be sensitive to our world. I would like to be someone who deal with environmental, economic and social problems and try to solve them. I want to be an earth-friendly, environmentally friendly individual. From now on, I will do my best to protect the world and achieve the 17 sustainable goals: no poverty, zero hunger, good health and well-being, quality education, gender equality. Prosperity: I will do my best to protect the world and achieve the 17 sustainable goals: clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reducing inequalities, sustainable cities and communities.

Table 4.25 Sample excerpts showing students' ERiA 4 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 4: Character	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 12: Planet: We pollute the world a lot. We need to be a person who keeps nature clean and befits nature. For example, we need to protect trees, forests. When we destroy nature, we destroy ourselves. Frankly, at the beginning of this course, I was not very careful not to throw my garbage into the environment. After the environmental education course and learning about sustainable development goals, I started to be more sensitive to the environment and world' challenges for livings. I will do my best to protect the world and achieve the 17 sustainable goals: responsible consumption and production, climate action, life below water, life on land. Peace: I will do my best to protect the world and achieve the 17 sustainable goals like peace, justice and strong institutions. I want a world where there are no wars and where people live in peace with easy, equal and fair access to resources. Partnership: I will do my best to protect the world and achieve the 17 sustainable goals with partnerships.

4.3.5 ERiA 5: Liberty

According to James Madison University (2018), the liberty dimension of ethical reasoning includes being able to identify and respect people's freedom, personal autonomy (ability to make decisions independently of another person or situation, self-government) and consent. In order to determine students' levels of liberty, the question 'How does respect for freedom, personal autonomy or consent apply?' was asked to students before and after the implementation. In this research, students were expected to identify liberty by considering pillara of sustainable development goals. Students' abilities to identify and respect other's freedom, personal autonomy (ability to make decisions independently of another person or situation, self-government) and consent considering pillars of sustainable development goals were determined before and after the unit implementation.

According to the results, before the unit implementation, 13 students were at the insufficient (0) level, 6 students were at the marginal (1) level and only one student (1) was at the good (2) level in identifying liberty considering the pillars of sustainable development goals. This means that most of the students could not identify liberty considering the pillars of sustainable development goals.

After the SDGs unit implementation, most students' liberty level improved and reached higher level reasoning skills. 2 students reached the extraordinary (4) level, 3 students reached the excellent (3) level, 8 students reached the good (2) level and 6 students remained at the marginal (1) level and only one student remained at the insufficient (0) level. Most students could generally define liberty considering a minimum of 2 aspects of sustainable development goals after the SDG unit implementation. Figure 4.14 shows the number of students according to liberty level before and after the implementation.

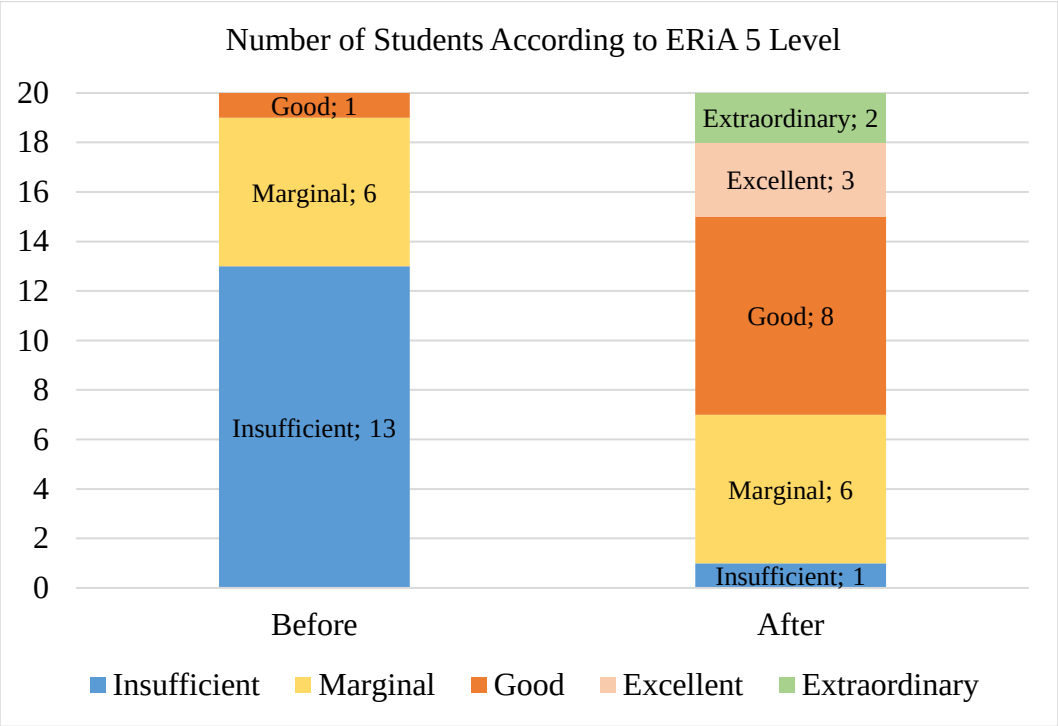


Figure 4.14 Number of students according to ERiA 5 level

Table 4.26 presents the results about students' ethical reasoning (liberty) (ERiA 5) before and after the SDG unit implementation. Table 4.26 shows students' levels of ERiA 5 and the pillars of the sustainable development goals considered by students in identifying liberty (ERiA 5).

Table 4.26 Students' ERiA 5 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	**Students**	**No. of Students**	**Students**
ERiA 5: Liberty	Insufficient (0)	No pillar	13	ST3, ST4, ST7, ST8, ST10, ST13, ST14, ST15, ST16, ST17, ST18, ST19, ST20	1	ST 17
	Marginal (1)	People	1	ST 9	2	ST 18, ST19
		Planet	5	ST1, ST2, ST6, ST11, ST12	4	ST8, ST10, ST12, ST13
	Good (2)	People-Planet	1	ST 5	7	ST1, ST3, ST6, ST11, ST14, ST16, ST20
		Planet-Prosperity			1	ST 4
	Excellent (3)	People-Planet-Prosperity			3	ST5, ST7, ST15
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			2	ST2, ST9

The findings revealed that at the beginning of the SDGs unit implementation, most of the students (13) (ST3, ST4, ST7, ST8, ST10, ST13, ST14, ST15, ST16, ST17, ST18, ST19 and ST 20) were at the insufficient (0) level and could not identify liberty by considering any pillar of sustainable development goals. 6 students (ST1, ST2, ST6, ST9, ST11, ST12) were at the marginal level and they could identify liberty by considering only one pillar of sustainable development goals (planet mostly). They identified liberty with respecting people's opinions and not harming the nature by respecting all life forms, protecting our world, which is the common living space of all living things. Only one student (ST 5) was at the good level and he could identify liberty by considering the 'people-planet' pillar of sustainable development goals. He explained the restrictions on people's freedom by referring to environmental pollution (air, water and soil pollution) in terms of living in healthy environment and the restriction on people's economical liberty by referring to poverty.

After the SDGs unit implementation, most students' reasoning levels about liberty were at good (2), excellent (3) and extraordinary (4) levels and they could identify liberty by considering two or more pillars of sustainable development goals. They explained liberty by mentioning reducing inequalities and respecting people's own decisions, educating people and raising awareness to solve environmental, social and economical challenges, guaranteeing people's rights through laws, working together to develop every region of the world, not throwing garbage, not polluting the nature, protecting all life forms, building sustainable cities (the scarcity of green areas limit people's freedom), acting equally to everyone, using natural resources by thinking future generations' needs. In addition, they defined liberty as respecting people's opinions, developing 'peace, justice, strong institutions' for liberty, protecting the environment for all humanity to live freely. 6 of the students were at the marginal level and they could identify liberty by one pillar of sustainable development goals (mostly planet). Only one student (ST 17) was at the insufficient level and she could not identify liberty by considering any pillar of sustainable development goals.

To sum up, most students could not identify liberty by considering any pillar of sustainable development goals before the SDG unit implementation. After the implementation, their ERiA 5 level improved and reached higher levels. Therefore,

more than half of the students could identify liberty in terms of a minimum of two pillars of sustainable development goals. Table 4.27 shows sample quotations from students at different levels before and after the SDG unit implementation.

Table 4.27 Sample excerpts showing students' ERiA 5 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
EriA 5: Liberty	Insufficient (0)	No pillar	ST 4: We should always respect a person's opinion and not prevent him from expressing his/her opinion. Every human being is free and no one can interfere with it. We must be respectful and courteous. We must respect his/her consent and freedom. My freedom ends where it begins to harm the freedom of others.	ST 17: We can respect people without interfering with his/her ideas, behavior, speech, lifestyle (clothing, etc.), by treating people well and listening people.
	Marginal (1)	People	ST 9: People: We must respect everyone's decision. All over the world women are not given too many rights. Freedom is restricted. We have to warn them. For example, there is violence against women. We have to say no to them. Penalties must be given. Women are not given the right to education or work. I think it is very wrong, people's freedom, decision making is restricted.	ST 18: People: As human beings, we can respect by treating people who are different from us (religion, gender, race, etc.) and not to discriminate. Men and women are equal, this will not change. We must respect all people's opinions.
		Planet	ST 2: Planet: I respect people's decisions. Some people throw garbage in nature, I have a hard time respecting such people. I politely warn those who disrespect. For example, someone collects garbage in the neighborhood, on the streets, others make fun of him instead of respecting his behavior. In fact, that person cleans the environment, contributes a lot to nature. He does this voluntarily of his own decision. Other people should respect and support this person's behavior. I don't think we can do much individually, we can do something all together.	ST 12: Planet: We should respect people and warn those who are not. I think it is wrong to think that I am free and I can do whatever I want. Saying that I am free and can throw garbage everywhere is wrong. If you say you can light a fire in places where fire is prohibited, it may cause forest fires. Saying you can cut trees but cutting them is wrong and this is not freedom. It harms the world. Protecting the environment is very important for all humanity to live freely. (After-planet

Table 4.27 Sample excerpts showing students' ERiA 5 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 5: Liberty	Good (2)	People-Planet	ST 5: People: Air pollution and plastics thrown into the sea can harm people's health and living things. People's freedom to swim in a clean sea is being prevented. Or it is prevented that the ships go due to pollution. Economic problems like poverty restrict freedom of people. Planet: All people in the world, people living in countries like Africa, should have freedom and right to live in clean environment. We are harming people's freedom by polluting. For example, we cause air and water pollution. This pollution affects everywhere. Water or air pollution reaches even the most remote areas and affect the nature negatively.	ST 1: People: For example, some people do not allow their children to receive education, especially girls. This is also related to gender inequality. I think this is very wrong. For example, some men want their wives to be examined by female doctors, but they prevent their own daughters from getting an education. This is very contradictory and wrong behavior. This restricts people's freedom. Quality education and gender equality goals are very important. Planet: Every person is free, free-thinking. Everyone has to respect that, but until the freedom of each person limits the freedom of another person. The moment someone else's freedom is restricted, there is no respect. My freedom is until I restrict someone else's freedom. Therefore, I respect everyone's and all living freedom. But for example, if a person harms the environment and says this is my freedom, I will oppose this, I will not respect this behavior because this nature belongs to all of us. For instance, as humanity, when we pollute the environment, we harm people's and other livings' freedom. For example, when we pollute the air with harmful gases, when we damage trees, we breathe the harmful gas in ourselves and other people, and we harm both people's freedom of life in a clean world and their health and well being. Or we can cause some kind of animals and plants to become extinct. When we cause pollution, it affects every part of the world, and since the world is cyclical, these pollutions reach us again.

Table 4.27 Sample excerpts showing students' ERiA 5 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 5: Liberty	Good (2)	Prosperity-Planet		ST 4: Prosperity: People in some regions of the world cannot find work and they have difficulty in meeting their basic needs. Every people deceive respectful and decent work in terms of freedom. Planet: We should act respectfully to all living. But I think those who pollute the environment and use more resources than necessary should be punished. Even small rewards can be given to those who protect the environment and do not pollute. For example, there was an example of good implementation. People earned points as they protected the environment, and thanks to them, shelters were built for pets. For example, there will be technology warning screens in different places to warn those who throw garbage on the ground.
	Excellent (3)	People-Planet-Prosperity		ST 5: People: If we show equality for evey people, we will be respectful. We should behave like human beings regardless of religion, race, language or gender. Because everyone is equal. We have to be kind and tolerant. We must speak in a polite and understandable language without insulting anyone, and we must respect values. A person is free to the extent that he does not harm the freedom of others. I respect everyone's freedom.

Table 4.27 Sample excerpts showing students' ERiA 5 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 5: Liberty	Excellent (3)	People-Planet-Prosperity		ST 5: Prosperity: The construction of buildings and the scarcity of green areas limit people's freedom. Population density limits freedom. Placards and posters should be hung so that everyone respects the environment. Planet: We should not throw garbage, we should not pollute the nature. We must show them respect. For example, when we pollute, we harm people's freedom. For example, when we pollute the waters and seas here, this pollution can even reach distant places like Africa. In Africa, we can block the waterways of people traveling by boat and damage their water. We can harm their freedom. Polluting the environment can restrict the freedom of people on the other side of the world. It may restrict the freedom of animals. Due to pollution in the water, aquatic creatures can swallow plastic, and these plastics can get stuck in their bodies and throats. Animals are being harmed. Their habitats are being destroyed. Environmental education should be given in schools so that people behave respectfully towards the environment.

Table 4.27 Sample excerpts showing students' ERiA 5 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 5: Liberty	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 2: People: Reducing inequalities and respecting people's own decisions is so important. I think that all problems can be solved with qualified education. So, if we educate people and raise awareness, we can solve problems such as inequality and not sending children to school. We can warn people who disrespect. To respect the freedom of others, we must listen to them. The 5th goal of the sustainable development goals is that men and women are equal and will be equal. Prosperity: I strive to reduce all kinds of inequalities (lack of access to healthcare, discrimination, job opportunities, income etc) to respect all people and other living. Planet: Moreover, all people should protect and respect nature and environment to respect everyone. Achieving this goal is very important. Peace: States can guarantee people's rights through laws. People's rights should be protected, unfair decisions should not be made. As in the 16th goal, I strive for peace, justice and strong institutions in my country. Partnership: Countries can work together to develop every region of the world. Public awareness can be raised about problems and solutions through public service announcements.

4.3.6 ERiA 6: Empathy

According to James Madison University (2018), the empathy dimension of ethical reasoning includes being able to feel empathy. In order to determine students' levels of empathy, the question 'What would you do if you were interested in the problems faced by people and living in different parts of our world? Explain?' was asked to students before and after the unit implementation. Students were expected to being able to feel empathy with people and living things facing problems in different parts of the world by considering all pillars of sustainable development goals.

According to the results, before the unit implementation, 4 students were at the insufficient (0) level, 14 students were at the marginal (1) level and 2 students were at the good (2) level in identifying empathy considering pillars of sustainable development goals. This means that most of the students identified empathy considering only one pillar of sustainable development goals. That is, they could identify empathy considering only one aspect of sustainable development goals, which is generally the planet (environmental) or people (social) aspects.

After the SDGs unit implementation, most students' empathy level developed and reached higher level reasoning skills. 4 students reached the extraordinary (4) level, 4 students reached the excellent (3) level, 7 students reached the good (2) level and 5 students remained at the marginal (1) level. Most students could generally define empathy considering a minimum of 2 aspects of sustainable development goals. Figure 4.15 shows the number of students according to empathy levels before and after the implementation.

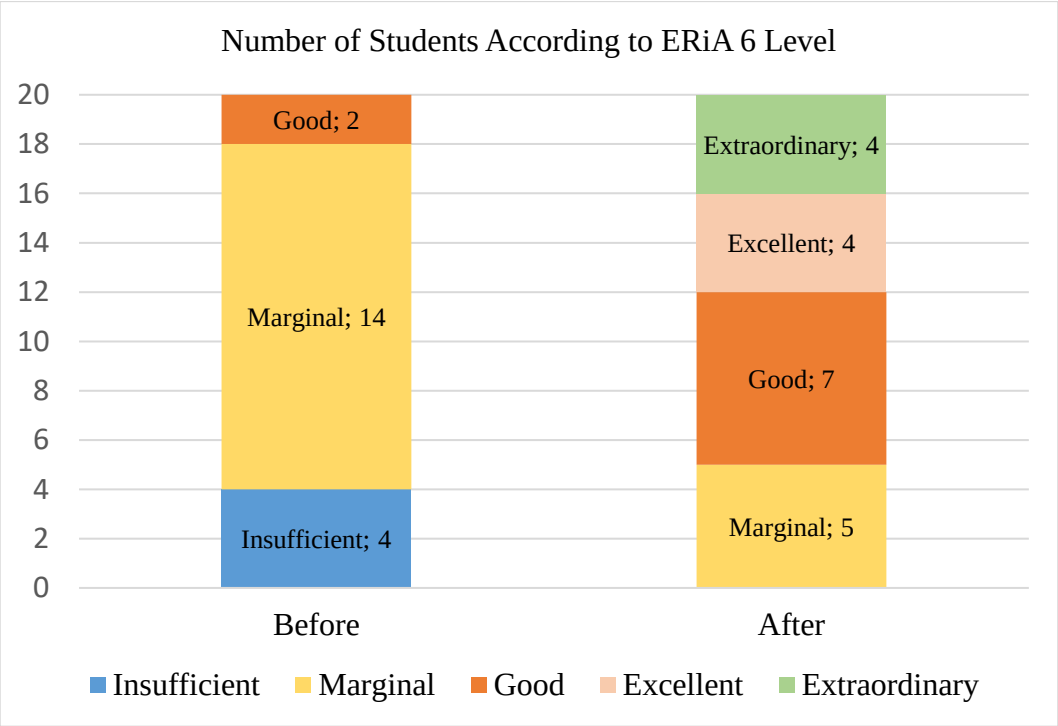


Figure 4.15 Number of students according to ERiA 6 level

Table 4.28 presents the results concerning students' ethical reasoning (empathy) (ERiA 6) before and after the SDG unit implementation. Table 4.28 shows students' levels of ERiA 6 and the pillars of the sustainable development goals considered by students in identifying empathy (ERiA 6).

Table 4.28 Students' ERiA 6 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
ERiA 6: Empathy	Insufficient (0)	No pillar	4	ST10, ST16, ST18, ST19		
	Marginal (1)	People	7	ST1, ST3, ST7, ST8, ST14, ST17, ST20	4	ST3, ST8, ST18, ST20
		Planet	7	ST4, ST5, ST6, ST11, ST12, ST13, ST15		
		Prosperity			1	ST19
	Good (2)	People-Planet	2	ST2, ST9	6	ST1, ST5, ST13, ST14, ST15, ST17
		People-Prosperity			1	ST10
	Excellent (3)	People-Planet-Prosperity			4	ST4, ST9, ST11, ST16
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			4	ST2, ST6, ST7, ST12

According to the results, at the beginning of the SDGs unit implementation, most of the students (14) (ST1, ST3, ST4, ST 5, ST 6, ST 7, ST8, ST11, ST12, ST13, ST14, ST15, ST17, ST20) were at the marginal (1) level and could identify empathy by considering only one pillar of sustainable development goals: people or the planet. Some of them showed empathy with social (people) problems such as helping people who suffer from poverty, hunger, lack of water, lack of health services, homelessness. The other half of them showed empathy with environmental (planet) problems like feeding and giving water to animals and building shelters for them, not hunting animals, cleaning and protecting seas and beaches, preventing global warming, not throwing garbage to the environment. 4 students (ST10, ST16, ST18, ST19) were at the insufficient (0) level and could not identify empathy by considering any pillar of sustainable development goals. 2 students (ST2 and ST 9) were at the good (2) level and could identify empathy by considering two pillars of sustainable development goals (people and the planet). They explained empathy as helping people with supplies and water, ensuring equality between men and women, protecting nature, forests and animals.

After the SDGs unit implementation, most the students (15) reached the good (2), excellent (3) and extraordinary (4) level. They showed empathy with people (social) problems such as helping people who suffer from poverty, lack of water, hunger, supporting sanitation of dirty and unhealthy waters in countries, supporting schooling, raising awareness and starting campaigns for poor people. They showed empathy with prosperity problems by mentioning building houses for those whose houses are in poor conditions, using electricity as much as necessary and not wasting it, using more renewable energy sources like solar energy, striving for the development of industry, innovation and infrastructure, helping people with job opportunities. They showed empathy with planet problems such as protecting a healthy environment for everyone, consuming responsibly, protecting and respecting all life forms, taking precautions for animals especially the endangered ones, working to stop or slow down global warming, protecting the natural habitats of animals and trying to stop illegal hunting, recycling, increasing green spaces for living things, planting trees, engaging in various activities to prevent soil, water and air pollution. They showed empathy with peace problems by mentioning treating everyone equally, bringing justice for equality. On the other hand, after the SDGs

unit implementation, 5 students remained at marginal level and they could identify empathy by considering one pillar of sustainable development goals (people mostly).

To sum up, most students could define empathy by considering one pillar of sustainable development goals (either people or the planet) before the SDG unit implementation. After the implementation, their ERiA 6 level improved and reached even higher levels. Therefore, more than half of the students could explain empathy in terms of a minimum of two pillars of sustainable development goals. Table 4.29 shows sample statements from students at different levels before and after the SDG unit implementation.

Table 4.29 Sample excerpts showing students' ERiA 6 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
EriA 6: Empathy	Insufficient (0)	No pillar	ST 10: I would be sad and help them. I would start a campaign and collect donations for them	
	Marginal (1)	People	ST 7: People: First, I would listen to their problems as much as I could and try to solve them. Then I would help them solve their problems. For example, I would give food aid for hunger. I would provide water, house, clothes, supplies, baby and women's items, toys for children, medicine aid and financial aid to people in need. I would like to protect and feed living things.	ST 8: People: If I had the opportunity, I would give a lot of clothing aid, food, water and whatever they need. I can provide food, water for people and animals, I can protect their homes, that is, nature. I help those in need. There is discrimination in many countries in the world, girls are not sent to school. I don't discriminate and racist people. I would work to achieve the 5th goal of the sustainable development goals. I would do my best to solve the problems
		Prosperity		ST 19: Prosperity: I would strive to reduce all kinds of inequalities (e.g work conditions, income, level of welfare). I would contribute to the development of industry, innovation and infrastructure. I think this solves many problems of world.

Table 4.29 Sample excerpts showing students' ERiA 6 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 6: Empathy	Marginal (1)	Planet	ST 5: Planet: For example, the natural habitat of polar bears is glaciers. As the glaciers melt, polar bears may be harmed and their numbers may decrease. Global warming is increasing the melting of glaciers. I pay attention to my behavior towards the environment so that global warming does not increase. Polar bears' habitats are disappearing due to global warming as the glaciers melt. I would try to find solutions to prevent their extinction. I would try to create living spaces for them. I would develop a project to prevent global warming. I was trying to raise people's awareness. I would try to find a solution to the rising of the waters due to global warming. I put a bowl of water or food for cats, dogs or creatures living on the street. I can help. I don't throw garbage around.	
	Good (2)	People-Planet	ST 9: People: I send them supplies and water. If I could, I would protect women. I would set up an institution for women. I would do my best to punish those who commit violence against women. Planet: I would keep the environment clean and protect environment. I would do my best not to harm the animals. I would like to make a nursing home for stray animals, which is useful.	ST 5: People: I can provide financial aid to poor people. I would give food aid. Instead of wasting food, we can send it to them. I would strive for a healthy and quality life for everyone. Planet: I would work to stop the pollutions. To solve these problems, we first need to take measures to stop global warming and prevent animals from becoming extinct. Unfortunately, we are destroying the habitats of animals in the glaciers. We must protect their habitats. Animals need to be protected. I would put nutritious, healthy foods and water for animals. I would put an end to pollution on land and sea.

Table 4.29 Sample excerpts showing students' ERiA 6 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 6: Empathy	Good (2)	People-Prosperity		ST 10: People: I would get the poor to go to school and I would remove gender inequality and Prosperity: I would strive for everyone to work in the jobs they want and that suit them. I would help people economically.
	Excellent (3)	People-Planet-Prosperity		ST 9: People: There are many problems in some countries, there is lack of water due to drought. I would build fountains. I would build houses for those whose houses are in poor condition. I would provide health services and send a doctor for their health, if I had opportunity. I would send help, I would go myself to solve their problems. In some countries, people are hungry and thirsty, there are water problems, and water wars may occur. Like Africa, for example. There is a drought. We can send help there. If we do not have the opportunity to help, at least we use our water economically and do not waste it, so that it can be delivered to those in need. I work to achieve the goals 1,2,3,4,5 and 6 of the sustainable development goals. Planet: I would put up warning signs for protecting environment. I work to achieve the environmental related goals 12,13,14 and 15 of the sustainable development goals.

Table 4.29 Sample excerpts showing students' ERiA 6 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 6: Empathy	Excellent (3)	People-Planet-Prosperity		ST 9: Prosperity: We use electricity as much as necessary and do not spend too much. We can benefit more from renewable energy like solar energy. We should not throw away the food we cannot eat, we do not waste it. We took too much food on our plate. If we don't, we will both save water and not waste our resources. I work to achieve the goals 7,8,10 of the sustainable development goals.
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 7: People: People at some countries are starving, dying from starving, we can send food to these people. I would strive to ensure quality education and gender equality in third world and developing countries. I would strive to provide education for children, who are not sent to school because of work at an early age or gender discrimination. Prosperity: I would build sustainable cities and communities, give importance to industry, innovation and infrastructure. I would accelerate the transition to electric cars. In some places, for example in Europe, you can enter some places if you have an electric vehicle, but you cannot enter if you have a gasoline vehicle. Applications can be made to encourage people to use electric vehicles.

Table 4.29 Sample excerpts showing students' ERiA 6 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 6: Empathy	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 7: Planet: We can live without touching in terrestrial and aquatic life. I try to be someone who consumes resources less. I would like to engage in behavior that does not harm nature. I can reduce the taxes on these vehicles to encourage people to switch to environmentally friendly vehicles. I can take actions that will encourage people to be more respectful to nature. I support public service announcements about protecting nature. I try to keep nature clean. I would punish those who harm the world. I used to put in food and water for animals. Peace: I would build peace, justice and strong institutions. I would strive that all people have equal rights. Partnership: I would contribute to finding solutions together with various countries for problems such as waste, global warming.

4.3.7 ERiA 7: Authority

According to James Madison University (2018), the authority dimension of ethical reasoning includes being able to identify the expectation of the legitimate authorities (e.g. experts, law). In order to determine students' abilities and level of authority, the question 'What do legal authorities (e.g. law, experts) expect from you in terms of protecting our world and its resources? Explain.' was asked to students before and after the implementation. In this research, students were expected to be able to identify the expectation of the legitimate authorities (e.g. experts, law) for protecting the world considering pillars of sustainable development goals. Students' abilities to identify the expectations of legitimate authorities (e.g. experts, law, legal people) for protecting the world considering all aspects of sustainable development were determined before and after the SDG unit implementation.

According to the results, before the unit implementation, 5 students were at the insufficient (0) level, 10 at the marginal (1) level, 4 at the good (2) level and only one student was at the excellent (3) level in identifying authority considering pillars of sustainable development goals. This means that half of the students identified authority considering only one pillar of sustainable development goals. That is, they can identify authority considering only one aspect of sustainable development goals, which is generally the planet (environmental) aspect.

After the SDGs unit implementation, most of the students' authority level developed and reached higher level reasoning skills. 4 students reached the extraordinary (4) level, 8 students reached the excellent (3) level, 4 students reached the good (2) level, and 4 students remained at the marginal (1) level. Most students could generally define authority considering a minimum of 3 aspects of sustainable development goals. Figure 4.16 shows the number of students according to authority level before and after the implementation.

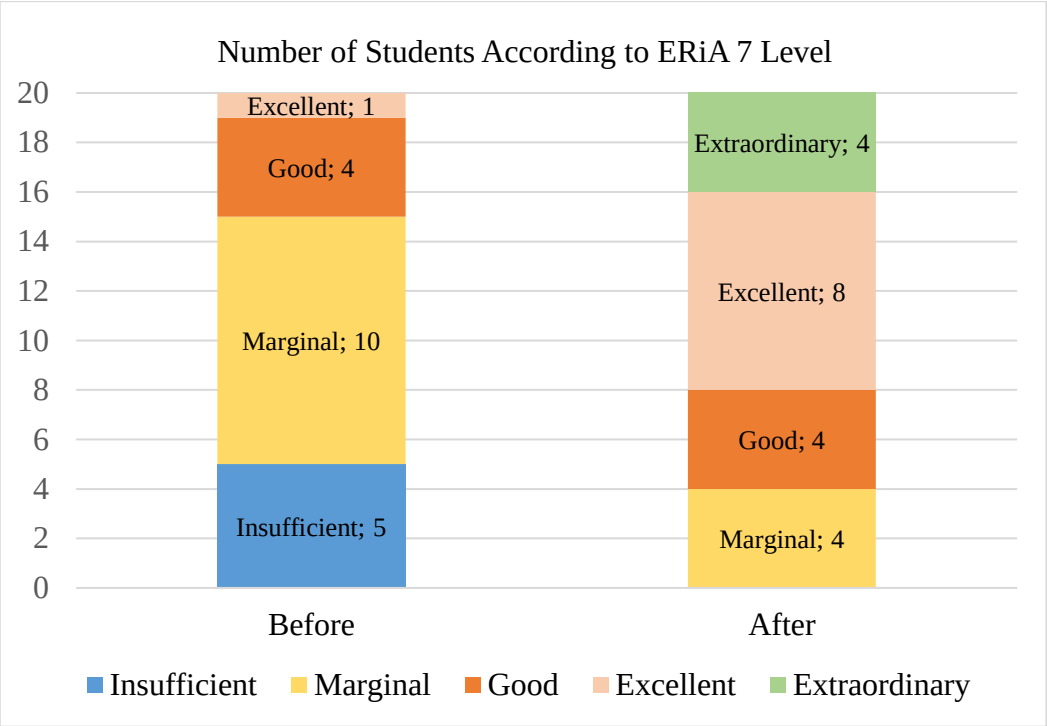


Figure 4.16 Number of students according to ERiA 7 level

Table 4.30 presents the results about students' ethical reasoning (authority) (ERiA 7) before and after the SDG unit implementation. Table 4.30 shows students' levels of ERiA 7 and the pillars of the sustainable development goals that were considered by students in identifying authority (ERiA 7).

Table 4.30 Students' ERiA 7 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
ERiA 7: Authority	Insufficient (0)	No pillar	5	ST7, ST16, ST17, ST18, ST19		
	Marginal (1)	Planet	10	ST3, ST4, ST6, ST8, ST10, ST12, ST13, ST14, ST15, ST20	4	ST3, ST15, ST17, ST18
		Prosperity				
	Good (2)	People-Planet	2	ST5, ST9	3	ST10, ST16, ST19
		Planet-Prosperity	2	ST1, ST2	1	ST 8
	Excellent (3)	People-Planet-Prosperity	1	ST11	8	ST1, ST2, ST4, ST5, ST7, ST9, ST13, ST20
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			4	ST6, ST11, ST12, ST14

According to the results, at the beginning of the SDGs unit implementation, most of the students (10) (ST3, ST4, ST6, ST8, ST10, ST12, ST13, ST14, ST15, ST20) were at the marginal (1) level and could identify authority by considering one pillar of sustainable development goals (the planet). They generally emphasized that the authorities expect them not to throw garbage, avoid behavior that cause global warming, prevent environmental pollution like polluting water, soil or air, recycling, dispose of garbage by classifying it in recycling bins, use resources sparingly. 5 of the students (ST 7, ST16, ST17, ST18, ST19) were at the insufficient (0) level and could not identify authority by considering any pillar of sustainable development goals. 4 of the students (ST 1, ST2, ST5 and ST9) were at the good (2) level and could identify authority by considering two pillars of sustainable development goals. ST 1 and ST2 could identify authority by considering the prosperity and planet pillars of sustainable development goals. They mentioned that the authorities expect them not to throw garbage, keep the environment clean, plant trees or raise people's awareness about environmental issues, prefer renewable energy sources and reduce all inequalities. ST 5 and ST9 could identify authority by considering the people and planet pillars of sustainable development goals. They mentioned that the authorities expect them not to throw garbage, recycle, keep the environment clean, planti trees, protect the environment and animals, not create waste such as food, and save water. One student (ST 11) was at the excellent (3) level and he could identify authority by considering three pillars of sustainable development goals (people, prosperity, and planet).

After the SDGs unit implementation, most of the students' levels in identifying authority developed and reached excellent (3) or extraordinary (4) levels. They identified that authorities expected them not to pollute the environment (water, air, and soil etc.), not to burn forests, not to waste resources, to respect green nature, plant trees, use less electricity and water, recycle, treat everyone justly and equally, reduce their carbon dioxide emissions, factory fumes, car exhausts etc, use electric vehicles, avoid buying more food than necessary, donate, use renewable energy sources, obey the laws, reduce inequalities, contribute to decent work and economic growth, choose homes that use solar energy, help people in need, consume responsibly, protect life on land and life below water, strive for gender equality and reduction of inequalities, and collaborate for achieving goals. 4 of the students (ST

8, ST10, ST16, ST19) were at the good (2) level and they could identify authority by considering two pillars of sustainable development goals. 4 of the students (ST3, ST15, ST17, ST18) were at the marginal (1) level and they could identify authority by considering only one pillar of sustainable development goals.

To sum up, half of the students could identify authority by considering one pillar of sustainable development goals (planet mostly) before the SDG unit implementation. After the implementation, their ERiA 7 level improved and reached higher levels. Therefore, more than half of the students could identify authority in terms of a minimum of three pillars of sustainable development goals. Table 4.31 shows sample excerpts from students at different levels before and after the SDGs unit implementation.

Table 4.31 Sample excerpts showing students' ERiA 7 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
EriA 7: Authority	Insufficient (0)	No pillar	ST 7: They expect us to use our resources carefully.	
	Marginal (1)	Planet	ST 14: Planet: They expect me and all people to keep nature clean and protect it. They expect us to recycle (plastic, glass etc.), which is protective against the environment, cleaning, warning people who harm the environment.	ST 15: Planet: It is expected from me not to pollute the world, not to harm the environment, to protect the climate, not to hunt animals. They expect us to plant trees and protect the green. They expect us to conserve resources and not to waste, encourage people about around us about these issues.
	Good (2)	People-Planet	ST 5: People: They expect us, not making waste such as food, saving water and protecting resources. Planet: They expect us to recycle, not throw our garbage around, planting tress, protecting our environment and animals and not hunting so that living things don't become extinct.	ST 16: People: We should not waste our resources, we should use less, and we should not throw food away. We should not waste water. They expect us to save water. For example, a lot of water is wasted while washing dishes. Technology has developed a lot, there are dishwashers that use less water, we can use them and we waste water as much as necessary and not too much. We must use our resources sparingly for no poverty and hunger. Planet: Simply put, they expect me not to pollute my environment and protect life in the water and on land. They expect us to warn those who pollute the nature.

Table 4.31 Sample excerpts showing students' ERiA 7 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 7: Authority	Good (2)	Prosperity -Planet	ST 2: Prosperity: They expect us to use less and save money, and to prefer renewable energy sources rather than non-renewable energy sources, reduce all inequalities. Planet: They expect us to throw our garbage in the trash, not to have barbecues in prohibited places (proteting forest fires), to save resources water, save electricity and save natural resources.	ST 8: Prosperity: They expect us to reduce inequalities because the world is full of inequalities. They expect us to be open to innovations and to live free from stereotypes. Planet: They expect me not to throw garbage, keep my environment clean, plant trees or raise people's awareness. They expect us to know our responsibilities by using resources.
	Excellent (3)	People-Prosperity-Planet	ST 11: People: As humanity, we need to empathize with those who cannot reach these resources and save our resources. Prosperity: They expect us to use renewable energy sources. Planet: They expect every person to become conscious, not throw their garbage into the environment, into the sea, and recycle. They expect us not to use water unnecessarily.	ST 7: People: Authorities expect to act without harming nature and to help people. We need to tell people about the issues like inequal distribution of resources and raise their awareness. We need to consume responsibly. For example, I can get enough food on my plate and not to waste the remaining food. Prosperity: Authorities expect us to save water, use electric vehicles, and choose homes that use renewable energy sources like solar energy. They expect us to use energy without wasting it. Planet: When we throw garbage on the ground, that garbage reaches the seas, harms the creatures in the sea, and pollutes the waters. For example, rope waste thrown into the sea entangles and harms seals. They expect us to not throw garbage, protect our nature, we are expected to recycle.

Table 4.31 Sample excerpts showing students' ERiA 7 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 7: Authority	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 14: People: We are expected to protect and save resources, for example by using water sparingly. Water wells can be opened to help African people. Donations can be made by sending non-obsolete items. Some people unfortunately waste resources. For example, they buy more food than necessary and throw it away because they cannot eat it. This can be donated and given to those in need. These are actually very easy and simple solutions that anyone can do. Prosperity: They expect us to use natural and renewable resources like solar, wind energy without wasting them. Planet: We need to reduce carbon dioxide emissions, factory fumes, car exhausts etc. To reduce these, filters can be used and electric vehicles can be switched. There's a lot that can be done. Peace: They expect us to obey the law, act fairly and live in peace. Partnership: They expect us to work together to achieve sustainable development goals.

4.3.8 ERiA 8: Rights

According to James Madison University (2018), the rights dimension of ethical reasoning includes being able to identify the rights (e.g. innate, legal, social). In order to determine students' level of rights, the question 'What rights (e.g. innate, legal, social) apply in our world?' was asked to students before and after implementation. In this research, students were expected to identify rights (e.g. innate, legal, social) for protecting the world considering pillars of sustainable development goals. Students' abilities to identify the rights (e.g. innate, legal, social) for protecting the world considering all aspects of sustainable development were determined before and after the unit implementation.

According to the results, before the unit implementation, 9 students were at the insufficient (0) level, 6 students were at the marginal (1) level, and 5 students were at the good (2) level in identifying rights considering pillars of sustainable development goals. This means that nearly half of the students could not identify rights considering any pillar of sustainable development goals.

After the SDGs unit implementation, most of the students' rights level developed and reached higher level reasoning skills. 3 students reached the extraordinary (4) level, 5 students reached the excellent (3) level, 6 students reached the good (2) level, 3 students the marginal (1) level and 3 students remained at the insufficient (0) level. Most students can generally define rights considering 2 aspects of sustainable development goals at least. Figure 4.17 shows the number of students according to their rights level before and after implementation.

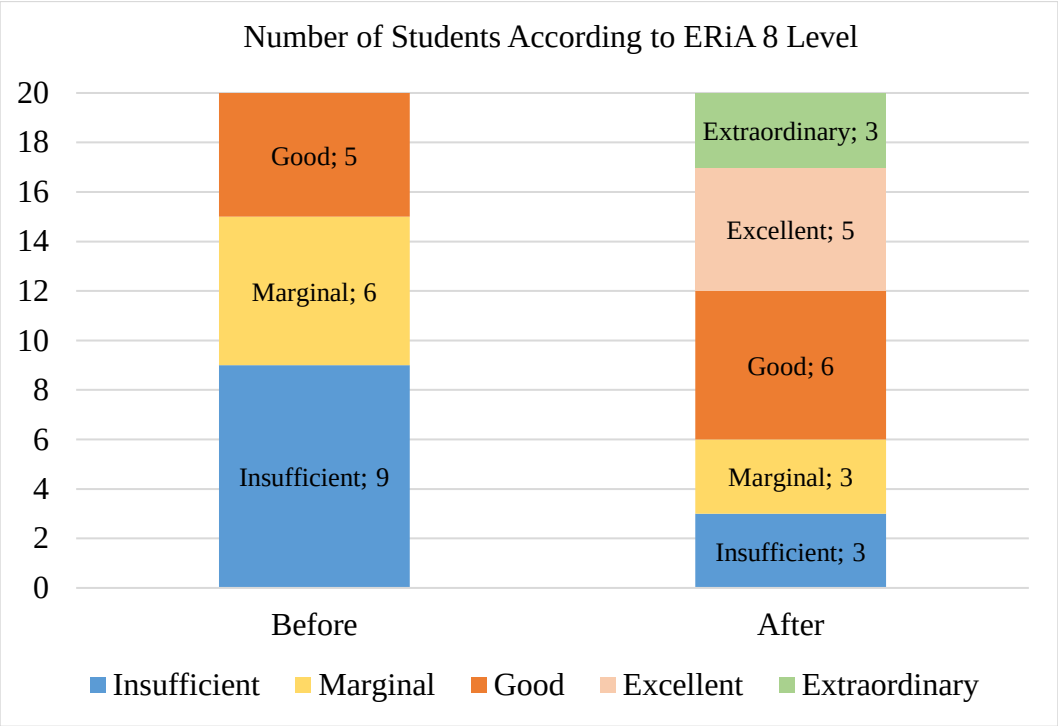


Figure 4.17 Number of students according to ERiA 8 level

Table 4.32 presents the results about students' ethical reasoning (rights) (ERiA 8) before and after the SDG unit implementation. Table 4.32 shows students' levels of ERiA 8 and the pillar of the sustainable development goals that were considered by students in identifying rights (ERiA 8).

Table 4.32 Students' ERiA 8 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before		After	
			No. of Students	Students	No. of Students	Students
ERiA 8: Rights	Insufficient (0)	No pillar	9	ST3, ST4, ST7, ST13, ST16, ST17, ST18, ST19, ST20	3	ST13, ST18, ST19
	Marginal (1)	People	4	ST2, ST8, ST11, ST15	2	ST2, ST8
		Planet	2	ST9, ST10	1	ST17
	Good (2)	People-Planet	4	ST1, ST5, ST6, ST12	4	ST3, ST6, ST10, ST20
		People-prosperity	1	ST14	2	ST4, ST12
	Excellent (3)	People-Planet-Prosperity			5	ST5, ST7, ST11, ST14, ST15
	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership			3	ST1, ST9, ST16

According to the results, at the beginning of the SDGs unit implementation, most of the students (9) (ST 3, ST 4, ST7, ST 13, ST16, ST17, ST18, ST19 and ST20) were at the insufficient (0) level and could not identify rights by considering any pillar of sustainable development goals. 6 of the students (ST 2, ST 8, ST9, ST 10, ST11 and ST15) were at the marginal (1) level and could identify rights by considering one pillar of sustainable development goals. 4 of these students identified rights relating to the people pillar of sustainable development goals. They identified rights like accessing health services, accessing quality education (girls are not sent to school in some countries), accessing food and water. 2 of the students identified rights in terms of the planet pillar of sustainable development goals. They identified rights like protecting the nature of all humanity or cleaning environment. 5 of the students (ST1, ST5, ST6, ST12, ST14) were at the good (2) level and could identify rights by considering two pillars of sustainable development goals (people-planet mostly). They mentioned rights like gender equality, the right to education, animals' right to life, protecting the environment of all humanity.

After the SDGs unit implementation, most of the students' (14) level in identifying rights developed and reached the good (2), excellent (3) and extraordinary (4) levels. They identified rights like gender equality, accessing natural resources, accessing food, clean water, accessing affordable and clean energy, accessing health services, quality education, accessing decent job and work opportunities, living in peace, living in fairly. 3 of the students (ST2, ST8, ST17) were at the marginal level (1) and could identify rights by considering only one pillar of the sustainable development goals. 3 of the students (ST13, ST18, ST19) remained at the insufficient (0) level and they could not identify rights by considering any pillar of sustainable development goals.

To summarize, nearly half of the students could not identify rights by considering any pillar of sustainable development goals before the SDG unit implementation. After the implementation, their ERiA 8 level improved and reached higher levels. Therefore, more than half of the students could identify rights in terms of a minimum of two pillars of sustainable development goals. Table 4.33 shows sample statements from students at different levels before and after the SDG unit implementation.

Table 4.33 Sample excerpts showing students' ERiA 8 levels before and after the SDGs unit implementation

	Level	Pillars of SDG	Before	After
EriA 8: Rights	Insufficient (0)	No pillar	ST 16: I think that legal, social and innate apply. That is, problems harm all rights.	ST 13: Problems harm them all, our rights (innate, social, and legal) are restricted.
	Marginal (1)	People	ST 11: People: Innate, legal and social rights are important in the problems experienced in the world. I think that the problems experienced in the world directly or indirectly harm all rights. Those born poor cannot benefitted from legal right such as the right of health or they cannot access the right to education (especially girls). Some people' life depends on chance. They may have the right to live in places where their country is in good condition. In poor countries, they cannot enjoy the right to education, children are sent to work or beg because of unemployment. For example, poor people cannot enjoy their innate rights. People in Africa may die at an early age due to hunger and water problems. They do not have courts to protect their rights. These problems are related to the economy, education. All problems harm all rights.	ST 2: People: Problems harm all rights. We, as humanity, violate all rights. For example, people should have equal rights, but those who do not have an identity cannot benefit from the rights in some countries. While the rich part of the people lives in security, the poor part have security problems. Anonymous and illiterate people do not send their children to school and they make ignorance widespread. Since they do not send their daughters to school, which is their right, they do not know their rights or cannot protect them. In some places, they experience violence and inequality because of their race (being black, etc.). Their rights are being harmed. Schools cannot be built in some places. People cannot benefit from their right to education.
		Planet	ST 10: Planet: Innate rights apply because every human being is free and deserves a clean environment. Legal rights are valid because global warming has started because of environmental pollution and it is harming the world, destroying people's right to live in a clean world.	ST 17: Planet: Environmental pollution affects rights of life of people and animals, plants. For example, if environment is polluted, all living live in a dirty environment.

Table 4.33 Sample excerpts showing students' ERiA 8 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 8: Rights	Good (2)	People-Planet	ST 1: People: Due to the inequality in the right to education, the inequality between girls and boys still continues in small areas in the villages. Legal rights suffer. Problems undermine all of these rights. Planet: Environmental pollution harms the right to life. When it harms the ecosystem, when it harms trees, our lives are affected and is damaged.	ST 10: People: It harms almost all of them. Problems such as inequality, gender equality, lack of quality education, hunger and poverty harms students innate, legal and social rights. Planet: If we, as humanity, harm nature, we may harm the right to life of future people. By polluting the environment, for example, we may cause the spread of disease. Throwing glass bottles and plastic bottles into forests can cause forest fires and our nature can be destroyed.
		People-Prosperity	ST 14: People: It harms innate rights, there are many people who cannot live their freedom. It also harms legal rights. Most people have no security of life. It harms social rights. There are many girls who cannot go to school. Problems in quality education, gender equality undermine all rights. Prosperity: Unemployment rate is very high. So many of rights can be harmed. Problems in inequalities (e.g, inequality of income), decent work and economic growth undermine all rights.	ST 4: People: It harms the rights to freedom, equality, security, work. For example, their right to education is harmed, some children are forced to work, or they work because their economic situation is not good. Their health is deteriorating. They cannot benefit from health services. Prosperity: Some of people' security rights are taken away because some people turn to theft because their economy is not good. They become bad people. They are racist and interfere with and restrict their freedom. They think they are powerful because they are rich and harm the freedom of the poor.

Table 4.33 Sample excerpts showing students' ERiA 8 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 8: Rights	Excellent (3)	People-Planet-Prosperity		ST 11: People: Problems harm them all because they are all interrelated. They harm all rights. In some countries there is no equality for women, no education, no right to work. In some parts of the world, education has not yet been adopted and they still do not send their children to school. For example, in some places they send boys to school but not girls, and this is inequality. It harms our right to education. Poverty prevents healthy eating. This is a fundamental right, drinking water is the same. There are security problems all over the world. Prosperity: For example, if there is an earthquake, all of these buildings will be destroyed due to unplanned urbanization and cause great damage to people's right to life. Planet: Environmental pollution and air pollution in the world can cause diseases. According to our way of life, it harms the environment and rights. It harms people's freedom to live in a clean environment.

Table 4.33 Sample excerpts showing students' ERiA 8 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 8: Rights	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 16: People: It can harm all of them because, for example, racism is inequality and can harm people's security. Someone experiencing racism can experience violence. I think quality education is a human's social rights. Unfortunately, gender inequality in legal rights is very high. Hunger and climate action harms people and living things as the weather gets warmer and can harm health. Clean water is very important, people have the right to access clean water. Lack of water undermines the innate right. It harms the quality of life that is our innate right. When it comes to social rights, quality education suffers from inequalities. Prosperity: Accessible and clean energy. For example, in our village the electricity is constantly cut off, which may cause problems. For example, we had the problem of not being able to attend our classes in distance and online education due to power and internet outages. This causes the efficiency to decrease. In regions of the world where there is no electricity, people may not be able to access education or information sources.

Table 4.33 Sample excerpts showing students' ERiA 8 levels before and after the SDGs unit implementation (cont.)

	Level	Pillars of SDG	Before	After
EriA 8: Rights	Extraordinary (4)	People-Prosperity-Planet-Peace-Partnership		ST 16: Planet: I think irresponsible consumption and production harms rights. Because if we do not consume responsibly, we may cause more famine in the future. It harms all rights. Future generations need energy, electricity, water, food and many resources, just like us. We need to use resources adequately. Therefore, we need to prepare a future for future generations. We should use all our resources economically and not pollute our nature. Peace: Living in peace, justice and with strong institutions are our social and legal rights. Because there is war in some countries, people go to other countries and have many problems finding a job, housing problem, conomical problems etc. Partnership: working together or collaborate with other people to achieve important goals provides to protect rights of all of us. We leave such a bad world to future generations that no one wants to live in such a world, no one can live in it, and no one has the right to live.

4.3.9 Summary of the results about students' ethical reasoning in action

The results indicated that before the SDG unit implementation, most of the students' ERiA levels were either insufficient (0) or marginal (1) in ethical reasoning in action. After the SDG unit implementation, most of the students' ERiA levels were enhanced and reached the good (2), excellent (3) or extraordinary (4) levels (Figure 4.18).

The results showed that the simplest skills are identified as ERiA 1, ERiA 2 that could be developed easily while the hardest skills are identified as ERiA 5, EriA 8 that could be developed with more difficulty.

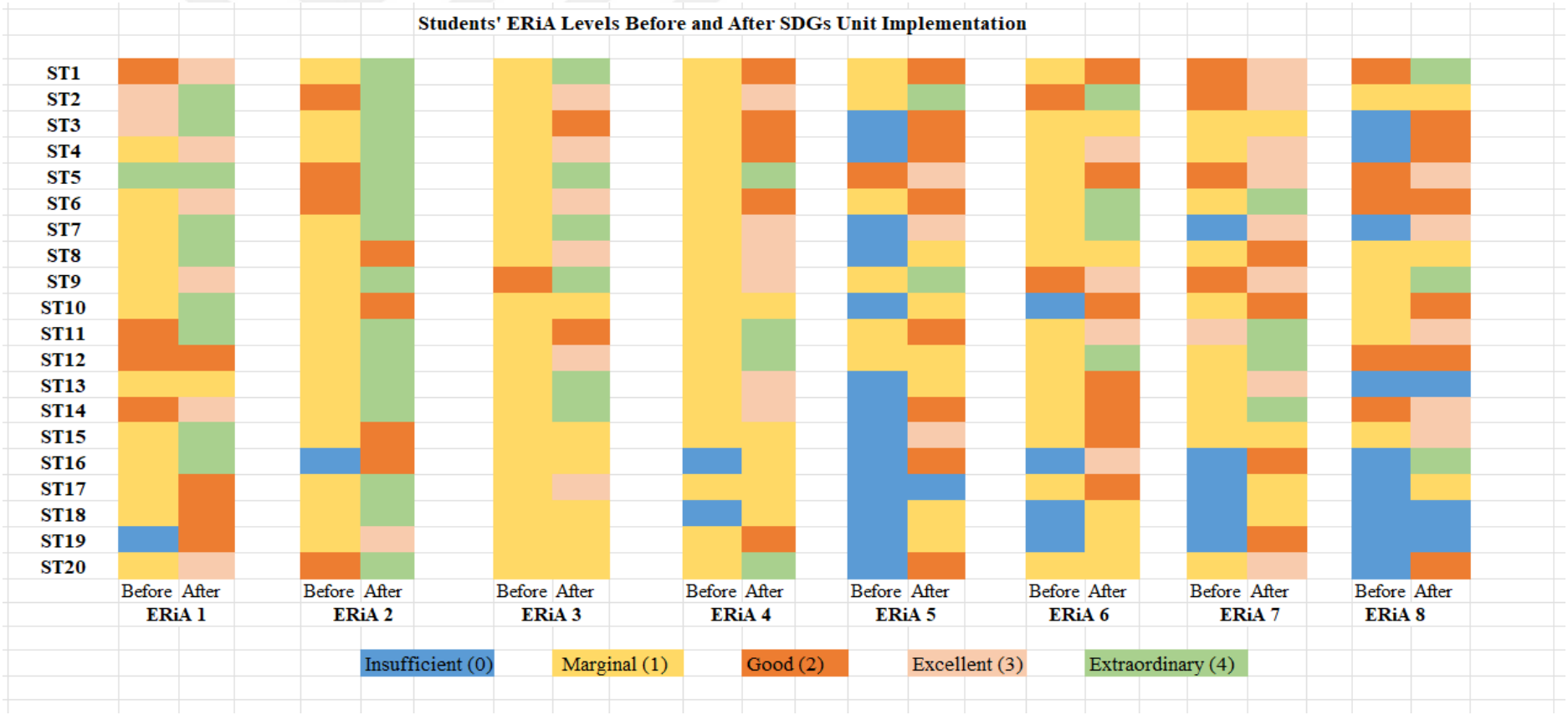


Figure 4.18 Students'ERiA levels before and after SDGs unit implementation

5
DISCUSSION AND IMPLICATIONS

5.1 Discussion and Implications of the Results

This chapter presents discussion and implications of the results under separate headings for the three main areas of research: (1) the learn–think–act approach-based Sustainable Development Goals unit, (2) students' systems thinking skills, and (3) students' ethical reasoning in action.

5.1.1 Sustainable Development Goals Unit

The first aim of this thesis is to develop SDGs unit for K-12 education to train students about sustainable development goals. Therefore, learn-think-act based Sustainable Development goals unit was developed for middle school students. The aim of this unit is to develop their systems thinking skills and ethical reasoning in action as global citizens to achieve the Sustainable Development Goals by 2030. The SDG unit included cognitive, socio-emotional and behavioral learning objectives for each SDGs. The cognitive learning objectives for each SDGs consisted of required knowledge and thinking skills to comprehend the SDGs better and the challenges to achieve them. For example, cognitive learning objective for 'SDG 1: No Poverty' in the unit is like 'Students explain the concept of poverty, distributions of poverty, causes and impacts of poverty.' The socio-emotional learning objectives for each SDGs in the unit involved social skills like attitudes, self-reflection skills, values and motivations so that learners can communicate, negotiate and collaborate for SDGs. For instance, socio-emotional learning objective for 'SDG 2: Zero Hunger' in the unit is like 'Students discuss critically on their own role and responsibilities for zero hunger.' The behavioral learning objectives for each SDGs in the unit included competencies for action. For example, behavioral learning objective for 'SDG 3: Good Health and Well-being' in the unit is like 'Students propose suggestions for promoting good health and well-being.'

The teaching procedure for each goal consisted of three main parts: Learn-Think-Act. The "learn" part for each SDGs involved theoretical knowledge about the

SDGs and different instructional videos. For instance, the learn part of 'SDG 4: Quality Education' included 2 instructional videos about SDG 4 and explanations about concept of quality education and the important role of quality education and lifelong learning opportunities for all. The "think" part for each SDGs consisted of practical educational resources such as different cases and learning activities about the 17 SDGs to make students think critically. For example, the "think" part of 'SDG 7: Affordable and Clean Energy' included the activity of 'Let's use renewable energy!' The "act" part for each SDGs covered different videos and learning activities about action and reflection. For instance, the "act" part of 'SDG 12: Responsible Consumption and Production' involved 2 videos about the examples of actions on SDG 12 and learning activity about the solutions' suggestions and actions for SDG 12.

In the relevant literature, most of the studies have focused on the implementation of the SDGs in higher education and university students' knowledge, perception, and awareness about the SDGs (e.g., Bezeljak et al., 2020; García-González et al, 2020; Albareda-Tiana et al, 2018; Cottafava et al. 2019; Jati et al, 2019; Kwee, 2021; Kopnina, 2018; Krishna et al., 2022; Leal Filho et al., 2020; Leal Filho et al., 2021; Leiva-Brondo et al., 2021; Manolis, 2020; Novieastari et al. 2022; Omisore et al., 2017; Smaniotto et al., 2020; Timm & Barth, 2021; Zamora-Polo et al., 2019) while there is limited research on implementation of the SDGs in K-12 education (e.g., Hoang et al., 2020; Eli et al., 2020; Summers & Kruger, 2003) One of the reasons for so few studies concerning implementation of the SDGs in K-12 levels is the lack of curriculum materials (learning tools) to put them into practice (Lee, 2008; Mckeown, 2002; Venkataraman, 2009). In addition, finding instructional materials rigorously tested for effectiveness in developing students' systems thinking skills and reasoning is challenging for educators (Booth et al., 2000; Gilbert et a., 2019). Leal Filho et al. (2022) emphasized that it is an important necessity to develop curriculum materials that may help systematically introduce the SDGs in classes (Leal Filho et al., 2022). Therefore, this research tried to fill out this gap in the current literature and provided the SDGs unit for K-12 education for teachers and researchers who can educate students about sustainable development goals as well as develop students' systems thinking skills and ethical reasoning in action.

The learn-think-act based SDG unit developed in the current research provided educational material to support teachers or educators working with young students to deepen their understanding of education about and for the SDGs and to see how global citizenship education (GCE) approaches and methodologies can underpin good practice as suggested in literature (MCIC, 2018; OXFAM, 2019; Putman & Byker, 2020; Rieckmann, 2017). In the present research, the learn-think-act based SDG unit integrated global citizenship education within instruction to support students see the world as a system and use ethical reasoning in acting to make our world a more sustainable place.

5.1.2 Students' Systems Thinking Skills

The second aim of this study was to investigate how the systems thinking skills of students could be developed through learn-think-act based Sustainable Development Goals Unit. In line with this aim, students' STS levels were assessed before and after SDG unit implementation. Before and after the SDG unit implementation, students' level of STS was determined through the data collection tools: open-ended questions and semi-structured interviews. The results indicated that although students' initial STS were at low levels (insufficient or marginal), most of the students' systems thinking skills developed to higher levels (excellent or extraordinary) after the SDGs unit implementation. The results of the study also revealed that there could be a hierarchy and complexity among the skills highlighted by Ben- Zvi Assaraf and Orion (2005,2010a) because the number of students who have low or high STS were directly proportional to complexity of the skills. That is, students' systems thinking skills at the higher level of STS model (especially implementation level abilities (STS 6-7-8) showed the decrease of number of students who achieve these skills as in literature (Ben- Zvi Assaraf & Orion,2005,2010a).

In other words, teaching SDGs with a learn-think-act approach-based unit contributed to develop students' systems thinking skills. In a similar way, a number of studies in the literature supported the results of the current research by revealing that systems thinking skills could be developed through interventions focused on issues of sustainability or environmental education (Ben-Zvi Assaraf & Orion, 2005, 2010a; Doganca Kucuk & Saysel, 2018; Evagorou et al.,2009; Lee et al., 2011; Rachmatullah & Wiebe, 2022; Riess & Mischo, 2010). All this research

focused on the interventions including environmental systems and revealed that students' systems thinking skills can be developed by those interventions that highlight the connections among environmental systems like ecosystems, water or carbon cycles, etc. Unlike the other studies, the current research also covered social and economical aspects of system as well as environmental aspect of system within SDGs unit intervention. For example, teaching SDGs issues like poverty, hunger, good health and well being, quality education, gender equality, clean water and sanitation in K-12 levels introduced social (related to people) issues in the world and help students to understand that social issues are part of the system and solving these challenges is closely linked to solving other aspects like prosperity, planet, peace and partnership. Training students about SDGs issues like affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reducing inequalities, sustainable cities and communities can introduce economical (related to prosperity) issues in the world and help students to comprehend that economical issues are part of the system and solving these challenges is closely linked to solving other aspects like people, planet, peace and partnership. Explaining SDGs issues like responsible consumption and production, climate action, life below water and life on land can introduce environmental (related to planet) issues in the world and help students understand that environmental issues are part of the system and solving these challenges is closely linked to solving other aspects like people, prosperity, peace and partnership. SDG issues also introduced issues like peace, justice and strong institutions in the world and help students to understand peace is part of the system and building peace, justice and strong institutions is closely linked to other aspects like people, prosperity, planet and partnership. In addition to all these aspects, students grasped the importance of partnerhips for solving local and global issues for a sustainable world.

The results of the present study supported that SDGs could promote students' systems thinking skills by enabling students to grasp the links and interactions within different aspects. In this way students' STS acquisition is developed in real time as they begin to use them to explore how people, planet, prosperity, peace and partnerships are interrelated in a complex way (Albers, De Winter & Voeten, 2017; Capra & Luisi, 2014; Martin, 2008; Nguyen & Bosch, 2013; Palmberg et al., 2017;

Torkar et al., 2019; United Nations, 2015). In addition, this result indicated that education for sustainable development goals (ESDG) can help learners think the world as a system by helping them to comprehend the complexity and dynamics of different domains (people,planet,prosperity, peace and partnership) across different scales like local to global (Armenia et al., 2022; Capra & Luisi, 2014; Meadows, 2008; Schuler et al., 2018; Sleurs, 2008; Torkar et al., 2019; Wiek et al., 2011a,b).

The results in the current research related to students' abilities to identify the components of a system and processes within the system (STS 1) showed that students could mostly identify the components and processes within the system in terms of only one pillar of the sustainable development goals before SDGs unit implementation. This pillar was the planet mostly. This means that they could identify the components and processes related to environmental issues like environmental pollution of the air, water, soil, climate change and global warming, greenhouse gases, receding glaciers, extinction of species, reduction of habitats, increased carbon emissions. After the SDGs unit implementation, most of the students' STS 1 level developed and they could identify the components of a system and processes within the system in terms of people, prosperity, the planet, peace and partnership included in the sustainable development goals. This means that they could identify the components and related processes related to people, planet, prosperity, peace and partnership. For example, students emphasize the planet aspect by mentioning environmental pollution, climate change, global warming, population growth and density, overconsumption, and people's lack of awareness of these issues. In addition, they identified prosperity aspects such as high unemployment, child labour, child marriage, income inequality, being unable to access affordable and clean energy, industrialization, unsustainable cities, underdeveloped infrastructure, flimsy buildings that are not resistant to disasters such as earthquakes, floods, etc., Moreover, they mentioned the people aspect by emphasizing lack of clean water, hunger, poverty, famine, decrease in agricultural lands, increased vulnerability to disease, epidemics, lack of health services, different kinds of inequalities (gender, race, etc), lacking opportunities for quality education, etc. In addition to these concerns, students could identify peace and partnership aspects by mentioning wars between countries, turmoil within

countries, civil wars, unequal rights, injustice, and the need for international collaboration to solve such challenges.

Similar to this research, STS 1 (identifying components of a system and processes within the system) has been examined in different contexts like Earth systems and the water cycle (Ben-Zvi Assaraf, 2005, 2010a Dutton-Lee, 2015; Lee et al., 2019); climate system (Shepardson et al. 2014); rock and carbon cycle (Sibley et al., 2007; Zangori et al., 2017); ecosystems (Eilam, 2012; Evagorou et al., 2009) and sustainable development (Demssie et al., 2023; Karaarslan Semiz & Teksöz, 2020). All such research supported that students' identifying different components of a system can show an improvement with implementation (Ben-Zvi Assaraf & Orion, 2005; Raved & Yarden, 2014). Ben-Zvi Assaraf & Orion (2010a) revealed that almost all students acquired the ability to analyze the components of a system and processes within the system after the inquiry-based earth systems intervention. During the SDGs unit implementation including informative videos and classroom activities, students explored systems' components and processes from different perspectives (people (social)- prosperity (economic)- planet (environmental) as well as peace and partnership) by discussing all goals from different pillars. This contributed to the development of students' STS 1 levels.

Results about STS 2 (the ability to identify simple relationships among the system's components) showed that nearly half of students could not identify simple relationships among the system's components in terms of any pillar of sustainable development goals before SDGs unit implementation. After SDGs unit implementation, most of the students' STS 2 level developed and they could identify simple relationships among the system's components in terms of all pillars of the sustainable development goals (people, prosperity, planet, peace and partnership). This means that they could identify simple relationships among the system's components by considering people-prosperity relationships (poverty-economic conditions; good health and well-being-decent work and economic growth; gender equality-reducing inequalities), people-planet relationships (clean water and sanitation-life below water; pollution-good health; quality education-responsible consumption and production; quality education-climate action, aquatic life, and terrestrial life), prosperity-planet relationships (affordable and clean energy-environmental protection and climate action), prosperity-prosperity

relationships (industry, innovation and infrastructure- sustainable cities and communities), people-people relationships (hunger-poverty-health and quality life; quality education-gender equality), planet-planet relationships (climate action-life on land, life below water, air, water, soil pollutions- climate change- global warming-greenhouse gases-glacier retreat-extinction of animals-reduction of plants-increased carbon emissions.), prosperity-peace relationships (reduction of inequalities-peace, justice and strong institutions; decent work and economic growth-peace, justice and strong institutions), people and peace relationship (hunger-peace, justice and strong institutions), planet-peace relationships (responsible consumption and production-peace,justice and strong institutions), people-partnership relationships (quality education-partnership for goals), planet-partnership relationships (climate action-partnership for goals), prosperity-partnership relationships (sustainable cities and communities-partnership for goals) peace-partnership relationships (peace, justice and strong institutions-partnerships for goals).

Similar to this research, STS 2 (the ability to identify simple relationships among the system's components) has previously been examined in different contexts like the water cycle (Ben-Zvi Assaraf, 2005; Dutton-Lee, 2015; Lee et al., 2019); climate system (Shepardson et al. 2014); rock and carbon cycle (Cox et al., 2017; Lee, 2015; Sibley et al., 2007; Zangori et al., 2017); ecosystems (Eilam, 2012; Evagorou et al., 2009) and sustainable development (Karaarslan Semiz & Teksöz, 2020). Research supported that students' identifying simple relationships among the system's components can show an improvement with implementation (Ben-Zvi Assaraf & Orion, 2005; Raved & Yarden, 2014). Similar to the current research, Ben-Zvi Assaraf & Orion (2010a) showed that most of the students developed the ability to identify simple relationships among system components after the inquiry-based earth systems intervention. During the SDGs unit implementation and activities, students explored the relationships among systems' components from different perspectives (people (social)- prosperity (economic)- planet (environmental) as well as peace and partnership) by discussing the causes, effects and relationships of local and global challenges addressed by SDGs. This contributed to the development of students STS 2 levels.

The results of the current study included examination of participants' STS 3 (the ability to identify dynamic relationships within the system). This showed that half of the sample could not identify dynamic relationships within the system in terms of any pillar of sustainable development goals prior to application of the SDG unit intervention. After the application it was seen that most of the students' STS 3 level improved and they could identify dynamic relationships within the system in terms of pillars of sustainable development goals. This means that they could identify dynamic relationships within the system related to environmental, social, economic issues by considering human influences in the planet pillar (human-environmental pollution (air,water, soil), climate change, global warming), human influences on the people pillar (human-gender discrimination, human-overuse of water,), human influences on the prosperity pillar (human-using non-renewable energy sources, human-building unsustainable cities), human influences on the peace pillar (human-injustice), and human influences on the partnership pillar (human-colloboration for achieving goals).

Similar to this research, STS 3 (the ability to identify dynamic relationships within the system) was earlier examined in different contexts such in the context of the water cycle (Ben-Zvi Assaraf, 2005; 2010a; Dutton-Lee, 2015; Lee et al., 2019); climate system (Shepardson et al. 2014); rock and carbon cycle (Cox et al., 2017; Lee, 2015; Sibley et al., 2007; Zangori et al., 2017); ecosystems (Eilam, 2012; Evagorou et al., 2009) and sustainable development (Karaarslan Semiz & Teksöz, 2020). This body of research supported that students' identifying dynamic relationships within the system can show an improvement with implementation (Ben-Zvi Assaraf & Orion, 2005; Raved & Yarden, 2014). During the administration of the SDGs unit and its various activities, students explored the dynamic relationships to be found within a system from different perspectives (people (social)- prosperity (economic)- planet (environmental) as well as peace and partnership) by discussing that humans were part of a global system as evidenced by the effects of humans on local and global challenges addressed by the SDGs. Furthermore, the development of students' skills to identify dynamic relationships within the system could be practiced in the supporting activities of the intervention, including students identifying evidence of human impacts.

Analysis of the results obtained for STS 4 (the ability to organize a systems' components, processes, and their interactions, within a framework of relationships) showed that more than half of students could not organize the systems' components, processes, and their interactions, within a framework of relationships) in terms of any pillar of sustainable development goals before SDGs unit implementation. After the implementation, most of the students' STS 4 level developed and they could organize the systems' components, processes, and their interactions, within a framework of relationships in terms of people, prosperity, planet, peace and partnership of sustainable development goals. This means that they could organize the systems' components, processes, and their interactions, within a framework of relationships related to environmental, social, economic issues like environmental pollution, climate change, global warming, population growth and density, unconsciousness of people, high unemployment, child labour, child marriage, famine, decrease in agricultural lands, lack of clean water, hunger, poverty, diseases, epidemics, lack of health services, different kinds of inequalities (gender, race etc), not accessing to opportunities and quality education, income inequality, income inequality, not accessing affordable and clean energy, industrialization, unsustainable cities, underdeveloped infrastructure, flimsy buildings, buildings that are not resistant to disasters such as earthquakes, floods etc., overconsumption, wars between countries, turmoil within countries, civil wars, inequality, rights violation, injustice, and the need for collaboration in solving such challenges.

Similar to the current research, the ability to organize the systems' components, processes, and their interactions, within a framework of relationships has been previously examined in different contexts (Ben-Zvi Assaraf, 2005; 2010a; Raved & Yarden, 2014). Research published in the literature showed that while students could mostly identify the components and processes in a system, they had difficulty trying to relate them in a framework (Orion, 2002; Ben-Zvi Assaraf, 2003). In this context it has also been found that students' STS 4 levels can show progress with implementation of a suitable intervention (Ben-Zvi Assaraf & Orion, 2005; Raved & Yarden, 2014). During the current study the implementation of the SDGs unit intervention and its supporting activities, students explored the classification of local and global issues in the world from different perspectives. For example, they gained knowledge about the organization of the issues of people (social)- prosperity

(economic)- planet (environmental) as well as those addressing peace and partnership. Therefore, their ability to organize a systems' components, processes, and their interactions was developed.

The results obtained from the current research in terms of students' acquisition of STS 5 (the ability to identify the cyclic nature of a system) also showed that most of them were unable to make such identifications in terms of any pillar of the sustainable development goals before SDGs unit implementation. After SDGs unit implementation, most of the students' STS 5 level developed and they could identify the cyclic nature of system in terms of people, prosperity, planet, peace and partnership of sustainable development goals. This means that they could identify the cyclic nature of a system related to the environmental, social, economic issues like renewable nature of the earth, ecological cycle, water cycle, carbon cycle, food chain, cyclic of life on land and life below water, seasons. As can be seen from the results of this study, students have difficulty in finding cyclic interactions among the environmental, social or economic pillars of the SDGs (Hmelo- Silver et al., 2007, Shepardson et al., 2014). On the other hand, Ben-Zvi Assaraf and Orion (2005) showed that the context of earth system education could improve eighth-grade students' understanding of the cyclic nature of the system (STS 5). In the current research, the development of students' skills to identify the cyclic nature of a system could be explained through conducting the learn-think-act based SDG unit (including informative videos, learn-think-act based classroom activities). During the unit implementation and supporting activities, students explored the cyclic nature of Earth system and human roles from different perspectives (people (social)- prosperity (economic)- planet (environmental) as well as peace and partnership).

Results concerning STS 6 (the ability to recognize hidden dimensions of the system) likewise showed that most of the students could not recognize hidden dimensions of the system in terms of any pillar of the sustainable development goals before SDG unit implementation. After SDG unit implementation, most of the students' STS 6 level developed and they could recognize hidden dimensions of the system in terms of people, prosperity, planet, peace and partnership of sustainable development goals. This means that they could recognize hidden dimensions of the system related to environmental, social, economic issues like human population,

migration, urbanization, usage of chemicals and pesticides in agriculture, unconsciousness of people. Ben-Zvi Assaraf and Orion (2005) showed that understanding hidden structures require in depth inquiry on the Earth system that can be improved by implementation. In the ESDG context, recognizing hidden dimensions enables students to comprehend the interactions between variables and problems of daily life about environmental, social and economic phenomena like, climate change, population growth and poverty (Karaarslan, 2016). In the current research, the development of students' skills to recognize hidden dimensions of the system could be explained through implementing the learn-think-act based SDG unit (including informative videos, learn-think-act based classroom activities). During the unit implementation and activities with the classroom discussion, students explored hidden dimensions of the system from different perspectives (people (social)- prosperity (economic)- planet (environmental) as well as peace and partnership).

Results about STS 7 (the ability to make generalizations) showed that most of the students could not identify to make generalizations in terms of any pillar of sustainable development goals before SDG unit implementation. Afterwards however, most students' STS 7 level developed and they could make generalizations in terms of people, prosperity, planet, peace and partnership of sustainable development goals. This means that they could make generalizations related to environmental, social, economic issues like humans as part of nature, effects of humans' activities on all over the world, several pieces coming together and becoming a whole, interconnection of problems, partnership for solving problems all over the world. This finding supports the outcome of the Ben-Zvi Assaraf and Orion (2005) which showed that students' ability to make generalizations were limited before the implementation but the context of earth system education improved eighth-grade students' ability to make generalizations in terms of STS 7. In the current research, students learned and thought about the causes and effects of issues related to people, prosperity, planet, peace and partnerships to solve problems based on understanding systems' mechanisms. During the SDGS unit implementation and activities, students explored and made generalizations about different perspectives (people (social)- prosperity (economic)- planet (environmental) as well as peace and partnership. The

development of students' skills to make generalizations could be explained through conducting learn-think-act based classroom activities which enable students to identify that a problem in one part of the world affects other parts of the world, that is, several pieces coming together and becoming a whole, interconnection of problems.

The findings of the current study regarding STS 8 (thinking temporarily: retrospection and prediction) showed that most of the students did not think temporarily in terms of any pillar of the sustainable development goals before SDGs unit implementation. After SDGs unit implementation, most students were observed to have developed their STS 8 level and they could think temporarily in terms of people, prosperity, planet, peace and partnership of sustainable development goals. Moreover, they could more readily find and relate environmental, social, and economic issues such as the impact of past relationships on the present and the future, severe implications for future generations of the environmental, economic and social effects of environmental pollution, climate change and global warming, consequences of using non-renewable energy, the effects of overconsumption or overuse of resources, lack of water, different kinds of inequalities. As seen in the results of study, it is emphasized in the literature that thinking in time dimensions were difficult for students in identifying Earth systems since it requires considerable knowledge of socio-biogeochemical-processes (Mohan et al., 2009; Zangori et al., 2017). On the other hand, Ben-Zvi Assaraf and Orion (2005,2010a) show that in the context of earth system education it is possible for teachers to improve junior students' thinking temporarily in relation to issues pertaining to STS 8.

In the current research, the development of students' skills to thinking temporarily: through retrospection and prediction, was seen to be developed by undertaking the learn-think-act based SDG unit (including informative videos, learn-think-act based classroom activities). During the SDG unit implementation and its various activities, students explored thinking temporarily (retrospection and prediction) from different perspectives (people (social)- prosperity (economic)- planet (environmental) as well as peace and partnership). Specifically, students discussed the change of the world over time, and they learnt about past actions in the world and how these affected today's world and how our present actions will affect the

world's future if we cannot achieve the sustainable development goals. The SDG unit developed students' systems thinking skills by enabling a holistic understanding of past, present, and future states and dynamics as stated in the literature (Brundiers et al.,2021).

5.1.3 Students' Ethical Reasoning in Action

The third aim of this research was to investigate how ethical reasoning of students could be developed through learn-think-act based Sustainable Development Goals Unit. In line with this major aim, students' ethical reasoning levels were assessed before and after SDG unit implementation. The results indicated that although students' initial ethical reasoning (fairness, outcomes, responsibilities, character, liberty, empathy, authority, rights) were at low levels (insufficient or marginal level), most of the students developed their ethical reasoning to higher levels (excellent and extraordinary level) after the SDGs unit implementation. Studies in the literature are compatible with the results of the present research (Bielby et al., 2011; DeHaan et al., 1997; Eynon et al., 1996; McQuaide et al., 1999; Smith et al., 2002; Sugahara et al., 2010; Hallman, 2016; Ames et al., 2017; Smith, 2017; Hornor, 2021; Vesala-Varttala et al., 2021; Willey et al., 2012). All this research showed that those courses that engage students in discussions about ethical issues can improve their ethical reasoning abilities considerably.

In the current research, teaching SDGs through a learn-think-act approach-based SDG unit contributed to develop students' ethical reasoning in action. Sanchez et al. (2017) emphasized that designing class activities that raise ethical and global issues can be effective on developing students ethical reasoning skills. Education for Sustainable Development Goals cover various ethical issues and challenges relating to social, environmental, economic, as well as cultural/political dimensions (Grice & Franck, 2017). Therefore, similar to the results of this study, ESDG can have fruitful outcomes that serve to enhance students' ethical reasoning (Vesala-Varttala et al., 2021). ESDG has been reported to advance students reason ethically on many scales (i.e on issues concerning the environment, and economic and social conditions) rather than on one scale (i.e only the environment), (Schlottmann, 2008).

In the present research, students' ethical reasoning developed through real-world learning opportunities which were placed in informative videos and experiential and collaborative learning activities of the SDGs unit as suggested in literature (Brundiers et al., 2010; Grice & Franck, 2017; Griswold & Chowning, 2013; Hornor, 2021; Seager & Selinger, 2009). In the current research, the real-world learning activities included in the SDG unit enabled students to practice using their voice and ethical reasoning for decision-making in new knowledge-creating and knowledge-based action. ESDG includes values and citizenship education with the intention to contribute to students' ethical reasoning (Grice & Franck, 2017). Therefore, the SDGs unit developed by the researcher can be considered to have helped students think critically about ethical issues addressed by the SDGs and to have triggered them to apply an ethical reasoning process to take actions about local and global issues.

Results about the ERiA 1 (fairness) dimension of ethical reasoning showed that students could mostly identify fairness in terms of only one pillar of sustainable development goals before undertaking the SDGs unit. These pillars were people and planet mostly. This means that students associated fairness with issues such as equality between men and women, equal and fair distribution of resources, responsible consumption, avoiding polluting and protecting the environment. After SDG unit implementation, they could identify the fairness dimension of ethical reasoning in terms of all five pillars: people, planet, prosperity, peace and partnership. They could identify fairness in terms of like access to health services, access to clean water and energy, education, economical conditions, work opportunities, rights, justice, collaborative work as well as equal and fair distribution of resources to all people, responsible consumption, not polluting and protecting all living things including terrestrial and aquatic life.

Similar to the current study, research in the relevant literature showed that ERiA interventions (inquiry-based activities or cases) developed students 'ethical reasoning on the fairness dimension in their studies (Ames et al., 2017; Linder et al., 2019; Smith, 2017). In the above mentioned studies, students 'ethical reasoning skills about fairness developed through interventions including that students were exposed to activities or cases including ethical issues and practiced fairness by applying key question of ERiA to solve these issues. Similarly, in the current

research, the development of students' identifying the fairness dimension of ethical reasoning could be explained by their undertaking the learn-think-act based SDG unit. This intervention included informative videos and classroom activities which highlight fair and equal distribution of resources/needs to all people all over the world, access to good health services, accessing to quality education, achieving gender equality and reducing inequalities (income inequality, work conditions, job opportunities), the importance of peace, rights, justice, and strong institutions, etc.

The results related to the ERiA 2 (outcomes) dimension of ethical reasoning in the present study indicated that students could identify outcomes in terms of either the people or planet pillars of the sustainable development goals before they learned more about SDGs. This means that they defined outcomes like not polluting nature and protecting the environment, recycling, using resources sparingly. After SDGs unit implementation, they could identify an expanded outcomes dimension of ethical reasoning in terms of people, the planet, prosperity, peace and partnership pillars. They could readily identify outcomes like ending poverty, hunger, access to health services, quality education for all, clean water for all, renewable energy, economic growth and sound work conditions, higher levels of productivity and technological innovation, building sustainable cities and communities, protecting life on land and life below water, taking action against climate change.

Similar to the current study, research in the literature revealed that ERiA interventions (inquiry-based activities or cases) developed students' ethical reasoning about the outcomes dimension in their studies (Ames et al., 2017; Linder et al., 2019; Smith, 2017). In these studies, students' ethical reasoning skills about outcomes dimension developed through implementations including activities or cases including ethical issues and practices about outcomes by applying key question of ERİA to solve these issues. Similar to these findings, in the present research, the development of students' identifying various outcomes dimensions to ethical reasoning could be explained by their taking the learn-think-act based SDG unit developed by the researcher. This included informative videos and classroom activities that highlight taking actions for best outcomes about solving local and global issues addressed by the SDGs.

Results concerning the ERiA 3 (responsibilities) dimension of ethical reasoning showed that most of the students could identify responsibilities in terms of the

planet pillars of sustainable development goals before the SDGs unit implementation. This means that they previously associated their responsibilities with issues like protecting the world and nature, not polluting air, water, soil, planting trees, responsible consumption of resources, recycling. After completing the SDGs unit, they could identify responsibilities dimension to ethical reasoning in terms of all pillars: people, planet, prosperity, peace and partnership. They could identify their responsibilities in terms of using resources without generating waste, using natural and renewable resources, reducing water use and saving water, protecting terrestrial and aquatic life, consuming responsively, treating everyone equally and fairly, helping people in difficult economic conditions, obeying the rules and laws, contributing to achieving peace and justice.

Similar to the current study, research in the literature showed that ERiA interventions (inquiry-based activities or cases) developed students' ethical reasoning about their responsibilities as a dimension of their studies (Ames et al., 2017; Linder et al., 2019; Smith, 2017). Previous studies have shown that students' ethical reasoning skills about the responsibilities dimension can be developed through implementations including activities or case studies including ethical issues and practices about their responsibilities by applying the key question of ERİA: what we can do to help solve these issues. In the current research, the reason for the improvement of students' responsibilities was found to have been derived from development of their ethical reasoning skills. This advancement being inspired by 'Take action for each SDG' videos and activities about taking appropriate action as address in the act part of the SDG unit. Such videos and classroom activities may have triggered students to think about their own responsibilities to solve people, prosperity, planet, peace and partnership issues addressed by the SDGs.

Results concerning the ERiA 4 (character) dimension of ethical reasoning showed that students could identify character in terms of only the planet pillar, meaning that they defined their character as an environmentally conscious person who protects the environment. Following their completion of the SDG unit they could identify a character dimension of ethical reasoning in terms of people, planet, prosperity, peace and partnership. They could, for example now identify themselves as an environmentally friendly person, one who respects the environment, protects animals, makes an effort to reduce inequalities, and takes action to end poverty and

hunger. Students were found to believe that they could take actions for people and the planet but they thought they couldn't do much for prosperity.

Similar to the current study, research in literature showed that ERiA interventions (inquiry-based activities or cases) developed students' ethical reasoning about the character dimension in their studies (Ames et al., 2017; Linder et al., 2019; Smith, 2017). In such studies, students' ethical reasoning skills about the character dimension were developed through interventions including activities or cases including ethical issues and practices about character, and by applying key questions of ERİA to solve these issues. Similarly, in the current research, the development of students' identifying a character dimension to ethical reasoning could be explained by their taking the learn-think-act based SDG unit, which includes informative videos and classroom activities that trigger students to think about their actions and who they want to be towards our world.

Results about the ERiA 5 (liberty) dimension of ethical reasoning showed that most of students could not identify liberty in terms of the pillars of sustainable development goals before they learned more about SDGs. After attending the SDG unit, they could identify a liberty dimension to ethical reasoning in terms of the people, planet, prosperity, peace and partnership pillars. They could identify liberty with respecting people' ideas and thoughts, gender equality, peace, justice, and strong institutions, both girls and boys' access to quality education, equally and fairly distributed resources for all, respectful for the environment, nature and all living things.

Similar to the current study, research in literature shows that ERiA interventions (inquiry-based activities or cases) developed students' ethical reasoning about a liberty dimension to their ethical reasoning (Ames et al., 2017; Linder et al., 2019; Smith, 2017). In this body of previous research, how students' ethical reasoning skills in the liberty dimension were developed through interventions including activities or cases including ethical issues and practices about liberty by applying key questions of ERİA to solve these issues. In the current research, the development of students' identifying a liberty dimension to ethical reasoning could be explained through them having completed the learn-think-act based SDG unit devised by the researcher. This included informative videos and classroom

activities which enable students to think and respect people and other living things and making informed and independent decisions to sustain our world.

Results about ERiA 6 (empathy) dimension of ethical reasoning showed that students could identify empathy in terms of either people or the planet pillars of the sustainable development goals before SDG implementation. That is, they showed empathy with people facing issues to do with poverty, hunger, lack of water, harmful effects of environmental pollution on people and other living things. After SDG unit implementation, they could identify an empathy dimension of ethical reasoning in terms of people, planet, prosperity, peace and partnership. They could express empathy with issues like access to quality education for all, good health services and well-being, affordable and clean energy for everyone, sustainable cities and communities for everyone, sustainable industry, infrastructure and innovation, decent work opportunities, responsible consumption, peace and justice all over the world as well as poverty, hunger, lack of water, harmful effects of environmental pollution on people and other living things.

Similar to the current study, research in literature showed that ERiA interventions (inquiry-based activities or cases) developed students' ethical reasoning about empathy dimension in their studies (Ames et al., 2017; Linder et al., 2019; Smith, 2017). In these studies, students' ethical reasoning skills about the empathy dimension was developed through interventions including activities or cases including ethical issues and practices about empathy by applying the key question of ERİA to solve these issues. In the current research, the development of students' identifying an empathy dimension of ethical reasoning could be explained through them having undertaken the learn-think-act based SDG unit which included informative videos and classroom activities. These experiences enabled students to grasp the challenges faced by people and other living things and to build empathy with them.

In terms of the researcher' findings concerning the ERiA 7 (authority) dimension of ethical reasoning, the present research showed that students could identify authority in terms of the planet pillars of sustainable development goals before SDG unit implementation. This means that they associated authority with issues like expectations about not polluting the environment and protecting nature, saving resources, recycling. After students took the SDGs unit, they could identify an

authority dimension of ethical reasoning in terms of people, planet, prosperity, peace and partnership. They could identify authority with the issues like expectations of using renewable energy resources, using resources adequately, saving water, reducing inequalities, protecting all living things like terrestrial and aquatic life, not polluting the environment and protecting nature, taking precautions to limit climate change, being aware of their shared responsibilities to world, acting fairly and striving to live in peace.

Similar to the current study, research in the literature showed that ERiA interventions (inquiry-based activities or cases) developed students' ethical reasoning about the authority dimension in their studies (Ames et al., 2017; Linder et al., 2019; Smith, 2017). In these research studies, students' ethical reasoning skills about authority dimension was reported to have been developed through interventions including activities or cases including ethical issues and practices about authority by applying the key question of ERİA to solve these issues. In the current research, the development of students' identifying an authority dimension of ethical reasoning could be explained through them having undertaken the learn-think-act based SDG unit devised by the author, which included informative videos and classroom activities that enable students to think of their expectations of legal authorities (e.g. law, experts) in terms of them protecting our world and its resources

Results about (ERiA 8) rights dimension of ethical reasoning showed that nearly half of students could not identify rights in terms of any pillars of sustainable development goals before they learn about SDGs. After completing an appropriate unit, they could identify a rights dimension to their ethical reasoning in terms of people, the planet, prosperity, peace and partnership. This means that they associated the rights with the issues like equal and fair distribution of resources to all people, responsible consumption, education. In addition, they could identify rights to healthy nutrition, clean water, affordable energy, good health services, quality education, work in good conditions, living in sustainable cities in solid buildings on the solid ground, good salaries, equality, women' rights, living in a clean environment, living freely and in peace.

Similar to the current study, research in literature showed that ERiA interventions (inquiry-based activities or cases) developed students' ethical reasoning about a

rights dimension in their studies (Ames et al., 2017; Linder et al., 2019; Smith, 2017). As reported in these studies, students' ethical reasoning skills about a rights dimension developed through interventions including activities or cases including ethical issues and practices about rights by applying key question of ERİA to solve these issues. In the current research, the development of students' identifying a rights dimension of ethical reasoning could be explained through their completing the learn-think-act based SDG unit which included informative videos and classroom activities which enable students to consider rights in our world.

6
CONCLUSION

In this chapter, conclusion of the findings and recommendations are provided for researchers, science teachers, science teacher educators, curriculum developers and ESDG educators for further research.

6.1 Conclusion

The current study has several unique contributions to the current literature. The current research showed that students' systems thinking skills and ethical reasoning are at low levels and they can be developed with Education for Sustainable Development Goals (ESDG). In this study, the learn-think-act based Sustainable Development goals unit was developed for middle school students. The aim of this unit is to develop students' systems thinking skills and ethical reasoning as global citizens to achieve the sustainable development goals by 2030.

The learn-think-act based SDG unit developed students' eight hierarchic characteristics of system thinking skills (STS 1-8). At the onset of the SDGs unit implementation, most of the students' systems thinking skills were at low levels (insufficient or marginal). After SDGs unit implementation, their systems thinking skills enhanced to higher levels (excellent or extraordinary).

The SDG unit also improved' eight characteristics of students'ethical reasoning in action (ERiA 1-8). At the beginning of SDGs unit implementation, most of the students' ethical reasoning in action were at low levels. After SDGs unit implementation, their ethical reasoning in action developed and enhanced to higher levels.

In order to cope with today's complex/systemic problems of the world, all individuals should learn local and global issues addressed by SDGs and should be able to think the world as system by realizing that everything is interrelated in the world. Moreover, individuals should be able to reason ethically to take action to solve local and global issues as addressed by SDGs. The current research provided

the learn-think-act based SDGs unit for K-12 education for teachers and researchers who can educate students about sustainable development goals as well as develop students 'systems thinking skills and ethical reasoning in action. In addition, development and implementation of the learn-think-act based SDGs unit in middle school enabled students to take an important step towards becoming system thinkers that can assess a system from different aspects of sustainable development goals (considering people, prosperity, planet, peace and partnership). Furthermore, ESDG in the current study helped students reason ethically to take action to solve local and global issues as addressed by SDGs.

The results of the current research are promising to open a new window to educate middle school students about sustainable development goals by developing their systems thinking skills and ethical reasoning in action.

6.2 Recommendations for Future Research

The aim of the current research was to develop and implement Sustainable Development Goals unit that help improve middle school students' systems thinking skills and ethical reasoning. The findings of the study have been discussed and conclusions and implications for educational practices have been provided, and in this section, some recommendations for related further research studies are addressed. The first recommendations are related to the sampling. First, the current study could be replicated with different grade levels at pre-school, elementary, secondary, high school or university levels. Moreover, other studies could be conducted with pre-service or in-service teachers, who have key responsibilities about training students for achieving sustainable development goals and a sustainable and better future for all.

The second recommendation is that the current research conducted with qualitative instruments. Developing and using quantitative data collection tools as a measurement tool can be suggested for further research.

The third recommendation is that the research can be designed as experimental and comparative research methods and the effect of learn-think-act based SDG unit on systems thinking skills and ethical reasoning can be compared with different teaching methods of SDGs or various educational contexts.

In conclusion, in K-12 education, research about students' systems thinking skills and ethical reasoning in ESDG context is in a preliminary stage especially in Türkiye. Therefore, it is suggested to conduct more research to test results of the current study in different ESDG contexts for achieving a more sustainable future for all.

REFERENCES

Albareda-Tiana, S., Vidal-Raméntol, S., & Fernández-Morilla, M. (2018). Implementing the sustainable development goals at University level. *International Journal of Sustainability in Higher Education*. 19, 473–497.

Albers, H., De Winter, J., & Voeten, H. (2017). *Inspiration Guide: Integrating the SDGs into Your Multiannual Policy Plan*. Available online: https://www.local2030.org/library/707/SDGs-in-policy-plan.pdf

Alkhuzaee, F.S., Ali, M., Goh, K.W., Al-Worafi, Y.M., & Ming, L.C. (2022). Situational judgment using ethical reasoning in Saudi undergraduate pharmacy students. *BMC medical ethics*. 2022, Dec; 23(1):1-9.

Ames, A., Smith, K. L., Sanchez, E. R. H., Pyle, L., Ball, T., & Hawk, W. J. (2017). Impact and persistence of ethical reasoning education on student learning: Results from a module-based ethical reasoning education program. *International Journal of Ethics Education*, 2, 77–96.

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research. *Educational Researcher*, 41(1), 16–25. https://doi.org/10.3102/0013189X11428813

Andersson, P. (2019). Embodied experiences of 'decision-making' in the face of uncertain and complex sustainability issues. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching* (pp. 222–233). Routledge.

Armenia, S., Tsaples, G., Papathanasiou, J., Barnabé, F., & Nazir, S. (2022). Systems Thinking as A Key Competence for Sustainable Development and Digital Transformation. In ICERI2022 Proceedings, pp. 2006-2011.

Arnold, R. D. & Wade, J. P. (2015) A definition of systems thinking: A systems approach. *Procedia Computer Science*. 44, 669–678.

Arnold, R. D., & Wade, J. P. (2017). A complete set of systems thinking skills. *Insight,* 20(3), 9–17.

Ary, D., Jacobs, L. C., & Sorensen, C. (2010). *Introduction to research in education.* 8th edition. Wadsworth: Cengage Learning.

Ateskan, A., & Lane, J.F. (2017) Assessing teachers' systems thinking skills during a professional development program in Turkey. *Journal of Cleaner Production,* 172:4348–4356. https://doi.org/10.1016/j.jclepro.2017.05.094

Aubrecht, K. B., Bourgeois, M., Brush, E. J., MacKellar, J., & Wissinger, J. E. (2019). Integrating green chemistry in the curriculum: building student skills in systems thinking, safety, and sustainability. *Journal of Chemical Education.* 96, 2872–2880 (2019).

Avelar, A.B.A., da Silva-Oliveira, K.D., & da Silva Pereira, R. (2019). Education for advancing the implementation of the sustainable development goals: A systematic approach. *The International Journal of Management Educatation.* 17 (3), 100322. https://doi.org/10.1016/j. ijme.2019.100322

Azungah T. (2018). Qualitative research: Deductive and inductive approaches to data analysis. *Qualitative Research Journal,* 18(4), 383–400. https://doi.org/10.1108/QRJ-D-18-00035

Barakat, B., Bengtsson, S., Muttarak, R., Kebede, E.B., Cuaresma, J.C., KC, S., & Striessnig, E. (2016). *Education & the Sustainable Development Goals.* "Paper commissioned for the Global Education Monitoring Report 2016, Education for people and planet: Creating sustainable futures for all". Available online: https://unesdoc.unesco.org/ark:/48223/pf0000245580?posInSet=1&queryId=5123d849-17a3-4109-b814-a5d8d7db5427

Batzri, O., Ben-Zvi Assaraf, O., Cohen, C., & Orion, N. (2015). Understanding the earth systems: expressions of dynamic and cyclic thinking among university students. *Journal of Science Education and Technology*, 24(6), 761- 775.

Bell, P. L. (2004). On the theoretical breadth of design-based research in education. *Educational Psychologist,* 39(4), 243–253. https://doi.org/10.1207/s15326985ep3904_6

Bennett, S., Harper, B., & Hedberg, J. (2002). Designing real life cases to support authentic design activities. *Australian Journal of Educational Technology*, 18(1), 1–12.

Benninghaus, J. C., Mühling, A., Kremer, K., & Sprenger, S. (2019). The mystery method reconsidered—A tool for assessing systems thinking in education for sustainable development. *Education Sciences*, 9(4), 260. https://doi.org/10.3390/educsci9040260

Ben-Zvi Assaraf, O. (2003). The influence of learning earth systems studies on, the development of systems' thinking skills in junior high school students. [Unpublished doctoral dissertation], Weizmann Institute of Science, Rehovot, Israel.

Ben-Zvi Assaraf, O., & Orion, N. (2005). Development of system thinking skills in the context of earth systems education. *Journal of Research in Science Teaching,* 42, 518–560. DOI: 10.1002/tea.20061.

Ben-Zvi Assaraf, O., & Orion, N. (2010a). System Thinking Skills at the Elementary School Level. *Journal of Research in Science Teaching*, 47, 540−563.

Ben-Zvi Assaraf, O., & Orion, N. (2010b). Four Case Studies, Six Years Later: Developing System Thinking Skills in Junior High School and Sustaining Them over Time. *Journal of Research in Science Teaching*, 47, 1253−1280.

Ben-Zvi Assaraf, O., Dodick, J. & Tripto, J. (2013). High School Students' Understanding of the Human Body System. *Research in Science Education,* 43, 33–56. https://doi.org/10.1007/s11165-011-9245-2

Bezeljak, P., Scheuch, M., & Torkar, G. (2020). Understanding of sustainability and education for sustainable development among pre-service biology teachers. *Sustainability,* 12, 6892

Biedenweg, K., Monroe, M.C., & Oxarart, A. (2013). The importance of teaching ethics of sustainability, *International Journal of Sustainability in Higher Education*, Vol. 14 No. 1, pp. 6-14.

Bielby, R. M., Harding, T. S., Carpenter, D. D., Finelli, C. J., Sutkus, J. A., Burt, B. A., Ra, E., & Holsapple, M. (2011). *Impact of different curricular approaches to ethics education on ethical reasoning ability*. In American society for engineering education, 2011 vancouver international conference centre (pp. 22.799.1–22.799.10).

Bingham, A.J., & Witkowsky, P. (2022). Deductive and inductive approaches to qualitative data analysis. In *Analyzing and Interpreting Qualitative Data: After the Interview;* Vanover, C., Mihas, P., Saldaña, J., Eds.; SAGE Publications: Thousand Oaks, CA, USA, 2022.

Bitsch, V. (2005) Qualitative Research: A Grounded Theory Example and Evaluation Criteria. *Journal of Agribusiness*, 23, 75-91.

Blatti, J.L., Garcia, J., Cave, D., Monge, F., Cuccinello, A., Portillo, J., Juarez, B., Chan, E., & Schwebel, F. (2019). Systems thinking in science education and outreach toward a sustainable future. *Journal of Chemical Education*, 96, 2852–2862.

Block, T., Van Poeck, K., & Östman, L. (2019). Tackling wicked problems in teaching and learning. Sustainability issues as knowledge, ethical and political challenges. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching* (pp. 28–39). Routledge.

Boardman, J., & Sauser, B. (2008). *Systems thinking: Coping with 21st century problems*. The USA: CRC Press.

Booth Sweeney, L., & Sterman, J. D. (2000). Bathtub dynamics: Initial results of a systems thinking inventory. *System Dynamics Review*, 16(4), 249–286

Bowen, G.A. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal*, Vol. 9 No. 2, pp. 27-40. https://doi.org/10.3316/QRJ0902027

Bradley, E.H., Curry, L. A., & Devers, K.J. (2007). Qualitative data analysis for health services research: developing taxonomy, themes, and theory, *Health Services Research*, Vol. 42 No. 4, pp. 1758-1772.

Brandi, C. (2015). Safeguarding the earth system as a priority for sustainable development and global ethics: The need for an earth system SDG. *Journal of Global Ethics*. 2015, 11, 32–36.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology, *Qualitative Research in Psychology*, Vol. 3 No. 2, pp. 77-101.

Brien, O. G., Sparrow, K., Morales, J., & Clayborn, J. (2015). Re-orienting a science methods course to prepare sustainability literate K-6 pre-service teachers. A mixed methods investigation. In S. K. Stratton, R. Hagevik, A. Feldman, &M. Bloom (Eds.), Educating science teachers for sustainability (pp. 205–234). USA: Springer.

Brookhart, S. M. (2018). Appropriate criteria: Key to effective rubrics. Frontiers in Education, 3 (22), 1–12. https://doi.org/10.3389/feduc.2018.00022

Brookhart, S. M. (2013). How to Create and Use Rubrics for Formative Assessment and Grading. ASCD. Alexandria, Virginia, USA.

Brookhart, S. M., & Chen, F. (2015). The quality and effectiveness of descriptive rubrics. Educational Review, 67(3), 343–368. https://doi.org/10.1080/00131911.2014.929565

Brookhart, S. M., Guskey, T. R., Bowers, A. J., McMillan, J. H., Smith, J. K., Smith, L. F., Stevens, M. T., & Welsh, M. E. (2016). A century of grading research: Meaning and value in the most common educational measure. *Review of Educational Research,* 86(4), 803–848. https://doi.org/10.3102/0034654316672069

Brookhart, S. M., & Nitko, A. J. (2015). *Educational assessment of students (*7th ed.). Pearson.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, 2(2), 141–178. https://doi.org/10.1207/s15327809jls0202_2

Brundiers, K., Barth, M., Cebrián, G. et al. (2021). Key competencies in sustainability in higher education—toward an agreed-upon reference framework. *Sustainability Science,* 16, 13–29. https://doi.org/10.1007/s11625-020-00838-2

Brundiers, K., Wiek, A. and Redman, C.L. (2010). Real-world learning opportunities in sustainability: from classroom into the real world, *International Journal of Sustainability in Higher Education*, Vol. 11 No. 4, pp. 308-324. https://doi.org/10.1108/14676371011077540

Burnard, P., Gill, P., Stewart, K., Treasure, E. and Chadwick, B. (2008), Analysing and presenting qualitative data. *British Dental Journal,* Vol. 204 No. 8, pp. 429-432.

Byker, E. J. (2013). Critical cosmopolitanism: Engaging students in global citizenship competencies. *English in Texas Journal,* 43(2), 18–22.

Can, H. (2020). *Implementation of systems thinking skills module for the context of energy.* [Unpublished doctoral dissertation]. Middle East Technical University, Ankara, Turkey.

Capra, F., & Luisi, P. L. (2014). *The systems view of life: A unifying vision*. UK: Cambridge University Press.

Carlsen, H., Weitz, N. & Bennich, T. (2023). A decision-making tool for systems thinking in SDG implementation. In A. Breuer, D. Malerba, S., Srigiri & P. Balasubramanian (Eds.), *Governing the Interlinkages between the SDGs* (pp. 211-224). Routledge. DOI: 10.4324/9781003254683

Cavana, R.Y., & Forgie, V.E. (2018). Overview and Insights from 'Systems Education for a Sustainable Planet'. *Systems,* 6, 5. https://doi.org/10.3390/systems6010005.

Chankseliani, M., & McCowan, T. (2021). Higher education and the Sustainable Development Goals. *Higher Education,* 81, 1–8. https://doi.org/10.1007/s10734-020-00652-w

Chilisa, B., & Preece, J. (Eds.) (2005). *Research Methods for Adult Educators in Africa.* Pearson Education. South Africa: Cape Town, South Africa. ISBN 9789282011188

Chowning, J.T., Griswold, J.C., Kovarik, D.N., & Collins, L.J. (2012). Fostering critical thinking, reasoning, and argumentation skills through bioethics education. *PLOS ONE,* 7, e36791.

Claesson, A. N., & Svanström, M. (2015). *Developing systems thinking for sustainable development in engineering education.* The 7th International Conference on Engineering Education for Sustainable Development, Vancouver, Canada.

Clark, S., MacLachlan, M., Marshall, K., Morahan, N., Carroll, C., Hand, K., Boyle, N., & O'Sullivan, K. (2022). Including Digital Connection in the United Nations Sustainable Development Goals: A Systems Thinking Approach for Achieving the SDGs. *Sustainability* 2022, 14, 1883. https://doi.org/10.3390/su14031883

Cloud, J. P. (2005). Some Systems Thinking Concepts for Environmental Educators during the Decade of Education for Sustainable Development. *Applied Environmental Education and Communication*. 4, 225−228. https://doi.org/10.1080/15330150591004625

Collins, A. (1992). Toward a Design Science of Education. In: Scanlon, E., O'Shea, T. (eds) *New Directions in Educational Technology*. NATO ASI Series, vol 96. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-642-77750-9_2.

Connell, K. Y. H., Remington, S. M., & Armstrong, C. M. (2012). Assessing systems thinking skills in two undergraduate sustainability courses: a comparison of teaching strategies. *Journal of Sustainability Education*, 3(3).

Cottafava, D., Cavaglià, G. & Corazza, L. (2019). Education of sustainable development goals through students' active engagement: A transformative learning experience. *Sustainability Accounting, Management and Policy Journal*, 10, 521–544.

Cox, M., Elen, J., & Steegen, A. (2017). Systems thinking in geography: can high school students do it? *International Research in Geographical and Environmental Education*, 28(2), 1–16.

Dale, A. & Newman, L. (2005). Sustainable development, education and literacy. *International Journal of Sustainability in Higher Education*, 6(4), 351-362. doi: 10.1108/14676370510623847

de Haan, G. (2010). The development of ESD-related competencies in supportive institutional frameworks. *International Review of Education*, 56, 315–328. https://doi.org/10.1007/s11159-010-9157-9

DeHaan, R., Hanford, R., Kinlaw, K., Philler, D. & Snarey, J. (1997). Promoting ethical reasoning, affect, and behavior among high school students: An evaluation of three teaching strategies. *Journal of Moral Education*, 26, 5–20.

Demssie, Y. N., Biemans, H. J., Wesselink, R. & Mulder, M. (2023). Fostering students' systems thinking competence for sustainability by using multiple real-world learning approaches. *Environmental Education Research,* 29(2), 261-286. https://doi.org/10.1080/13504622.2022.2141692

Denzin, N. K., & Lincoln, Y. S. (2005). Introduction: The Discipline and Practice of Qualitative Research. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (3rd ed., pp. 1–32). Sage Publications Ltd.

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

Doganca Kucuk, Z., & Saysel, A.K. (2018). Developing Seventh Grade Students' Understanding of Complex Environmental Problems with Systems Tools and Representations: A Quasi-experimental Study. *Research in Science Education*, 48, 491–514. https://doi.org/10.1007/s11165-017-9620-8

Draper, F. (1993). A proposed sequence for developing systems thinking in a grades 4–12 curriculum. *System Dynamics Review,* 9(2), 207–214

Dutton-Lee, T. (2015). Science teachers'representational competence and systems thinking (Unpublished PhD dissertation). North Carolina State University, USA.

Eberbach, C., Hmelo-Silver, C. E., Jordan, R., Taylor, J., & Hunter, R. (2021). Multidimensional trajectories for understanding ecosystems. *Science Education*,105(3), 521–540. https://doi.org/10.1002/sce.2161

Eilam, B. (2012). System thinking and feeding relations: learning with a live ecosystem model. *Instructional Science: An International Journal of The Learning Sciences*, 40(2), 213-239.

Ekselsa, R. A., Purwianingsihb, W., Anggraenib, S., Ghofar, A., & Wicaksonoc, C. (2023). Developing system thinking skills through project-based learning loaded with education for sustainable development, *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 9(1), 62-73. DOI: https://doi.org/10.22219/jpbi.v9i1.24261

Eli, M., Scheie, E., Gabrielsen, A., Jordet, A., Misund, S., & Øyehaug, A.B. (2020). Interdisciplinary primary school curriculum units for sustainable development. *Environmental Education Research,* 26, 795–811

Elo S., Kääriäinen M., Kanste O., Pölkki T., Utriainen K., & Kyngäs H. (2014). *Qualitative content analysis: A focus on trustworthiness*. Sage Open, 4(1), 1–10.

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing,* 62(1): 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Elsawah, S., Ho, A.T.L., & Ryan, M.J. (2021). Teaching Systems Thinking in Higher Education. *INFORMS Transaction on Education.* 22, 66–102

English, L.D. (2006). Introducing young children to complex systems through modeling. In: P. Grootenboer, R. Zevenbergen, & M. Chinnappan (Eds.), *Identities, cultures, and learning spaces* (pp. 195–202). Adelaide: Mathematics Education Research Group of Australasia.

Evagorou, M., Korfiatis, K., Nicolaou, C., & Constantinou, C. (2009). An investigation of the potential of interactive simulations for developing system thinking skills in elementary school: a case study with fifthgraders and sixth-graders. *International Journal of Science Education,* 31(5), 655–674.

Eynon, G., Hill, N. T., Stevens, K. T., & Clarke, P. (1996). An international comparison of ethical reasoning abilities: Accounting students from Ireland and the United States. *Journal of Accounting Education*, 14(4), 477–492.

Feriver, S. (2022). Pre-Schoolers as Systems Thinkers: Testing the Water. *Environmental Education Research,* 28 (3): 430–456. doi:10.1080/13504622.2021.2002820.

Feriver, S., Olgan, R., Teksöz, G. & Barth, M. (2022). Impact of early childhood education settings on the systems thinking skills of preschool children through the lens of Brofenbrenner's theory. *Systems Research and Behavioral Science,* 39, 85–103.

Ferrer-Estévez, M. & Chalmeta, R. (2021). Integrating Sustainable Development Goals in educational institutions. *The International Journal of Management Education,*19, 100494.

Fisher, D. M., & Systems Thinking Association. (2023). Systems thinking activities used in K-12 for up to two decades. *Frontiers in Education,*8), https://doi.org/10.3389/feduc.2023.105973

Forrester, J.W. (2007). System dynamics—A personal view of the first fifty years. *System Dynamics Review,* 23, 345–358.

Freire, P. (1970). Pedagogy of the oppressed (M. Bergman Ramos, Trans.). New York, NY: Herder and Herder

Gadotti, M. (2010). Reorienting education practices towards sustainability. *Journal of Education for Sustainable Development,* 4, 203–211. https://doi.org/10.1177/097340821000400207

García-González, E., Jiménez-Fontana, R., & Azcárate, P. (2020). Education for Sustainability and the Sustainable Development Goals: Pre-Service Teachers' Perceptions and Knowledge. *Sustainability,* 12, 7741.

Gero, A. & Danino, O., (2016). High-School Course on Engineering Design: Enhancement of Students'Motivation and Development of Systems Thinking Skills. *International Journal of Engineering Education*, 32 (1): 100–110.

Giangrande, N., White, R.M., East, M., Jackson, R., Clarke, T., Saloff Coste, M., & Penha-Lopes, G. (2019). A Competency Framework to Assess and Activate Education for Sustainable Development: Addressing the UN Sustainable Development Goals 4.7 Challenge. *Sustainability*, 11, 2832. https://doi.org/10.3390/su11102832

Gilbert, L.A., Gross, D.S., & Kreutz, K.J. (2019). Developing Undergraduate Students' Systems Thinking Skills with an Integrate Module. *Journal of Geoscience Education,* 67, 34–49.

Gilissen, M. G.R., Knippels, M.-C. P. J. & van Joolingen, W. R. (2020). Bringing Systems Thinking into the Classroom. *International Journal of Science Education,* 42 (8), 1253-1280. https://doi.org/10.1080/09500693.2020.1755741

Goldie, J. (2000). Review of ethics curricula in undergraduate medical education. *Medical Education,* 34, 109–119.

Goldstone, R.L., & Wilensky, U. (2008). Promoting transfer complex systems principles. *Journal of the Learning Sciences*, 17, 465–516.

Graneheim, U.H., & Lundman, B. (2004) Qualitative Content Analysis in Nursing Research: Concepts, Procedures and Measures to Achieve Trustworthiness.

Nurse Education Today, 24, 105-112. http://dx.doi.org/10.1016/j.nedt.2003.10.001

Green, C., Molloy, O., & Duggan, J. (2021). An Empirical Study of the Impact of Systems Thinking and Simulation on Sustainability Education. *Sustainability*, 14, 394. https://doi.org/10.3390/su14010394

Gregory, A. & Miller, S. (2014). Using Systems Thinking to Educate for Sustainability in a Business School. *Systems*, 2, 313–327.

Grice, M., & Franck, O. (2017). Conceptions of Ethical Competence in Relation to Action Readiness in Education for Sustainable Development. *Reflective Practice,* 18 (2): 256–267. https://doi.org/10.1080/14623943.2016.1269001

Griswold, J. C., & Chowning, J. T. (2013). Strategies to support ethical reasoning in student argumentation. *Issues in Teacher Education, 22*(1), 63–75.

Guba, E.G. (1981). Criteria for assessing the trustworthiness of naturalistic inquiries. Educational Technology Research and Development, 29, 75–91 (1981). https://doi.org/10.1007/BF02766777

Guba, E.G., & Lincoln, Y.S. (1982). Epistemological and methodological bases of naturalistic inquiry. *Educational Communication & Technology Journal*, 30, 233–252 (1982). https://doi.org/10.1007/BF02765185

Guerra, J. B. S. O. A., Hofmann, M., Bianchet, R. T., Medeiros, P., Provin, A. P., & Iunskovski, R. (2021). Sustainable development goals and ethics: Building "the future we want." *Environment, Development and Sustainability*, 24, 1–22.

Gupta, J. & Vegelin, C. (2016). Sustainable development goals and inclusive development. *International environmental agreements: Politics, law and economics,* 2016, 16, 433–448.

Guthrie (2023). SDG Thinking: A hands-on learning activity for the SDGs. Available online: https://ic-sd.org/wp-content/uploads/2023/10/2023-submission_388.pdf

Hallman, S. K. (2016). *Development and assessment of student social/civic responsibility and ethical reasoning*. TLTC Paper No. 5. CRLT Occasional Paper No. 36.Center for Research on Learning and Teaching, University of Michigan.

Harris, J. M. (2000). *Basic principles of sustainable development.* https://ase.tufts.edu/gdae/publications/working_papers/Sustainable%2520Development.pdf. Accessed 15 December 2022.

Hart Research Associates (2013). *It takes more than a major: Employer priorities for college learning and student success*. Retrieved from http://www.aacu.org/sites/default/files/files/LEAP/2013_EmployerSurvey.pdf

Hickey, E. (2021). *Systems Thinking Teaching Strategies Using the UN Sustainable Development Goals to Help Best Prepare Students to be Future Ready.* School of Education and Leadership Student Capstone Projects. 749. https://digitalcommons.hamline.edu/hse_cp/749

Hjorth, P., & Bagheri, A. (2006). Navigating towards sustainable development: A system dynamics approach. *Futures*, 38(1), 74-92.

Hmelo, C.E., Holton, D.L., & Kolodner, J.L. (2000). Designing learning about complex systems. *The Journal of the learning Science*, 9, 247–298.

Hmelo-Silver, C. E., Marathe, S., & Liu, L. (2007). Fish swim, rocks sit, and lungs breathe: expert-novice understanding of complex systems. *The Journal of the Learning Sciences*, 16(3). 307-331.

Hoang, A.D., Pham, H.H., Nguyen, Y.C., Nguyen, L.K.N., Vuong, Q.H., Dam, M.Q., & Nguyen, T.T. (2020). Introducing a tool to gauge curriculum quality under sustainable development goal 4: The case of primary schools in Vietnam. *International Review of Education*, 66, 457–485.

Hofman, M. (2015). What is an education for sustainable development supposed to achieve–a question about what, how and why. *Journal of Education for Sustainable Development,* 9, 213–228.

Hofman-Bergholm, M. (2018). Could Education for Sustainable Development Benefit from a Systems Thinking Approach? *Systems*, 6, 43. https://doi.org/10.3390/systems6040043.

Hogan, K., & Weathers, K.C. (2003). Psychological and Ecological Perspectives on the Development of Systems Thinking. In: *Understanding Urban Ecosystems*. Springer, New York, NY. https://doi.org/10.1007/0-387-22615-X_15

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, 4, 390-405. doi:10.1007/s10021-001-0101-5

Holshouser, K.O. & Medina, A.L. (2021). For a better world for all: Teaching the sustainable development goals through trade books. *The Reading Teacher*, 74, 456–462.

Hopkins, C., & McKeown, R. (2002). Education for sustainable development: an international perspective. In D. Tilbury, R.B. Stevenson, J.Fien, & D. Schreuder (Eds.) *Education and sustainability: Responding to the global challenge* (pp. 13-24). Commission on Education and communication IUCN

Hopper, M., & Stave, K. A. (2008*). Assessing the effectiveness of systems thinking interventions in the classroom.* In The 26th International Conference of the System Dynamics Society (pp. 1–26). Athens, Greece

Hornor, T. (2021). Strengthening College Students' Confidence in Their Ethical Reasoning Ability, *Journal of Leadership Education,* 124-132. DOI: 10.12806/V20/I4/R9

Hrin, T. N., Milenkovic, D. D., Segedinac, M. D., & Horvat, S. (2017). Systems thinking in chemistry classroom: The influence of systemic synthesis questions on its development and assessment. *Thinking Skills and Creativity*,23, 175–187.https://doi.org/10.1016/j.tsc.2017.01.003

Hung, W. (2008). Enhancing Systems Thinking Skills with Modelling. British *Journal of Educational Technology.*,39(6), 1099−1120

Hurd, E., & Ormsby, A.A. (2020). Linking Sustainability Education with the Sustainable Development Goals in K-12 Schools. *Journal of Sustainability Education,* 2020, 24, 1–19

Jacobson, M., & Wilensky, U. (2006). Complex systems in education: Scientific and educational importance and implications for the learning sciences. *Journal of the Learning Sciences*, 15(1),11–34. https://doi.org/10.1207/s15327809jls1501_4.

Jacobson, S. K., McDuff, M. D., & Monroe, M. C. (2015). *Conservation education and outreach techniques*. Oxford: Oxford University Press.

James Madison University (2013). The Madison Collaborative: Ethical Reasoning in Action. Available online: https://www.jmu.edu/ethicalreasoning/docs/qep-proposal.pdf

James Madison University (2018). *Eight Key Questions Handbook.*Available online: https://www.jmu.edu/ethicalreasoning/docs/8kq-handbook-web.pdf

Jati, H.F., Darsono, S.N.A.C., Hermawan, D.T., Yudhi, W.A.S., & Rahman, F.F. (2019). Awareness and Knowledge Assessment of Sustainable Development Goals among University Students. *Jurnal Ekonomi & Studi Pembangunan*, 20, 163–175.

Jensen, E. (2008). A Fresh Look at Brain-Based Education. *Phi Delta Kappan*, 89, 409-417.http://dx.doi.org/10.1177/003172170808900605

Jin, H., Hokayem, H., Shin, H., & Qureshi, F. (2019). Secondary Students' Understanding of Ecosystems: a Learning Progression Approach. *International Journal of Science and Mathematics Education*, 17(2), 217–235.

Juuti, K., & Lavonen, J. (2006) Design-based research in science education: one step towards methodology. *Nordic studies in science education* 2(2):54–68.

Kali, Y., Orion, N., & Eylon, B. (2003). The effect of knowledge integration activities on students' perception of the earth's crust as a cyclic system. *Journal of Research in Science Teaching*, 40(6),545–565.https://doi.org/10.1002/tea.10096.

Karaarslan, G. (2016). Science teachers as esd educators: An outdoor esd model for developing systems thinking skills. [Unpublished doctoral dissertation]. Middle East Technical University, Ankara, Turkey.

Karaarslan Semiz, G. & Teksöz, G. (2020). Developing the systems thinking skills of pre-service science teachers through an outdoor ESD Course. *Journal of Adventure Education and Outdoor Learning*, 20(4), 337-356.

Karaarslan Semiz, G., Teksöz, G. (2023). Tracing System Thinking Skills in Science Curricula: A Case Study from Turkey. *International Journal of Science and Mathematics Education*, 22, 515–536, https://doi.org/10.1007/s10763-023-10383-w

Kasser, J., Hitchins, D., Frank, M., & Zhao, Y. Y. (2013). A framework for benchmarking competency assessment models. *Systems Engineering*, 16, 29–44.

Keitsch, M. (2018). Structuring Ethical Interpretations of the Sustainable Development Goals—Concepts, Implications and Progress. *Sustainability*, 10, 829. https://doi.org/10.3390/su10030829

Kenny, B., Lincoln, M. & Killian, F. (2015). Ethics Cases: Do they Elicit Different Levels of Ethical Reasoning? *Journal of Academic Ethics* 13, 259–275. https://doi.org/10.1007/s10805-015-9234-6

Khayesi, M. (2021). What is the ethical reflection of the sustainable development goals? *Sustainability and Climate Change*,2021, 14, 138–144.

Kioupi, V., & Voulvoulis, N. (2019). Education for Sustainable Development: A Systemic Framework for Connecting the SDGs to Educational Outcomes. *Sustainability*, 11, 6104. https://doi.org/10.3390/su11216104

Koch, T. (1994) Establishing rigour in qualitative research: The decision trail. *Journal of Advanced Nursing*, 19, 976-986. doi:10.1111/j.1365-2648.1994.tb01177.x

Koch T. (2006) Establishing rigour in qualitative research: the decision trail. *Journal of Advanced Nursing*, 53(1), 91-100

Kolarova, T., Hadjiali, I., & Denev, I. (2013). High school students' reasoning in making decisions about socio-ethical issues of genetic engineering: case of gene therapy. *Biotechnology & Biotechnological Equipment*, 27(2), 3737-3747.

Kopnina, H. (2018). Teaching Sustainable Development Goals in The Netherlands: A critical approach. *Environmental Education Research.* 2018, 24, 1268–1283

Kopnina, H. (2020a). Education for the future? Critical evaluation of education for sustainable development goals, *The Journal of Environmental Education*, DOI: 10.1080/00958964.2019.1710444.

Kopnina, H. (2020b). Education for Sustainable Development Goals (ESDG): What Is Wrong with ESDGs, and What Can We Do Better? *Education Sciences*, 10, 261.

Kordova, S., M. Frank, and A. Nissel Miller. (2018). Systems Thinking Education—Seeing the Forest through the Trees. *Systems* 6 (3): 29. doi:10.3390/systems6030029.

Krefting, L. (1991). Rigor in Qualitative Research: The Assessment of Trustworthiness. *American Journal of Occupational Therapy*, 45, 214-222. https://doi.org/10.5014/ajot.45.3.214

Krippendorf, K. (2018). *Content Analysis: An Introduction to Its Methodology*, 4th ed.; Sage Publications: Los Angeles, CA, USA.

Krishna, S.H., Ilankumaran, G., Balakrishnan, C., Aute, K. & Patil, S.R. (2022). Knowledge, perception, and awareness about Sustainable Development Goals (SDGs). Among students of Indian public university. *Journal of Positive School Psychology*, 6, 2501–2511

Kwee, C.T.T. (2021). I Want to Teach Sustainable Development in My English Classroom: A Case Study of Incorporating Sustainable Development Goals in English Teaching. *Sustainability*, 13, 4195.

Kyngäs, H. & Kaakinen, P. (2020). Deductive Content Analysis. In: Kyngäs, H., Mikkonen, K., Kääriäinen, M. (eds) *The Application of Content Analysis in Nursing Science Research.* Springer, Cham. https://doi.org/10.1007/978-3-030-30199-6_3

Kyngäs, H., Kääriäinen, M., & Elo, S. (2020). The trustworthiness of content analysis. In H. Kyngäs, K. Mikkonen, & M. Kääriäinen (Eds.), *The application of content analysis in nursing science research* (pp. 41–48). Springer.

Lampe, J. R. (1994). *Teacher education students' moral development and ethical reasoning processes,* paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, LA, April, 4-8.

Lau, C. L. L. (2010). A step forward: Ethics education matters! *Journal of Business Ethics*, 92(4), 565–584.

Leal Filho, W., Frankenberger, F., Salvia, A.L., Azeiteiro, U., Alves, F., Castro, P., Will, M., Platje, J., Lovren, V.O., Brandli, L. et al. (2021). A framework for the implementation of the Sustainable Development Goals in university programmes. *Journal of Cleaner Production.* 299, 126915.

Leal Filho, W., Salvia, A.L. & Eustachio, J.H.P.P. (2022). An overview of the engagement of higher education institutions in the implementation of the UN sustainable development goals. *Journal of Cleaner Production.* 386, 135694

Leal Filho, W., Salvia, A.L., Pretorius, R.W., Brandli, L.L., Manolas, E., Alves, F., Azeiteiro, U., Rogers, J., Shiel, C. & Do Paco, A. (2020). *Universities as Living Labs for Sustainable Development: Suporting the Implementation of the Sustainable Development Goals*. Springer: Cham, Switzerland, ISBN 9783030156039.

Lee, H., Kwon, Y., Oh, H.-J., & Lee, H.-D. (2011). Development and Application of the Educational Program to Increase High School Students' Systems Thinking Skills- Focus on Global Warming. *Journal of the Korean Earth Science Society*, 32(7), 784-797. https://doi.org/10.5467/JKESS.2011.32.7.784

Lee, S.K. (2008). Possibilities and Challenges of Education for Sustainable Development in Korean Schools. *International Textbook Research*, 30, 608–620.

Lee, T. D. (2015). Science teachers' representational competence and systems thinking (Doctoral Dissertation). North Carolina State University, USA.

Lee, T. D., Jones, M. G., & Chesnutt, K. (2019). Teaching systems thinking in the context of the water cycle. *Research in Science Education*, 49(1), 137–172.

Leite, S. (2022). Using the SDGs for global citizenship education: Definitions, challenges, and opportunities. *Globalisation Societies and Education*. 20, 401–413.

Leiva-Brondo, M.; Ramos, A.; Nebauer, S.G.; Noguera, C.L. (2021*). A Comparative Study on the Sustainable Development Goals Knowledge by Primary School and University Students.* In Proceedings of the 14th Annual International Conference of Education, Research and Innovation, ICERI2021 Proceedings, Paper Presentation, Online, 8–9 November 2021; pp. 4329–4335.

Lewis, E. J., Ludwig, P. M., Nagel, J., & Ames, A. (2019). Student ethical reasoning confidence pre/post an innovative makerspace course: A survey of ethical reasoning. *Nurse Education Today*,75, 75–79.

Li, D. (2004). Trustworthiness of think-aloud protocols in the study of translation processes. *International Journal of Applied Linguistics,* 14(3), 301-313. doi: 10.1111/j.1473-4192.2004.00067.x

Lincoln, Y.S., & Guba, E.G. (1985) Naturalistic Inquiry. SAGE, Thousand Oaks, 289-331.http://dx.doi.org/10.1016/0147-1767(85)90062-8

Linder, G.F., Ames, A.J., Hawk, W.J., Pyle, L.K., Fulcher, K.H. & Early, C.E. (2019). Teaching ethical reasoning: program design and initial outcomes of ethical reasoning in action. *Teaching Ethics,* 19 (2), 147–170.

Liu, L., & Hmelo-Silver, C.E. (2009). Promoting complex systems learning through the use of conceptual representations in hypermedia. *Journal of Research in Science Teaching*, 46, 1023–1040. doi.10.1002/tea.20297

Lotz-Sisitka, H., A. E. Wals, D. Kronlid, and D. McGarry. (2015). Transformative, Transgressive Social Learning: Rethinking Higher Education Pedagogy in Times of Systemic Global Dysfunction. *Current Opinion in Environmental Sustainability*,16: 73–80. doi:10.1016/j.cosust.2015.07.018.

Lönngren, J. & Svanström, M. (2016). Systems Thinking for Dealing with Wicked Sustainability Problems: Beyond Functionalist Approaches. *In New Developments in Engineering Education for Sustainable Development*; Leal Filho, W., Nesbit, S., Eds.; Springer International Publishing: Berlin/Heidelberg, Germany, 2016; pp. 151–160.

Mambrey, S., Schreiber, N., & Schmiemann, P. (2022). Young students' reasoning about ecosystems: The role of systems thinking, knowledge, conceptions, and representation. *Research in Science Education*, 1–20. https://doi.org/10.1007/s11165-020-09917-x

Mambrey, S., Timm, J., Landskron, J. J., & Schmiemann, P. (2020). The impact of system specifics on systems thinking. *Journal of Research in Science Teaching*, 57(10), 1632–1651. https://doi.org/10.1002/tea.21649

Manitoba Council for International Cooperation (MCIC) (2018). *A Guide for Teaching the Sustainable Development Goals.* Retrieved from http://mcic.ca/pdf/SDG_Primer_FINAL.pdf.

Manolis, E.N. & Manoli, E.N. (2020). Raising awareness of the Sustainable Development Goals through Ecological Projects in Higher Education. *Journal of Cleaner Production*, 279, 123614.

Martin, S. (2008). Sustainable development, systems thinking and professional practice. *Journal of Education for Sustainable Development*, 2(1), 31- 40. https://doi.org/10.1177/097340820800200

McKenney, S., & Reeves, T.C. (2014). Educational Design Research. In: Spector, J., Merrill, M., Elen, J., Bishop, M. (eds) *Handbook of Research on Educational Communications and Technology*. Springer, New York, NY. https://doi.org/10.1007/978-1-4614-3185-5_11

Mckeown, R. (2002). *Education for Sustainable Development Toolkit; Waste Management Research and Education Institution*, University of Tennessee: Knoxville, TN, USA, 2002; Available online: https://unesdoc.unesco.org/ark:/48223/pf0000152453 (accessed on 7 January 2023).

McKibben, W. B., Cade, R., Purgason, L. L., & Wahesh, E. (2020). How to conduct a deductive content analysis in counseling research. *Counseling Outcome Research and Evaluation*, 1–13. DOI: 10.1080/21501378.2020.1846992.

McQuaide, J., Leinhardt, G. & Stainton, C. (1999). Ethical reasoning: Real and simulated. *Journal of Education Computer Research*, 21(4), 433–474

Meadows, D. (2008). *Thinking in Systems: A Primer*. Chelsea Green Publishing: New York, NY, USA.

Mehren, R., Rempfler, A., Buchholz, J., Hartig, J., & Ulrich-Riedhammer, E. M. (2018). System competence modeling: theoretical foundation and empirical validation of a model involving natural, social, and human environment systems. *Journal of Research in Science Teaching*, 55(5), 685–711.

Menzel, D. C. (2009). Teaching and learning ethical reasoning with cases. *Public Integrity*,11(3), 239–250.

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

Merriam, S. B. & Tisdell, E. J. (2015). *Qualitative research: A guide to design and implementation*. Wiley.

Meyer, K. (2023). Moral education through the fostering of reasoning skills. *Ethical Theory and Moral Practice.* Online first, https://doi.org/10.1007/s10677-023-10367-3

Mezirow, J. (2000). *Learning as transformation: Critical perspectives on a theory in progress*. San Francisco: Jossey-Bass.

Michalopoulou, E., Shallcross, D., Atkins, E., Tierney, A., Norman, N. C., Preist, C., O'Doherty, S., Saunders, R., Birkett, A., Willmore, C., and Ninos, I. (2019). The End of Simple Problems: Repositioning Chemistry in Higher Education and Society Using a Systems Thinking Approach and the United Nations' Sustainable Development Goals as a Framework. *Journal of Chemical Education*, 96 (12): 2825–2835. https://dialnet.unirioja.es/servlet/articulo?codigo=7162111

Miles, M, B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. (2nd ed). Thousand Oaks, CA: Sage.

Miles, M.B., Huberman, A.M. & Saldana, J. (2014) *Qualitative Data Analysis: A Methods Sourcebook*. Sage, London.

Mohan, L., Chen, J., & Anderson, C. (2009). Developing a multi-year learning learning progression for carbon cycling in socio-ecological systems. *Journal of Research in Science Teaching*, 46(6), 675–698.

Molderez, I. & Ceulemans, K. (2018). The power of art to foster systems thinking, one of the key competencies of education for sustainable development. *Journal of Cleaner Production*, 186, 758– 770. https://doi.org/10.1016/j.jclepro.2018.03.120

Moretti, F., van Vliet, L., Bensing, J., Deledda, G., Mazzi, M., Rimondini, M., Zimmermann, C. & Fletcher, I. (2011). A standardized approach to qualitative content analysis of focus group discussions from different countries. *Patient education and counseling*, 82(3), 420-428.

Munkebye, E., Scheie, E., Gabrielsen, A., Jordet, A., Misund, S., Nergård, A., Bergljot, A.B. (2020). Interdisciplinary primary school curriculum units for sustainable development. *Environmental Education Research,* 26(6):795–811.

National Research Council (2012). *A framework for K-12 science education: practices, crosscutting concepts, and core ideas*. Washington, DC: The National Academies Press.

Nazar, R., Chaudhry, I.S., Sajid, A., & Faheem, M. (2018) Role of quality education for sustainable development goals (SDGS). *PEOPLE: International Journal of Social Sciences*, 4(2):486–501.

Neuendorf, K.A. (2018). Content analysis and thematic analysis. In Advanced Research Methods for Applied Psychology: Design, Analysis and Reporting; Brough, P., Ed.; Routledge: London, UK.

Next Generation Science Standards (NGSS). (2013). Next generation science standards: For states, by states. Washington, D.C.: The National Academic Press. Available online: https://www.nextgenscience.org/

Nguyen, N. C., & Bosch, O. J. H. (2013). A systems thinking approach to identify leverage points for sustainability: A case study in the Cat Ba Biosphere Reserve, Vietnam. *Systems Research and Behavioral Science,* 30(2), 104–115. https://doi.org/10.1002/sres.2145

Nguyen, N. C., Graham, D., Ross, H., Maani, K., & Bosch, O. J. H. (2012). Educating systems thinking for sustainability: Experience with a developing country. *Systems Research and Behavioral Science*, 29(1), 14-29.

Novieastari, E., Pujasari, H., Abdul Rahman, L., Ganefianty, A. & Rerung, M. (2022). Knowledge, Perception and Awareness about Sustainable Development Goals (SDGs) among Students of a Public University in Indonesia. *International Journal of Health Promotion and Education,* 60, 195–203.

Odell, V., Molthan-Hill, P., Martin, S., Sterling, S. (2020). Transformative Education to Address All Sustainable Development Goals. In: Leal Filho, W., Azul, A.M., Brandli, L., Özuyar, P.G., Wall, T. (eds) *Quality Education. Encyclopedia of the UN Sustainable Development Goals.* Springer, Cham. https://doi.org/10.1007/978-3-319-95870-5_106

Omisore, A.G., Babarinde, G.M., Bakare, D.P. & Asekun-Olarinmoye, E.O. (2017). Awareness and knowledge of the sustainable development goals in a University Community in Southwestern Nigeria. *Ethiopian Journal of Health Sciences*. 2017, 27, 669.

Onwuegbuzie, A. J., & Leech, N. L. (2007). Sampling Designs in Qualitative Research: Making the Sampling Process More Public. *The Qualitative Report,* 12(2), 238-254. https://doi.org/10.46743/2160-3715/2007.1636.

Orion, N. (2002). An Earth Systems Curriculum Development Model. In: Mayer, V.J. (eds) *Global Science Literacy.* Science & Technology Education Library, vol 15. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-5818-9_11

Orion, N., & Basis, T. (2008). *Characterization of High School Students' System Thinking Skills in the Context of Earth Systems*. Presented in the 2008 NARST Annual Meeting. March, 2008. Baltimore, U.S.A.

Owens, T.L. (2017). Higher education in the sustainable development goals framework. *European Journal of Education,* 52, 414–420.

OXFAM (2019). *The Sustainable Development Goals: A Guide for Teachers;* Oxfam GB: Oxford, UK, 2019; Available online: https://oxfamilibrary.openrepository.com/bitstream/handle/10546/620842/edu-sustainable-development-guide-15072019-en.pdf?sequence=4&isAllowed=y (accessed on 25 November 2022).

Öhman, J., & Östman, L. (2019a). Different teaching traditions in environmental and sustainability education. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching* (pp. 70–82). Routledge.

Öhman, J., & Östman, L. (2019b). The ethical tendency typology: ethical and moral situations in environmental and sustainability education. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching* (pp. 83–92). Routledge.

Östman, L., Van Poeck, K., & Öhman, J. (2019). Principles for sustainable development teaching. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching* (pp. 40–56). Routledge.

Öztaş, M. (2018). Assessing pre-service science teachers' systems thinking skills using real life scenario. [Unpublished master's thesis]. Middle East Technical University, Ankara, Turkey.

Palmberg, I., Hofman-Bergholm, M., Jeronen, E. & Yli-Panula, E. (2017). Systems Thinking for Understanding Sustainability? Nordic Student Teachers' Views on the Relationship between Species Identification, Biodiversity and Sustainable Development. *Education Sciences,* 7, 72. https://doi.org/10.3390/educsci7030072

Pandey, J. (2019). Deductive approach to content analysis, in Gupta, M., Shaheen, M. and Reddy, K.P. (Eds), *Qualitative Techniques for Workplace Data Analysis,* IGI Global, PA, 145-169

Parkin, S., Johnson, A., Buckland, H., & White, E. (2004). Learning and skills for sustainable development: Developing a sustainability literate society. *Higher Education Partnership for Sustainability (HEPS)*, London.

Patton. M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Paul, R. & Elder, L. (2006). *The thinker's guide to understanding the foundations of ethical reasoning: Based on critical thinking concepts & tools. Santa Barbara: Foundation for Critical Thinking*. 2nd Edition. Available online: https://home.miracosta.edu/rfrench/documents/ethical_reasoningdc.pdf

Phillmore, J., & Goodson, L. (2004). *Qualitative Research in Tourism: Ontologies, Epistemologies and Methodologies.* London: Routledge.

Polit, D. & Beck, C. (2012). Data Collection in Quantitative Research. In: Polit, D. and Beck, C., Eds. *Nursing Research, Generating and Assessing Evidence for Nursing Practice,* 9th Edition, Wolters Kluwer Health/Lippincott Williams & Wilkins, Philadelphia, 293-327.

Prabawani, B., Hadi, S.P., Zen, I.S., Hapsari, N.R., & Ainuddin, I. (2022). Systems Thinking and Leadership of Teachers in Education for Sustainable

Development: A Scale Development. *Sustainability*, 14, 3151. https://doi.org/10.3390/su1406315

Putman, M. & Byker, E.J. (2020). Global Citizenship 1-2-3: Learn, Think, and Act. *Kappa Delta Pi Record*. 2020, 56, 16–21.

Rachmatullah, A. & Wiebe, E. N. (2022). Building a computational modelof food webs: Impacts on middle school students' computational andsystems thinking skills. *Journal of Research in Science Teaching,* 59(4), 585–618. https://doi.org/10.1002/tea.21738

Raved, L. & Yarden, A. (2014). Developing 7th grade students' systems thinking skills in the context of the human circulatory system. *Frontiers in Public Health*. doi:10.3389/fpubh.2014.00260

Reimann, P. (2011). Design-based research. In L. Markauskaite, et al. (Eds.), *Methodological choice and design: Scholarship, policy and practice in social and educational research* (pp. 37–50). New York: Springer.

Remington-Doucette, S. M., Hiller Connell, K. Y., Armstrong, C. M., & Musgrove, S. L. (2013). Assessing sustainability education in a transdisciplinary undergraduate course focused on real-world problem solving: a case for disciplinary grounding. *International Journal of Sustainability in Higher Education,* 14(4), 404-433

Reynolds, M., Blackmore, C., Ison, R., Shah, R. & Wedlock, E. (2018). The Role of Systems Thinking in the Practice of Implementing Sustainable Development Goals. In: Leal Filho, W. (eds) *Handbook of Sustainability Science and Research. World Sustainability Series*. Springer, Cham. https://doi.org/10.1007/978-3-319-63007-6_42.

Ribeiro, T., & Orion, N. (2021). Educating for a holistic view of the Earth system: A review. *Geosciences*, 11(12), 485. https://doi.org/10.3390/geosciences11120485

Richmond, B. (2010). The thinking in systems thinking: eight critical skills. *The Systems Thinker*, 21(3), 2-9. https://thesystemsthinker.com/%EF%BB%BFthe-thinking-in-systems-thinking-eight-critical-skills/

Rickinson, M., Lundholm, C., Hopwood, N. (2009). *Environmental learning: insights from research into the student experience.* Springer Netherlands. https://doi.org/10.1007/978-90-481-2956-0

Rieckmann, M. (2017). Education for Sustainable Development Goals: Learning Objectives; UNESCO Publishing: Paris, France, 2017; Available online: https://unesdoc.unesco.org/ark:/48223/pf0000247444 (accessed on 15 January 2021).

Rieckmann, M (2012). Future-oriented higher education: Which key competencies should be fostered through university teaching and learning? *Futures*, 44, 127–135.

Rieckmann M. (2018). Learning to transform the world: Key competencies in education for sustainable development. In Leicht A., Heiss J., Byun W. J. (Eds.), *Issues and trends in education for sustainable development* (pp. 39–60). UNESCO Publishing.

Riess, W. & Mischo, C. (2010). Promoting systems thinking through biology lessons. *International Journal of Science Education,* 32(6), 705–725.

Rimmel, G., & Cordazzo, M. (2021). Deductive versus inductive content analysis: A methodological research note to disclosures studies in intellectual capital research. In J. Dumay, C. Nielsen, M. Lund, M. Massaro, & J. Guthrie (Eds.), *Research handbook on intellectual capital and business* (pp. 109–124). Edward Elgar Publishing.

Ritchie, T. A. (2017). Developing and Measuring Systems Thinking Skills in Students and Teachers. (Unpublished doctoral dissertation). University of Florida.

Roychoudhury, A., Shepardson, D. P., & Hirsch, A. S. (2017). Systems thinking and teaching in the context of climate system and climate change. In D. P. Shepardson, A. Roychoudhury, & A. S. Hirsch (Eds.), *Teaching and learning about climate change: A framework for educators* (pp. 29–42). Taylor & Francis.

Rudsberg, K. & Öhman, J. (2019). Classroom discussions: students' learning in argumentation about ethical and political aspects of sustainability issues. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching* (pp. 175–184). Routledge

Sadler, T.D. (2004). Informal reasoning regarding socioscientific issues: A critical review of research. *Journal of Research in Science Teaching*, 41: 513–536

Sanchez, E. R. H., Fulcher, K. H., Smith, K. L., Ames, A. J. & Hawk, W. J. (2017). Defining, Teaching, and Assessing Ethical Reasoning in Action. *Change: The Magazine of Higher Learning*, 49 (2):30–6. March-April). https://doi.org/10.1080/00091383.2017.1286215

Sandri, O.J. (2013). Threshold concepts, systems and learning for sustainability. *Environmental Education Research*, 19(6), 810-822.

Sanneh, E.S. (2018). *Systems thinking for sustainable development*, Cham: Springer International Publishing.

Schlottmann, C. (2008). Educational ethics and the DESD: considering trade-offs. *Theory and Research in Education*, 6(2), 207-219.

Schram, A. B. (2014). A Mixed Methods Content Analysis of the Research Literature in Science Education. *International Journal of Science Education*, 36 (15): 2619–2638. http://dx.doi.org/10.1080/09500693.2014.908328

Schuler, S., Fanta, D., Rosenkraenzer, F., & Riess, W. (2018). Systems thinking within the scope of education for sustainable development (ESD)- a heuristic competence model as a basis for (science) teacher education. *Journal of Geography in Higher Education,*42(2), 192–204.

Schwandt, T. A., Lincoln, Y. S., & Guba, E. G. (2007). But Is It Rigorous? Trustworthiness and Authenticity in Naturalistic Evaluation. *New Directions for Evaluation*, 11-25. https://doi.org/10.1002/ev.223

Seager, T. P., & Selinger., E. (2009). *Experiential teaching strategies for developing ethical reasoning skills relevant to sustainability*. Proceedings of the 2009 IEEE International Symposium on Sustainable Systems and

Technology. Phoenix AZ, 18–22 May 2009. Available online at https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=5156721

Sheehy, N. P., Wylie, J. W., McGuinness, C., & Orchard, G. (2000). How children solve environmental problems: Using computer simulations to investigate systems thinking. *Environmental Education Research,* 6, 109–126. https://doi.org/10.1080/713664675

Shenton, A. K. (2004). Strategies for Ensuring Trustworthiness in Qualitative Research Projects. *Education for Information*, 22, 63-75. https://doi.org/10.3233/EFI-2004-22201

Shepardson, D. P., Roychoudhury, A., Hirsch, A., Niyogi, D., & Top, S. M. (2014). When the atmosphere warms it rains and ice melts: Seventh grade students'conceptions of a climate system. *Environmental Education Research*, 20, 333–353

Shidiq, A. S., & Permanasari, A. (2020*). Review on education for sustainable development: system thinking for sustainable chemistry education curriculum.* In Journal of Physics: Conference Series (Vol. 1521, No. 4, p. 042080). IOP Publishing.

Sibley, D., Anderson, C., Heidemann, M., Merrill, J., Parker, J., & Szymanski, D. (2007). Box Diagrams to Assess Students' Systems Thinking about the Rock, Water and Carbon Cycles. *Journal of Geoscience Education*, 55(2), 138– 146.

Singh, J. A. (2015). The sustainable development goals: the role of ethics. *Sight and life*, Vol 29, No. 2, pp. 58 – 63.

Slavich, G. M. & Zimbardo, P.G. (2012). Transformational Teaching: Theoretical Underpinnings, Basic Principles, and Core Methods. *Educational Psychology Review*, 24, 569–608. https://doi.org/10.1007/s10648-012-9199-6

Sleurs, W. (2008). *Competences for ESD (Education for Sustainable Development) teachers. A framework to integrate ESD inthe curriculum of teacher training institutes*. Belgium: Commenius 2.1 Project. Available online: https://unece.org/fileadmin/DAM/env/esd/inf.meeting.docs/EGonInd/8mtg/CSCT%20Handbook_Extract.pdf

Smaniotto, C., Battistella, C., Brunelli, L., Ruscio, E., Agodi, A., Auxilia, F., Baccolini, V., Gelatti, U., Odone, A., Prato, R., Tardivo, S., Voglino, G., Valent, F., Brusaferro, S., Balzarini, F., Barchitta, M., Carli, A., Castelli, F., Coppola, C., Iannelli, G., Milazzo, M., Rosina, B., Salerno, C., Siliquini, R. & Sisi, S. (2020). Sustainable development goals and 2030 agenda: awareness, knowledge and attitudes in nine Italian universities, *International Journal of Environmental Research and Public Health*, Vol. 17 No. 23, p. 8968.

Smith, C.A., Strand, S.E., and Bunting, C.J. (2002). The influence of challenge course participation on moral and ethical reasoning. *Journal of Experiential Education*, 25 2 278-280.

Smith, K. (2017). *Integrating Implementation Fidelity and Learning Improvement to Enhance Students' Ethical Reasoning Abilities.* [Unpublished doctoral dissertation]. James Madison University, Harrisonburg, Virgina, USA.

Smith, K., Fulcher, K., & Sanchez, E. H. (2017). Ethical reasoning in action: validity evidence for the ethical reasoning identification test (erit). *Journal of Business Ethics*, 144(2), 417–436. https://doi.org/10.1007/s10551-015-2841-8

Smith, T. (2011) Using critical systems thinking to foster an integrated approach to sustainability: a proposal for development practitioners. *Environment, Development and Sustainability*, 13:1–17.

Soderquist, C., & Overakker, S. (2010). Education for sustainable development: A systems thinking approach. *Global Environmental Research,* 14, 193–202.)

Sommer, C., & Lucken, M. (2010). System competence—Are elementary students able to deal with a biological system? *Nordic Studies in Science Education*, 6(2), 125–143.

Stave, K., & Hopper, M. (2007). *What constitutes systems thinking? A proposed taxonomy*. In Proceedings of the 25th International Conference of the System Dynamics Society. Available online: https://pdfs.semanticscholar.org/506d/f8001a8b9190a6f9b22abf7c1495e96de72d.pdf

Stephens, A., Lewis, E. D., & Reddy, S. M. (2018). *Inclusive systemic evaluation (ISE4GEMs): A new approach for the SDG era*. New York: UN Women.

Sterling, S. (2016). A commentary on Education and Sustainable Development goals. *Journal of Education for Sustainable Development*, 10(2):208–213

Sterling, S. (2003). *Whole systems thinking as a basis for paradigm change in education: Explorations in the context for sustainability* (Unpublished doctoral dissertation). University of Bath, UK.

Sterling, S., Maiteny, P., Irving, D., & Salter, J. (2005). *Linking thinking: New perspectives on thinking and learning for sustainability.* Scotland: WWF.

Sternberg, R. J. (2012a). Teaching for ethical reasoning. *International Journal of Educational Psychology*,1(1), 35–50

Sternberg, R. J. (2012b). A model for ethical reasoning. *Review of General Psychology*, 16(4),319–326.https://doi.org/10.1037/a0027854

Sternberg, R. J. (2015). Epilogue: Why is ethical behavior challenging? A model of ethical reasoning. In R. J. Sternberg & S. T. Fiske (Eds.), *Ethical challenges in the behavioral and brain sciences* (pp. 219–226). New York, NY: Cambridge University Press.

Sugahara, S., Urasaki, N., Wei, M., & Boland, G. (2010). The effect of students' ethics learning experiences to develop ethical reasoning abilities: A comparative study between Japanese and Chinese students. *International Journal of Accounting, Auditing and Performance Evaluation*, 6(1), 54–79. https://doi.org/ 10.1504/IJAAPE.2010.030479

Summers, M. & Kruger, C. (2003). Teaching sustainable development in primary schools: Theory into practice. *The Curriculum Journal,* 14, 157–180.

Sund, L., & Pashby, K. (2019). Taking up ethical global issues in the classroom. In K. Van Poeck, L. Östman, & J. Öhman (Eds.), *Sustainable development teaching* (pp. 204–212). Routledge.

Sweeney, B., & Sterman, J. D. (2007). Thinking about systems: student and teacher conceptions of natural and social systems. *System Dynamics Review*, 23(2/3), 285-311. doi:10.1002/sdr.366

Teddlie, C., & Yu, F. (2007) Mixed Methods Sampling: A Typology with Examples. *Journal of Mixed Methods Research*, 1, 77-100.https://doi.org/10.1177/2345678906292430

Tejeda, J. & Ferreira, S. (2014). Applying systems thinking to analyze wind energy sustainability. *Procedia Computer Science*, 28, 213–220.

Thomas, D.R. (2006), A general inductive approach for analysing qualitative evaluation data, *American Journal of Evaluation*, Vol. 27 No. 2, pp. 237-246. https://doi.org/10.1177/1098214005283748

Tilbury, D. (2011). *Education for sustainable development: expert review of process and learning.* Paris: UNESCO.

Timm, J. M. & Barth, M. (2021). Making education for sustainable development happen in elementary schools: The role of teachers. *Environmental Education Reserach*, 2021, 27, 50–66

Tinsley, H. E., & Brown, S. D. (2000). Multivariate statistics and mathematical modelling. In H. E. Tinsley & S.D. Brown (Eds.) *Handbook of applied multivariate statistics and mathematical modeling (*pp. 8-34). San Diego, CA: Academic Press

Torjman, S. (2000). *The Social Dimension of Sustainable Development;* Caledon Institute of Social Policy: Toronto, Canada, ISBN 1-894598-00-8.

Torkar, G., McCloat, A., O'Donoghue, M., Thoresen, V.W., Didham, R.J. & de Raaf Kalseth, S.I. (2019). *Playing for the Future. Sustainable Development Games.* Available online: https://www.inn.no/english/ccl/teaching-materials-and-resources/active-learning-methodology-series/toolkit-11-playing-for-the-future-+-supporting-materials.pdf

Tripto, J., Ben-Zvi Assaraf, O., & Amit, M. (2013). Mapping what they know: Concept maps as an effective tool for assessing students' systems thinking. *American Journal of Operations Research*, 3(1a), 1–15.

Tripto, J., Ben-Zvi Assaraf, O., & Amit, M. (2018). Recurring patterns in the development of high school biology students' system thinking over time. *Instructional Science*, 46(5), 639–680

Tripto, J., Ben-Zvi Assaraf, O., Snapir, Z., Amit, M. (2016). The 'what is a system' reflection interview as a knowledge integration activity for high school students' understanding of complex systems in human biology. *International Journal of Science Education*, 38(4), 564-595. http://dx.doi.org/10.1080/09500693.2016.1150620

UNECE. (2011). *Learning for the future. Competences in education for sustainable development.* Available online: https://unece.org/fileadmin/DAM/env/esd/ESD_Publications/Competences_Publication.pdf

UNESCO (2012). *Education for Sustainable Development: Sourcebook* United Nations Educational, Scientific and Cultural Organization: Paris, France. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000216383

UNESCO (2013). *Education for Sustainable Development.* United Nations Educational, Scientific and Cultural Organization: Paris, France. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000222120?posInSet=1&queryId=2491da34-add3-4a54-90f9-b84ed7d579b0

UNESCO (2014a). *Shaping the Future We Want. UN Decade of Education for Sustainable Development (2005-2014) Final Report.* United Nations Educational, Scientific and Cultural Organization: Paris, France. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000230171?posInSet=9&queryId=7b821a69-af94-4b57-a88d-a911e70cc573

UNESCO. (2014b). *Education for All Global Monitoring Report. Teaching and Learning*: Achieving Quality for All, UNESCO Publishing: Paris.

UNESCO. (2015). *Education for All Global Monitoring Report. Teaching and Learning: Achieving Quality for All*, UNESCO Publishing: Paris

UNESCO (2020). *Education for Sustainable Development: A Roadmap*; United Nations Educational, Scientific and Cultural Organization: Paris, France. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000374802

United Nations (UN) (2015). Transforming Our World: The 2030 Agenda for Sustainable Development. Resolution Adopted by the General Assembly on 25 September 2015. Available online: https://www.un.org/sustainabledevelopment/ (accessed on 10 September 2021).

Vachliotis T., Salta K. & Tzougraki C. (2021). Developing basic systems thinking skills for deeper understanding of chemistry concepts in high school students, *Thinking Skills and Creativity*, 41, 100881, DOI: 10.1016/j.tsc.2021.100881.

Vasconcelos, C., & Orion, N. (2021). Earth science education as a key component of education for sustainability. *Sustainability*, 13, 1316. https://doi.org/10.3390/su13031316

Venkataraman, B. (2009). Education for Sustainable Development. *Environment: Science and Policy for Sustainable Development*, 51, 8–12.

Vesala-Varttala, T., Humala, I., Isacsson, A., Salonen, A. & Nyberg, C. (2021). Fostering Sustainability Competencies and Ethical Thinking in Higher Education: Case Sustainable Chocolate. *eSignals Research*. Available online: https://urn.fi/URN:NBN:fi-fe202201051276

Vladimirova, K., & Le Blanc, D. (2016). Exploring links between education and sustainable development goals through the lens of UN flagship reports. *Sustainable Development*. 24, 254–271

Voulvoulis, N., Giakoumis, T., Hunt, C., Kioupi, V., Petrou, N., Souliotis, I., Vaghela, C., & Rosely, W. (2022). Systems thinking as a paradigm shift for sustainability transformation. *Global Environmental Change*, 75 (August 2021), 102544. https://doi.org/10.1016/j.gloenvcha.2022.102544

Wallendorf, M. and Belk, R.W. (1989) Assessing Trustworthiness in Naturalistic Consumer Research. In: Hirschman, E.C., Ed., *Interpretive Consumer Research,* Association of Consumer Research, Provo, 69-84.

Wamsler, C. (2018). Mind the gap: the role of mindfulness in adapting to increasing risk and climate change. *Sustainability Science,* 13:1121–1135. https://doi.org/10.1007/s11625-017-0524-3

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development*, 53(4), 5–23. doi:10.1007/bf02504682.

Weber, J.M., Lindenmeyer, C.P., Liò, P. and Lapkin, A.A. (2021). Teaching sustainability as complex systems approach: a sustainable development goals workshop, *International Journal of Sustainability in Higher Education,* Vol. 22 No. 8, pp. 25-41, doi: 10.1108/IJSHE-06- 2020-0209.

Wells, S. & McLean, J. (2013). One Way Forward to Beat the Newtonian Habit with a Complexity Perspective on Organisational Change. *Systems*, 1, 66-84. https://doi.org/10.3390/systems1040066

Wheeler, K. (2023). Educating children as sustainable citizen-consumers: A qualitative content analysis of sustainability education resources. *Journal of Moral EducatİOn*, https://doi.org/10.1080/03057240.2022.2159344

Whittemore, R., Chase, S.K., & Mandle, C.L. (2001). Validity in qualitative research. *Qualitative Health Research.* 2001;11(4):522-537.

Wiek, A., Withycombe, L. & Redman, C.L. (2011a). Key competencies in sustainability: A reference framework for academic program development. *Sustainability Science.* 2011, 6, 203–218.

Wiek, A., Withycombe, L., Redman, C., & Mills, S.B. (2011b). Moving forward on competence in sustainability research and problem solving. *Environment: Science and Policy for Sustainable Development*, 53(2):3–12. https://doi.org/10.1080/00139157.2011.554496

Wiggins, G. & McTighe, J. (2005). *Understanding by Design*, 2nd ed.; Association for Supervision and Curriculum Development ASCD: Alexandria, VA, USA.

Willey, S. L., Mansfield, N. R., & Sherman, M. B. (2012). Integrating ethics across the curriculum: A pilot study to assess students' ethical reasoning. *Journal of Legal Studies Education,* 29(2), 263–296.

World Bank (2015). *Global Monitoring Report: Ending Poverty and Sharing Prosperity*, World Bank–International Monetary Fund: Washington, DC

World Commission on Environment and Development (WCED). (1987). Our common future, 1987. Retrieved from http://www.un-documents.net/ocf-02.htm#I.

World's Largest Lesson. Available online: http://worldslargestlesson.globalgoals.org (accessed on 15 March 2023).

Yoon, S. A. (2008). An evolutionary approach to harnessing complex systems thinking in the science and technology classroom. *International Journal of Science Education*, 30(1), 1-32. https://doi.org/10.1080/09500690601101672

Zamora-Polo, F., Sánchez-Martín, J., Corrales-Serrano, M. & Espejo-Antúnez, L. (2019). What Do University Students Know about Sustainable Development Goals? A Realistic Approach to the Reception of this UN Program Amongst the Youth Population. *Sustainability*, 11, 3533.

Zangori, L., Peel, A., Kinslow, A., Friedrichsen, P., & Sadler, T. (2017). Student development of model-based reasoning about carbon cycling and climate 174 change in a socio-scientific issues unit. *Journal of Research in Science Teaching*, 54(10), 1249–1273

Zeidler, D.L., Sadler, T.D., Simmons, M.L., & Howes, E.V. (2005) Beyond STS: A research-based framework for socioscientific issues education. *Science Education*. pp. 357–377. https://doi.org/10.1002/sce.20048

Zhang, B. H. & Ahmed, S. A. M. (2020). Systems thinking—Ludwig Von Bertalanffy, Peter Senge, and Donella Meadows. In B. Akpan & T. Kennedy (Eds.), *Science education in theory and practice* (pp. 419–436). Springer. https://doi.org/10.1007/978-3-030-43620-9_28

Zoller, U. (2015). Research-based transformative science/STEM/STES/STESEP education for "sustainability thinking": From teaching to "know" to learning to "think". *Sustainability*, 7(4),4474-4491.https://doi.org/10.3390/su7044474502U.

Zulauf, C. A. (2007). Learning to think systemically: what does it take? *The Learning Organization*, 14(6), 489-498. doi:10.1108/09696470710825105

A
SDG UNIT LESSON PLANS

SUSTAINABLE DEVELOPMENT AND SUSTAINABLE DEVELOPMENT GOALS LESSON PLAN 	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	People, Planet, Prosperity, Peace, Partnership
Subject	Sustainable Development and Sustainable Development Goals
Time	2 lesson hours (80 min)
Learning Objectives	**Cognitive Learning Objective** Students explain the concept of sustainable development and what 17 SDGs are.
	Socio-Emotional Learning Objective Students discuss their own role and responsibilities of achieving sustainable development and 17 goals.
	Behavioural Learning Objective Students propose local and global suggestions for achieving sustainable development and sustainable development goals.

<table>
<tr><td colspan="2">Teaching Approach</td><td>Learn-Think-Act Approach</td></tr>
<tr><td rowspan="2">Teaching Procedure</td><td>Learn</td><td>The teacher starts the lesson by showing the students 2 videos about sustainable development and sustainable development goals.

Video: What is sustainable development? https://www.youtube.com/watch?v=7V8oFI4GYMY&t=138s accessed on 20 January 2023
Video: Sustainable Development Goals: What are SDGs? https://www.youtube.com/watch?v=7dzFbP2AgFo accessed on 2 February 2023
Then, teacher gives information about the concept of sustainable development and sustainable development goals.</td></tr>
<tr><td>Think</td><td>Classroom activity: Let’s meet sustainable development and Sustainable Development Goals!

Go Goals! Board Game (https://go-goals.org/)
Teacher divides the students into 4 groups including 5 students. Students places their token on the start field of game board. They take turns to roll the dice and move their tokens forward the number of spaces as shown on the dice. There are three playing rules as follows:
If a student lands on a Sustainable Development Goals (1-17), they can draw a card corresponding to the number of SDG. Another student read the card question. A correct answer from the card drawer allows the student to roll the dice once again
If a student lands at the bottom of a ladder, they can immediately climb to the top.</td></tr>
</table>

		• If a student lands at the top of a waterslide, they immediately move to the bottom of the slide. The first student to arrive on the field ’2030’ is the winner! If students throw the necessary number, they should step forward into field ‘2030’ and then move backwards the excess number of spaces.
	Act	Teacher gives activity sheets to all students. The activity sheet includes the questions ‘What are the biggest problems faced by people around the world today? What can you do for the world we want to live in?’ Students answer these questions and all students discuss their opinions with each other.
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions ‘What is the sustainable development? Please explain.’ ‘What are the Sustainable Development Goals? How many goals are there, and what are they? Please explain.’

SDG 1: NO POVERTY LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	People
Subject	SDG 1- No Poverty
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive Learning Objective** Students explain the concept of poverty, distributions of poverty, causes and impacts of poverty.
	Socio-Emotional Learning Objective Students discuss their own role and responsibilities for no poverty.
	Behavioural Learning Objective Students propose local and global solutions for no poverty.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 1. Videos: Understand SDG 1: No Poverty https://www.youtube.com/watch?v=A2O1HU6FMfk accessed on 20 January 2023 https://www.youtube.com/watch?v=T7qiM0quEf4&t=2s accessed on 2 February 2023 Then, teacher gives information about the concept of poverty, local, national and global distributions of poverty, causes and impacts of poverty and SDG 1.
	Think	Teacher distributes 1 page comic about SDG 1: No poverty (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about poverty. **Classroom activity:** The world's resources are not fairly or equally distributed! Teacher divides the students into 4 groups including 5 students and she gives each group a map and jellybeans (or beans, seeds, buttons). Using the map, the teacher wants students to put a number of jellybeans on countries by pointing out the richest countries (e.g. 10 jellybeans for Canada, United States, European countries), countries with middle economies (5 jellybeans for Turkey, Egypt, India etc.) and the most economically disadvantaged countries (e.g. 1 jelybean for Ethiopia, Haiti, Rwanda, Malawi, etc.) (World's Largest Lesson, http://worldslargestlesson.globalgoals.org) Teacher asks questions to make students think and discuss about poverty. -What are the causes and effects of poverty? -Why does poverty matter?

		-Who and what are affected by poverty? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 1 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 1 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do to end poverty?' Students answer this question and all students discuss their solutions and suggestions for no poverty with each other. What can be done for for local, national and international poverty reduction? The teacher shows the students 2 videos about taking action for SDG 1. Videos: Take Action on SDG 1: No Poverty https://www.youtube.com/watch?v=VbYXMxeRoAc accessed on 20 January 2023 https://www.youtube.com/watch?v=T66qWMHg83c accessed on 20 January 2023
Assesment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "No poverty" is stated? Please explain.'

SDG 2: ZERO HUNGER LESSON PLAN 	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	People
Subject	SDG 2- Zero hunger
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concept of hunger, distributions of hunger, causes and impacts of hunger.
	Socio-emotional learning objective Students discuss critically on their own role and responsibilities for zero hunger.
	Behavioural learning objective Students propose local and global solutions for zero hunger.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 2. Videos: Understand SDG 2: Zero Hunger https://www.youtube.com/watch?v=JjE76M0a054 accessed on 20 January 2023 https://www.youtube.com/watch?v=ifCQ4LqT8G8 accessed on 2 February 2023 Teacher gives information about hunger, malnutrition, and their main physical and psychological effects on human life, the amount and distribution of hunger and malnutrition, the causes and effects of hunger and sustainable agriculture
	Think	Teacher distributes 1 page comic about SDG 2: Zero hunger (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about hunger. **Classroom activity:** What's on our plate? Every plate tells people' story (World's Largest Lesson, http://worldslargestlesson.globalgoals.org (accessed on 15 March 2023). Teacher divides the students into 4 groups including 5 students and she gives the poster 'What's On My Plate' and activity sheet of 'Every Plate Tells a Story' activity sheet and worksheet instructions of 'My Plate Pledge' Teacher shows the "Every Plate Tells a Story" activity sheet to the students. Then, teacher want students to choose any meal (e.g. recent meal, favorite meal, regular meal) and search a selected meal and discover its story until it reaches the plate. Students illustrate or photograph

		a representative meal and then use their chosen meal to complete the questions in activity sheets. Students can use resources like books, maps, websites during answering questions. When all students have completed the activity, teacher distribute the "My Plate Pledge" poster to evaluate the meals based on their answers on the activity sheet and the identified global goals. Teacher asks questions to make students think and discuss about hunger. -What are the causes and effects of hunger? -Who and what are affected by hunger? -Why does hunger matter? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 2 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 2 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets includes the question 'What can you do for zero hunger?' Students answer this question and all students discuss their solutions and suggestions for zero hunger with each other. The teacher shows the students 2 videos about taking action for SDG 2.

		Videos: Take Action on SDG 2: Zero Hunger https://www.youtube.com/watch?v=LuovkHAGios accessed on 20 January 2023 https://www.youtube.com/watch?v=1iUIKgcMDV4 accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Zero hunger" is stated? Please explain.'

SDG 3: GOOD HEALTH AND WELL-BEING LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	People
Subject	SDG 3-Good health and well-being
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concepts of good health, hygiene and well-being and importance of good health and well-being.
	Socio-emotional learning objective Students discuss their own role and responsibilities for good health and well-being for all.
	Behavioural learning objectives Students propose suggestions for promoting good health and well-being.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 3. Videos: Understand SDG 3: Good Health and Well-Being https://www.youtube.com/watch?v=9qiVBF_7wvY accessed on 20 January 2023 https://www.youtube.com/watch?v=ArmBCl4nid0 accessed on 2 February 2023 Teacher explains concepts of health, hygiene and well-being, facts about diseases and importance of good health and well-being.
	Think	Teacher distributes 1 page comic about SDG 3: Good health and well-being (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about good health and well-being. **Classroom activity:** A healthy and prosperous life for everyone! Teacher gives each student a sticky note and want them to write sentences showing a characteristic of good health and well-being on their sticky note and place it on the board. When all sticky notes have been added on the board, teacher read them aloud. Students discuss with qualities and characteristics of good health and well-being and the importance of SDG 3. Teacher asks questions to make students think and discuss about good health and well-being. -Why does good health and well being matter? -What are the causes and effects of good health and well-being?

		Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 3 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 3 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets includes the question 'What can you do for good health and well-being?' Students answer this question and all students discuss their solutions and suggestions for good health and well-being with each other. The teacher shows the students 2 videos about taking action for SDG 3. Video: Take Action on SDG 3: Good Health and Well-Being https://www.youtube.com/watch?v=moLWJ1zzMPI accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Good health and well-being" is stated? Please explain.'

SDG 4: QUALITY EDUCATION LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	People
Subject	SDG 4-Quality Education
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain quality education and the important role of quality education and lifelong learning opportunities for all.
	Socio-emotional learning objective Students communicate their own role and responsibilities for quality education
	Behavioural learning objective Students propose suggestions for quality education for all.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 4. Videos: Understand SDG 4: Quality Education https://www.youtube.com/watch?v=4HXyJmY--gM accessed on 20 January 2023 https://www.youtube.com/watch?v=LIExX9St4oA accessed on 2 February 2023 Teacher explains concept of quality education and the important role of quality education and lifelong learning opportunities for all.
	Think	Teacher distributes 1 page comic about SDG 4: Quality Education (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about quality education. **Classroom activity:** Quality education can change and transform our world! Teacher explains to students before the activity that they investigate a problem and need to think like a journalist. They need to use 5 Ws and 1 H question throughout the lesson (who, what, why, where, when and how). Then, teacher gives the text: A group of children from different parts of the world all sit together at summer camp and discuss their stories about school. Their conservation like that: Boy from India: 'I can't go to school because I have to go to work, otherwise my family can't afford to basic needs like eating, housing etc. I so wish I could go to school, see my friends, and learn new things."

		Girl from Nigeria: 'I can't go to school because I'm a girl. People think I should be married and having babies, not at school learning. They think it's a waste of time. I want to be a doctor, but I won't ever have the chance.' Girl from UK: 'You have to work but you're only 8? And get married? I go to school everyday and learn many things, and I want to be a doctor too. Can I do something for you? Boy from Middle East: I and my siblings cannot go to school because there is a war and horrible conflict in my hometown. Bombs and rockets shattered our school. I want to learn how to become a mechanical engineer and need teachers to do their best to help me. I dream that when the war ends, I and my siblings will be able to go to school and play freely like other children (World's Largest Lesson, http://worldslargestlesson.globalgoals.org.) • What would it be like to be this child? • How different is their life to your life? • Write three questions that you would like to ask this child about their life. Teacher asks questions to make students think and discuss about the quality education -Why does quality education matter? -Who and what are affected by quality education? -What is being done for quality education? - What are the causes and effects of quality education? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 4 with

		with other SDGs they think are related. e.g. what impact does the lack of quality education have on responsible consumption and production, healthcare, freedom of movement? In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 4 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for quality education?' Students answer this question and all students discuss their solutions and suggestions for quality education with each other. The teacher shows the students 2 videos about taking action for SDG 4. Videos: Take Action on SDG 4: Quality Education https://www.youtube.com/watch?v=mVvaGmdvdwo accessed on 20 January 2023 https://www.youtube.com/watch?v=AIMS9sNISOs accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Quality education" is stated? Please explain.'

SDG 5: GENDER EQUALITY LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	People
Subject	SDG 5-Gender equality
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concepts of gender, gender equality and gender discrimination, basic rights of women and girls and the importance.
	Socio-emotional learning objective Students discuss their own role and responsibilities for gender equality.
	Behavioural learning objective Students propose solutions for gender equality.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 5. Videos: Understand SDG 5: Gender Equality https://www.youtube.com/ watch?v=vz7IUDOYvXk accessed on 20 January 2023 https://www.youtube.com/ watch?v=F-OURmsmEKo accessed on 2 February 2023 Teacher explains concepts of gender, gender equality and gender discrimination, basic rights of women and girls and the importance.
	Think	Teacher distributes 1 page comic about SDG 5: Gender Equality (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about gender equality. **Classroom activity:** Everybody wins if gender equality exists all around the world! Teacher divides the students into 4 groups including 5 students and she gives marker and the large sheets of paper that students divide into three sections. They want students to either write “Act Like a Man” or “Act Like a Woman” on the top of the middle column and make a list of what it means to act like a man or woman in this column. Each group will have a different heading. On the left column, teacher want students to write down what people might "say" or "do" if someone does not act like a man or woman as defined in the middle column. Then, teacher wants students divide the right column in half and list the jobs one would choose if they acted like the

		descriptions listed in the middle column. For instance, the traditional female role and career choice might not include welder, construction worker while a traditional male role and career choice might not include elementary teacher, nurse. Then, students hang up their list on the board and each group make comments about their lists and discuss to analyze these lists (World's Largest Lesson, http://worldslargestlesson.globalgoals.org). Possible questions for discussion include: • How and where do we learn our perception of male and female roles? • Do these roles and descriptions limit or enhance us in life choices? • Have you or someone you know ever acted differently from how your gender is "supposed" to act? • Have you or someone you know ever stood up for a person who challenged the gender stereotypes? • What other conclusions/statements do you have about this topic? Teacher asks questions to make students think and discuss about the gender equality. -Why does gender equality matter? -Who and what are affected by gender equality? -What is being done for gender equality? -What are the causes and effects of gender equality? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 5 with with other SDGs they think are related. e.g. what impact does the lack of gender equality have on access to education, healthcare, freedom of movement?

		In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 5 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for gender equality?' Students answer this question and all students discuss their solutions and suggestions for gender equality with each other. The teacher shows the students 2 videos about taking action for SDG 5. Videos: Take Action on SDG 5: Gender Equality https://www.youtube.com/watch?v=yMQX0y-D6Sg accessed on 20 January 2023 https://www.youtube.com/ watch?v=j4Mcvb2MnOc accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Gender equality" is stated? Please explain.'

SDG 6: CLEAN WATER AND SANITATION LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	People
Subject	SDG 6-Clean water and sanitation
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concepts of clean water and sanitation and the importance of water quality and quantity.
	Socio-emotional learning objective Students communicate their own role and responsibilities for clean water and sanitation.
	Behavioural learning objective Students propose solutions for reducing their individual water footprint and saving water resources.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 6. Videos: Understand SDG 6: Clean Water and Sanitation https://www.youtube.com/ watch?v=7x2Ch-aMqEY accessed on 20 January 2023 https://www.youtube.com/watch?v=dpaUBRl8c6A&t=19s accessed on 2 February 2023 Teacher explains concepts of clean water and sanitation, water pollution, water access, safe drinking water, the importance of water quality and quantity, and sustainable management of water.
	Think	Teacher distributes 1 page comic about SDG 6: Clean Water and Sanitation (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about clean water and sanitation. **Classroom activity:** Can you live with dirty water? Clean water for all! Teacher brings two cups with water (one cup with clean water and the other cup with dirty or muddy water) to the classroom. Then, she wants students discuss the differences between the two cups. -What are these differences? - What would be the possible impacts of drinking from these two cups? -If they choose between the two cups, which one do they think would be safe for drinking? Why?

		Then, teacher distributes the world map indicating access to clean water and sanitation all over the world. She ask students to answer the following questions: • Where is your country on the clean water map? • Where are the countries with good access to clean water? Why these countries have good access to clean water? Do they have more water resources? • Where are the countries with less access to clean water? Why these countries have good access to clean water? Do they have less water resources? • How equal is access to clean water and sanitation around the world? Is it the same for everyone? • What can be done for equal is access to clean water and sanitation? Teacher asks questions to make students think and discuss about the clean water and sanitation. -Why does clean water and sanitation matter? -Who and what are affected by clean water and sanitation? -What are the causes and effects of clean water and sanitation? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 6 with with other SDGs they think are related. e.g. what impact does the lack of clean water and sanitation have on healthcare, freedom of movement? In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 6 with

		correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question ‘What can you do for clean water and sanitation?’ Students answer this question and all students discuss their solutions and suggestions for clean water and sanitation with each other. The teacher shows the students 2 videos about taking action for SDG 6. Videos: Take Action on SDG 6: Clean Water and Sanitation https://www.youtube.com/watch?v=00DrfwOwPHs accessed on 20 January 2023 https://www.youtube.com/ watch?v=TVOFh-5dorc accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions ‘What comes to your mind when the goal of “Clean water and sanitation” is stated? Please explain.’

SDG 7: AFFORDABLE AND CLEAN ENERGY LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Prosperity
Subject	SDG 7 Affordable and Clean Energy
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concepts of affordable and clean energy, different energy resources-renewable and non-renewable- and their respective advantages and disadvantages.
	Socio-emotional learning objective Students discuss their own role and responsibilities for affordable and clean energy, energy efficiency and sufficiency.
	Behavioural learning objective Students propose solutions for affordable and clean energy, energy efficiency and sufficiency.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 7. Videos: Understand SDG 7: Clean Water and Sanitation https://www.youtube.com/ watch?v=7x2Ch-aMqEY accessed on 20 January 2023 https://www.youtube.com/ watch?v=dpaUBRl8c6A&t=19s accessed on 2 February 2023 Teacher gives information about the concepts of affordable and clean energy, different energy resources – renewable and non-renewable – and their respective advantages and disadvantages, energy efficiency and sufficiency. energy production, supply, demand and usage.
	Think	Teacher distributes 1 page comic about SDG 7: Affordable and Clean Energy (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about affordable and clean energy. **Classroom activity:** Let's use renewable energy! Teacher distributes the activity sheets including the case about energy and ask students to read the case and answer questions about the case. Case: William Kamkwamba was born in Malawi and he had a poor family and they were farming to survive. When he was at fourteen, he had to leave school because of faminein Malawi. His family could no longer pay his tuition fees. William were desperate and began to often visit the library of village in order to continue his education. William explored his true love for electronics when they read books. The pictures in the book "Using

		Energy" of windmills inspired him and he started to gather materials to provide a steady source of water for his family's farm. He used a bicycle wheel, plastic pipe and other bits and pieces and he built a working windmill and provided energy for four light bulbs and two radios. This achievement got international attention and granted the financial support for young William to build windmills that served to irrigate the farms (https://worldslargestlesson.globalgoals.org/). -What do you think about this case? -Why is it important to provide our own energy? Teacher asks questions to make students think and discuss about the affordable and clean energy. -Why does of affordable and clean energy matter? -Who and what are affected by of affordable and clean energy? -What are causes and effects of of affordable and clean energy Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 7 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 7 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).

	Act	Teacher gives activity sheets to all students. The activity sheets include the question ‘What can you do for affordable and clean energy?’ Students answer this question and all students discuss their solutions and suggestions for affordable and clean energy with each other. The teacher shows the students 2 videos about taking action for SDG 7. Video: Take Action on SDG 7: Affordable and Clean Energy https://www.youtube.com/ watch?v=i6aQA8jJrxM accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions ‘What comes to your mind when the goal of “Affordable and clean energy” is stated? Please explain.’

SDG 8: DECENT WORK AND ECONOMIC GROWTH LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Prosperity
Subject	SDG 8: Decent work and economic growth
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concepts of decent work and economic growth.
	Socio-emotional learning objective Students discuss their own role and responsibilities for decent work and economic growth
	Behavioural learning objective Students propose suggestions for decent work and economic growth.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 8. Videos: Understand SDG 8: Decent Work and Economic Growth https://www.youtube.com/ watch?v=JVBypZdv8qw accessed on 20 January 2023 https://www.youtube.com/ watch?v=lj0JlrIWx2k accessed on 2 February 2023 Teacher gives information about the concepts of decent work and economic growth, employment and unemployment rates, working conditions, fair wages, labour force.
	Think	Teacher distributes 1 page comic about SDG 8: Decent work and economic growth (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about decent work and economic growth. **Classroom activity:** Decent work and economic growth for a better world! Teacher shows several pictures including people working in different fiels like doctors, agricultural laborer, fisher, farmer, teacher, police, engineer etc. Teacher asks questions to make students think and discuss about the decent work and economic growth. -What do you think about the works of the people and their work conditions? -How do these people contribute to economic growth? -Why does of decent work and economic growth matter?

		-Who and what are affected by of decent work and economic growth.? -What are causes and effects of decent work and economic growth? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 8 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 8 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for decent work and economic growth?' Students answer this question and all students discuss their solutions and suggestions for decent work and economic growth with each other. The teacher shows the students 2 videos about taking action for SDG 8. Videos: Take Action on SDG 8: Decent Work and Economic Growth https://www.youtube.com/ watch?v=9c2hR3r7x6Q accessed on 20 January 2023 https://www.youtube.com/ watch?v=xSzwWE3juS8 accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Decent work and economic growth" is stated? Please explain.'

SDG 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE LESSON PLAN 	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Prosperity
Subject	SDG 9: Industry, Innovation, and Infrastructure
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concepts of industry, innovation and sustainable infrastructure and industrialization.
	Socio-emotional learning objective Students argue their own role and responsibilities for sustainable industry, innovation, and infrastructure.
	Behavioural learning objective Students propose suggestions for sustainable industry, innovation and industrialization.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 9. Videos: Understand SDG 9: Industry, Innovation, and Infrastructure https://www.youtube.com/ watch?v=HjX4rlMP-eg accessed on 20 January 2023 https://www.youtube.com/ watch?v=J57rRolByqY&t=51s accessed on 2 February 2023 Teacher gives information about the concepts of industry, innovation and sustainable infrastructure and industrialization, greener and more resilient approaches to infrastructure, their overall benefits for societies, and the pitfalls of unsustainable industrialization.
	Think	Teacher distributes 1 page comic about SDG 9: Industry, Innovation, and Infrastructure (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about industry, innovation, and infrastructure **Classroom activity:** The world's future: industry, innovation, and infrastructure! Teacher distributes the activity sheets including facts about industry, innovation, and infrastructure to students. • There are more than 4 billion people in the world who do not have internet access. • Sustainable durable infrastructures are insufficient. • Inequalities in access to information and communication technologies are an important problem.

		• Innovation in science and industry does not receive the necessary attention and support. Teacher asks questions to make students think and discuss about industry, innovation, and infrastructure. -Why does of industry, innovation, and infrastructure matter? -Who and what are affected by of industry, innovation, and infrastructure? -What are causes and effects of industry, innovation, and infrastructure? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 9 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 9 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for sustainable industry, innovation, and infrastructure?' Students answer this question and all students discuss their solutions and suggestions for sustainable industry, innovation, and infrastructure with each other. The teacher shows the students 2 videos about taking action for SDG 9. Videos: Take Action on SDG 9: Industry, Innovation, and Infrastructure

		https://www.youtube.com/ watch?v=7m-rqNHDdrM accessed on 20 January 2023 https://www.youtube.com/ watch?v=Do7XUKaAdMI accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Industry, innovation, infrastructure" is stated? Please explain.'

SDG 10: REDUCED INEQUALITIES LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Prosperity
Subject	SDG 10: Reduced Inequalities
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concept of different dimensions of inequality.
	Socio-emotional learning objective Students discuss their own role and responsibilities for reducing inequalities.
	Behavioural learning objective Students propose solutions for reducing inequalities.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 10. Videos: Understand SDG 10: Reduced Inequalities https://www.youtube.com/ watch?v=6DlQq2xLw_0 accessed on 20 January 2023 https://www.youtube.com/ watch?v=-5wo1ArN88w accessed on 2 February 2023 Teacher gives information about the concepts of different dimensions of inequality, hinder equality, causes and effects for inequalities.
	Think	Teacher distributes 1 page comic about SDG 10: Reduced Inequalities (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about reduced inequalities **Classroom activity:** We're not so different each other—Let's stand as one! Teacher divides students into groups and wants them make a list of all of the different forms of inequality that they think. In addition, teacher ask students think and write the effects of the inequalities on the individual, local community, whole country and the world. In addition, they could also think about economic, social, political and environmental effects. When they are finished, students share their lists and reflect on what they've learned. Teacher asks questions to make students think and discuss about the reduced Inequalities

		-Why does of inequalities matter? -Who and what are affected by inequalities? -What are the causes and effects of inequalities? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 10 with with other SDGs they think are related. e.g. what impact does the inequalities have on access to education, healthcare, freedom of movement? In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 10 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for reducing inequalities?' Students answer this question and all students discuss their solutions and suggestions for reducing inequalities with each other. The teacher shows the students 2 videos about taking action for SDG 10. Video: Take Action on SDG 10: Reduced Inequalities https://www.youtube.com/ watch?v=v2DADIIyhrM accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Reduced inequalities" is stated? Please explain.'

SDG 11: SUSTAINABLE CITIES AND COMMUNITIES LESSON PLAN 	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Prosperity
Subject	SDG 11- Sustainable Cities and Communities
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concepts of sustainable cities and communities.
	Socio-emotional learning objective Students discuss their own role and responsibilities for sustainable cities and communities.
	Behavioural learning objective Students propose suggestions for sustainable cities and communities.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 11. Videos: Understand SDG 11: Sustainable Cities and Communities https://www.youtube.com/ watch?v=VrBrpSTwPK8 accessed on 20 January 2023 https://www.youtube.com/ watch?v=7hEYtozmb5o accessed on 2 February 2023 Teacher gives information about the concepts of sustainable cities and communities, sustainable planning, building and settlements.
	Think	Teacher distributes 1 page comic about SDG 11: Sustainable Cities and Communities (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about sustainable cities and communities. **Classroom activity:** Build a dream city! Eco-friendly homes and sustainable living for everyone! For classroom activity, the teacher divides the students into 4 groups including 5 students. Teacher gives students creative freedom that they can build their dream cities. Then, she wants students to think themselves as city planners and develop sustainable cities and communities. She asks for students to think how they can build the sustainable cities in terms of infrastructure, population density, supermarkets (food, water etc), health services (hospitals etc.), transportation (railways etc.), access to education,

		energy resources, job opportunities, waste disposal, sanitation, green areas, smart systems. When all groups have built or drawn their cities, they present their cities and the thoughts behind their designing of city. Moreover, teacher guides them to discuss how you can all live more sustainably in your own community. Then, teacher asks questions to make students think and discuss about sustainable cities and communities. -What are causes and effects of sustainable cities and communities? -Why does of sustainable cities and communities matter? -Who and what are affected by sustainable cities and communities? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 11 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 11 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for sustainable cities and communities?' Students answer this question and all students discuss their solutions and suggestions for sustainable cities and communities with each other.

		The teacher shows the students 2 videos about taking action for SDG 11. Videos: Take Action on SDG 11: Sustainable Cities and Communities https://www.youtube.com/watch?v=sPmPmMackUs accessed on 20 January 2023 https://www.youtube.com/ watch?v=phyRNpV9asA accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Sustainable cities and communities" is stated? Please explain.'

SDG 12: RESPONSIBLE CONSUMPTION AND PRODUCTION LESSON PLAN 	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Planet
Subject	SDG 12: Responsible Consumption and Production
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concepts of responsible consumption and production.
	Socio-emotional learning objective Students communicate their own role and responsibilities for responsible consumption and production.
	Behavioural learning objective Students propose solutions for responsible consumption and production.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 12. Videos: Understand SDG 12: Responsible Consumption and Production https://www.youtube.com/watch?v=2Ypif-QElok accessed on 20 January 2023 https://www.youtube.com/watch?v=dn-hLQk49eA accessed on 2 February 2023 Teacher gives information about the concepts of responsible consumption and production, strategies and practices of sustainable production and consumption, impacts of sustainable production and consumption.
	Think	Teacher distributes 1 page comic about SDG 12: Responsible Consumption and Production (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about responsible consumption and production **Classroom activity:** Reduce, reuse, recycle for a better life! Understanding the challenge of finite resources. The teacher opens the recycle city game using the smart board (https://www3.epa.gov/recyclecity/). In this game, students explore Recycle City to see how its people reduce waste, use less energy, and save money by doing simple things at home, at work, and in their neighborhoods. There's lots to do here. Students think that people and places to visit and plenty of ways to explore how all the city kids and adults reduce waste, reuse and repair things, recycle, and compost. Moreover, students answer the questions about reducing, reusing and recycling during the game.

		Teacher asks questions to make students think and discuss about the responsible consumption and production -Why does of Responsible Consumption and Production matter? -Who and what are affected by responsible consumption and production? -What are causes and effects of responsible consumption and production? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 12 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 12 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for responsible consumption and production?' Students answer this question and all students discuss their solutions and suggestions for responsible consumption and production with each other. The teacher shows the students 2 videos about taking action for SDG 12. Videos: Take Action on SDG 12: Responsible Consumption and Production https://www.youtube.com/ watch?v=a5B2Sg-0lmM accessed on 20 January 2023

		https://www.youtube.com/ watch?v=gnZ5YbNKcqs accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions ‘What comes to your mind when the goal of “Responsible consumption and production” is stated? Please explain.’

SDG 13: CLIMATE ACTION LESSON PLAN 	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Planet
Subject	SDG 13-Climate Action
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concept of climate change.
	Socio-emotional learning objective Students argue their own role and responsibilities for climate change.
	Behavioural learning objective Students propose solutions for climate change.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 13. Videos: Understand SDG 13: Climate Action https://www.youtube.com/watch?v=6YqmEYlg4IY accessed on 20 January 2023 https://www.youtube.com/watch?v=jhoa3OHivN8 accessed on 2 February 2023 Teacher gives information about the concepts of climate change, greenhouse effect, causes and effects of climate change.
	Think	Teacher distributes 1 page comic about SDG 13-Climate Action (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about climate action **Classroom activity:** Climate action: Let's calculate our carbon footprint! Teacher wants students to calculate their carbon footprint at the website (https://www.carbonfootprint.com/calculator.aspx) and discuss their results and how they can reduce their carbon footprints with classmates. Then, teacher asks questions to make students think and discuss about climate change. -Why does of climate change matter? -Who and what are affected by climate change? -What are causes and effects of climate change?

		Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 13 with with other SDGs they think are related. e.g. what impact does climate change have on access to education, healthcare, freedom of movement? In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 13 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for climate action?' Students answer this question and all students discuss their solutions and suggestions for climate change with each other. The teacher shows the students 2 videos about taking action for SDG 13. Videos: Take Action on SDG 13: Climate Action https://www.youtube.com/watch?v=b61FPARMsv8 accessed on 20 January 2023 https://www.youtube.com/watch?v=ugWV-mx5h6o accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Climate action" is stated? Please explain.'

SDG 14: LIFE BELOW WATER LESSON PLAN 	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Planet
Subject	SDG 14: Life Below Water
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain life below water and its importance.
	Socio-emotional learning objective Students communicate their own role and responsibilities for protecting life below water.
	Behavioural learning objective Students propose solutions for protecting life below water.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 14. Videos: Understand SDG 14: Life below Water https://www.youtube.com/ watch?v=muMwekvfmBY accessed on 20 January 2023 https://www.youtube.com/watch?v=u-l3KfmFNx0 accessed on 2 February 2023 Teacher gives information about the concepts of life below water, marine ecology, ecosystems, predator-prey relationships, threats to ocean systems, sustainable use of living marine resources.
	Think	Teacher distributes 1 page comic about SDG 14: Life Below Water (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about life below water **Classroom activity:** Marine litter-Protect life below water! Teacher divides students into groups involving 5 students. Teacher shows students a series of images of damaged seas or oceans, e.g. plastic waste, acidification or overfishing and ask students to write or discuss with their groupmates what they think happened before the photo and what will happen after. Teacher asks questions to make students think and discuss about the life below water. -Why does of life below water matter?

		-Who and what are affected by life below water? -What are causes and effects of protecting life below water? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 14 with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 14 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for protecting life below water?' Students answer this question and all students discuss their solutions and suggestions for life below water with each other. The teacher shows the students 2 videos about taking action for SDG 14. Videos: Take Action on SDG 14: Life Below Water https://www.youtube.com/ watch?v=iatuNzxKDiw accessed on 20 January 2023 https://www.youtube.com/ watch?v=dKhlPz1nNWM accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Life below water" is stated? Please explain.'

SDG 15: LIFE ON LAND LESSON PLAN 	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Planet
Subject	SDG 15: Life on Land
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain life on land and its importance.
	Socio-emotional learning objective Students communicate their own role and responsibilities for protecting life on land.
	Behavioural learning objective Students propose solutions for protecting life on land.
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 15. Videos: Understand SDG 15: Life on Land https://www.youtube.com/watch?v=qAfmUc7HJr0 accessed on 20 January 2023 https://www.youtube.com/watch?v=HRtua9GpzhY accessed on 2 February 2023 Teacher gives information about the concepts of life on land, biodiversity, local and global ecosystems and threats to ecosystems and biodiversity.
	Think	Teacher distributes 1 page comic about SDG 15: Life on Land (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about life on land **Classroom activity:** Earth: It's everybody's home! The impact of pollution on our planet and our lives. Teacher shows the pictures of animals and plants from all different parts of world. In addition, she shows endangered species and effects of environmental pollution. Teacher asks questions to make students think and discuss about causes and effects of life on land. -Why does of life on land matter? -Who and what are affected by Life on Land? -What are causes and effects of protecting life on land?

		Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 15 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 15 with correct pillar of sustainable development goals (people, prosperity, planet,peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do to protect life on land?' Students answer this question and all students discuss their solutions and suggestions for life on land with each other. The teacher shows the students 2 videos about taking action for SDG 15. Videos: Take Action on SDG 15: Life on Land https://www.youtube.com/watch?v=zxYQYU9wTZU accessed on 20 January 2023 https://www.youtube.com/watch?v=FI9SewsqYP0 accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions 'What comes to your mind when the goal of "Life on land" is stated? Please explain.'

SDG 16: PEACE, JUSTICE AND STRONG INSTITUTIONS LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Peace
Subject	SDG 16: Peace, justice and strong institutions
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** Students explain the concepts of peace, justice, and strong institutions.
	Socio-emotional learning objective Students communicate their own roles and responsibilities for peace, justice, and strong institutions.
	Behavioural learning objective Students propose suggestions for peace, justice, and strong institutions nationally and globally
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 16. Videos: Understand SDG 16: Peace, justice and strong institutions https://www.youtube.com/watch?v=AjwL5vWqp-Y accessed on 20 January 2023 https://www.youtube.com/watch?v=Ki33yMnfAso accessed on 2 February 2023 Teacher gives information about the concepts of peace, justice, and strong institutions, human rights, and their importance.
	Think	Teacher distributes 1 page comic about SDG 16: Peace, justice and strong institutions (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about peace, justice and strong institutions **Classroom activity:** The power of peace, justice, and strong institutions Students are shown the 'Most Shocking Second a Day' video by Save the Children. (https://www.youtube.com/watch?v=nKDgFCojiT8). and ask them 'What happens to the girl in the film? What has she lost in terms of family, community, safety, security, possessions, hope for the future, etc? How do you think she feels? What are her prospects for the future?' Teacher asks questions to make students think and discuss about the peace, justice, and strong institutions.

		-Why does of peace, justice, and strong institution matter? -Who and what are affected by peace, justice, and strong institution? -What are the causes and effects of peace, justice, and strong institution? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 16 with with other SDGs they think are related. e.g. what impact does the lack of peace have on access to education, healthcare, freedom of movement? In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 16 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).
	Act	Teacher gives activity sheets to all students. The activity sheets include the question 'What can you do for peace, justice, and strong institutions?' Students answer this question and all students discuss their solutions and suggestions for peace, justice, and strong institutions with each other. The teacher shows the students 2 videos about taking action for SDG 16. Videos: Take Action on SDG 16: Peace and Justice https://www.youtube.com/ watch?v=4NbU2ER-ylU accessed on 20 January 2023 https://www.youtube.com/ watch?v=i5aPYAUJq_4 accessed on 20 January 2023

Assessment	Teacher distributes the activity sheets to all students. The activity sheet includes the questions ‘What comes to your mind when the goal of “Peace, justice and strong institutions” is stated? Please explain.’

SDG 17: PARTNERSHIPS FOR THE GOALS LESSON PLAN	
Course	Environmental Education and Climate Change
Grade Level	7
Unit	Sustainable Development Goals
Theme	Partnership
Subject	SDG 17 Partnerships for the Goals
Time	1 lesson hour (40 min)
Learning Objectives	**Cognitive learning objective** -Students explain the concepts of global issues, global partnerships and global citizenship.
	Socio-emotional learning objective -Students communicate their own role and responsibilities for partnerships for the goals.
	Behavioural learning objective -Students propose suggestions for global partnerships for achieving sustainable development goals
Teaching Approach	Learn-Think-Act Approach

Teaching Procedure	**Learn**	The teacher starts the lesson by showing the students 2 videos about SDG 17. Videos: Understand SDG 17 https://www.youtube.com/watch?v=4uThM0pgjB0 accessed on 20 January 2023 https://www.youtube.com/watch?v=jcfoWx14lv0 accessed on 2 February 2023 Teacher gives information about the concepts of global issues, global citizenship, the interconnectedness and interdependency of different countries and populations, the importance of global multi-stakeholder partnerships and the shared accountability for sustainable development goals.
	Think	Teacher distributes 1 page comic about SDG 17 Partnerships for the Goals (https://worldslargestlesson.globalgoals.org/resource/global-goals-comic-posters/) to make students think about partnerships for the goals **Classroom activity:** Heroes for Change: Global citizens—Working together to achieve sustainable development goals (Board Game (The world's future)). The class is divided into 4 groups (consisting of 5 students). All groups roll the dice for the right to start. A group who rolls the big dice starts the game. The group who has the right to play starts rolls the dice again and they move on the map according to the number of dice received. According to the purpose or other information written in the box where the dice falls, the second phase is passed and the dice is rolled once. The number of dice rolled determines how many sub-goal

		cards we will choose for that goal. (For example, if a 3 is rolled, the third row. The object's bottom card number 3 is drawn.) The opposing player reads the card front/back to the player who threw the dice, tells the explanation note and asks the question. If the answer is satisfactory, the card belongs to the player who gave the answer; otherwise, the card goes to the player who gave the answer. The opponent also has the right to respond to this card and once the card is taken by one side. Then the turn passes to the 2nd player and the same phase applies to him. The player with a joker randomly draws one of the joker cards and gives it to the opponent. The opponent reads and retrieves wildcard information. If it is a question, s/he gives the answer; if it is not, s/he takes the joker card and the otheradds to cards. Teacher asks questions to make students think and discuss about the partnerships for goals. -Why does of global partnerships for goals matter? -Who and what are affected by global partnerships for goals? -What are the causes and effects of global partnerships for goals? Teacher gives a sheet of paper including all SDGs icon to all students and she wants students to match SDG 17 with with other SDGs they think are related. In addition, teacher distributes the sheets involving matching exercise and ask students associate SDG 17 with correct pillar of sustainable development goals (people, prosperity, planet, peace and partnership).

	Act	Teacher gives activity sheets to all students. The activity sheets include the question ‘What can you do in terms of partnerships for the goals?’ Students answer this question and all students discuss their solutions and suggestions for partnerships for the goals with each other. The teacher shows the students 2 videos about taking action for SDG 17. Videos: Take Action on SDG 17: Partnerships for the Goals https://www.youtube.com/watch?v=Fjxzr4S51gg accessed on 20 January2023 https://www.youtube.com/watch?v=73_A-xQKLbc accessed on 20 January 2023
Assessment		Teacher distributes the activity sheets to all students. The activity sheet includes the questions ‘What comes to your mind when the goal of “Partnerships for the goals” is stated? Please explain.’

B

SYSTEMS THINKING SKILLS QUESTIONS

STS	**Questions**
STS 1- Identify components of a system and processes within the system	What are the components (problems) of the world? Please explain.
STS 2- The ability to identify simple relationships between or among the system's components.	What are the relationships between the components (problems) of the world? Explain by giving an example.
STS 3- The ability to identify dynamic relationships within the system.	Is there a human impact on the problems experienced in the world? What do you think about whether there is a relationship between the problems experienced in the world and people's lifestyles? Please explain.
STS 4- The ability to organize the systems' components, processes, and their interactions, within aframework of relationships.	How can you classify/organize the components (problems) experienced in the world? Explain by giving an example.
STS 5- The ability to identify the cyclic nature of systems.	Is the world cyclical? How? Explain. Does a problem occurring anywhere in the world affect only that region or the whole world? How? Explain by giving an example.
STS 6- The ability to recognize hidden dimensions of the system—to understand natural phenomenathrough patterns and interrelationships not seen on the surface.	What are the hidden components (problems) of the world? Please explain.
STS 7- The ability to make generalizations—to solve problems based on understanding systems'mechanisms.	What do you think what the system is? Is the world a system? Is there a relationship between humans and what happens in the world? Are humans part of the world? Explain.
STS 8- The ability to think temporally: retrospection and prediction. Understanding that	Have the actions of people in the past affected the world today? Will the human activities done today

some of the presented interaction within the system took place in the past, while future events may be a result ofpresent interactions	affect the world of the future? Do you think there is a relationship between the past, present and future in terms of the problems experienced in the world? If so, what do you think the world will be like in the future? Explain.

C
ETHICAL REASONING QUESTIONS

Ethical Reasoning in Action	Eight Key Questions When you think about the problems experienced in the world,
Fairness	How can you treat all people and living in different parts of our world fairly and equally? Explain.
Outcomes	What possible actions achieve the best short- and long-term outcomes for all people and living in the world? Explain.
Responsibilities	What duties and obligations do you have towards our world? Explain.
Character	What actions best reflect who you are and who you want to be towards our world? Explain.
Liberty	How can you respect the freedom, personal autonomy (the ability to make decisions independently of another person or situation, self-government) and consent of people and other living all over the world? Explain.
Empathy	What would you do if you were interested in the problems faced by people and living in different parts of our world? Explain.
Authority	What do legal authorities (e.g. law, experts) expect from you in terms of protecting our world and its resources? Explain.
Rights	What rights (e.g. innate, legal, social) apply in our world?

D

RUBRIC FOR STS

STS	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
STS 1: The ability to identify the components of a system and processes within the system	No ability to identify the components of a system and processes within the system	The ability to identify the components of a system and processes within the system considering only one pillars of sustainable development goals (e.g. people)	The ability to identify the components of a system and processes within the system considering two pillars of sustainable development goals (e.g. people, planet)	The ability to identify the components of a system and processes within the system considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify the components of a system and processes within the system considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

STS	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
STS 2: The ability to identify simple relationships among the system's components	No ability to identify simple relationships among the system's components	The ability to identify simple relationships among the system's components considering only one pillars of sustainable development goals (e.g. people)	The ability to identify simple relationships among the system's components considering two pillars of sustainable development goals (e.g. people, prosperity)	The ability to identify simple relationships among the system's components considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify simple relationships among the system's components considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

STS	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
STS 3: The ability to identify dynamic relationships within the system	No ability to identify dynamic relationships within the system	The ability to identify dynamic relationships within the system considering only one pillar of sustainable development goals (e.g. people)	The ability to identify dynamic relationships within the system considering two pillars of sustainable development goals (e.g. people, prosperity)	The ability to identify dynamic relationships within the system considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify dynamic relationships within the system considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

STS	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
STS 4: The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	The ability to organize the systems' components, processes, and their interactions, within a framework of relationships	The ability to organize the systems' components, processes, and their interactions, within a framework of relationships considering only one pillar of sustainable development goals (e.g. people)	The ability to organize the systems' components, processes, and their interactions, within a framework of relationships considering two pillars of sustainable development goals (e.g. people, prosperity)	The ability to organize the systems' components, processes, and their interactions, within a framework of relationships considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to organize the systems' components, processes, and their interactions, within a framework of relationships considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

STS	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
STS 5: The ability to identify the cyclic nature of systems	STS 5- The ability to identify the cyclic nature of systems	STS 5- The ability to identify the cyclic nature of systems considering only one pillar of sustainable development goals (e.g. people)	STS 5- The ability to identify the cyclic nature of systems considering two pillars of sustainable development goals (e.g. people, prosperity)	STS 5- The ability to identify the cyclic nature of systems considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	STS 5- The ability to identify the cyclic nature of systems considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

STS	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
STS 6: The ability to recognize hidden dimensions of the system	No ability to recognize hidden dimensions of the system	The ability to recognize hidden dimensions of the system considering only one pillar of sustainable development goals (e.g. people)	The ability to recognize hidden dimensions of the system considering two pillars of sustainable development goals (e.g. people, prosperity)	The ability to recognize hidden dimensions of the system considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to recognize hidden dimensions of the system considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

STS	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
STS 7: The ability to make generalizations	No ability to make generalizations	The ability to make generalizations considering only one pillar of sustainable development goals (e.g. people)	The ability to make generalizations considering two pillars of sustainable development goals (e.g. people, prosperity).	The ability to make generalizations considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to make generalizations considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

STS	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
STS 8: The ability to think temporally: retrospection and prediction.	No ability to think temporally: retrospection and prediction.	The ability to think temporally: retrospection and prediction considering only one pillar of sustainable development goals (e.g. people).	The ability to think temporally: retrospection and prediction considering two pillars of sustainable development goals (e.g. people, prosperity).	The ability to think temporally: retrospection and prediction considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to think temporally: retrospection and prediction considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership).

E

RUBRIC FOR ERiA

Ethical Reasoning	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
ERiA 1: Fairness	No ability to identify fairness	The ability to identify fairness considering one pillar of sustainable development goals (e.g. people)	The ability to identify fairness considering two pillars of sustainable development goals (e.g. people, planet)	The ability to identify fairness considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify fairness considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

Ethical Reasoning	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
ERiA 2: Outcomes	No ability to identify the best short- and long-term outcomes for themselves and all others in our world	The ability to identify the best short- and long-term outcomes for themselves and all others in our world considering one pillar of sustainable development goals (e.g. people)	The ability to identify the best short- and long-term outcomes for themselves and all others in our world considering two pillars of sustainable development goals (e.g. people, planet)	The ability to identify the best short- and long-term outcomes for themselves and all others in our world considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify the best short- and long-term outcomes for themselves and all others in our world considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

Ethical Reasoning	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
ERiA 3: Responsibilities	No ability to identify the duties and obligations to our world	The ability to identify the duties and obligations to our world considering one pillar of sustainable development goals (e.g. people)	The ability to identify the duties and obligations to our world considering two pillars of sustainable development goals (e.g. people, planet)	The ability to identify the duties and obligations to our world considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify the duties and obligations to our world considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

Ethical Reasoning	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
ERiA 4: Character	No ability to identify actions reflecting who you are and who you want to be for world	The ability to identify actions reflecting who you are and who you want to be for world considering one pillar of sustainable development goals (e.g. people)	The ability to identify actions reflecting who you are and who you want to be for world considering two pillars of sustainable development goals (e.g. people, planet)	The ability to identify actions reflecting who you are and who you want to be for world considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify actions reflecting who you are and who you want to be for world considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

Ethical Reasoning	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
ERiA 5: Liberty	No ability to identify the respect people's freedom, personal autonomy (ability to make decisions independently of another person or situation, self-government) and consent	The ability to identify the respect people's freedom, personal autonomy (ability to make decisions independently of another person or situation, self-government) and consent considering one pillar of sustainable development goals	The ability to identify the respect people's freedom, personal autonomy (ability to make decisions independently of another person or situation, self-government) and consent considering two pillars of sustainable development goals (e.g. people, planet)	The ability to identify the respect people's freedom, personal autonomy (ability to make decisions independently of another person or situation, self-government) and consent considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify the respect people's freedom, personal autonomy (ability to make decisions independently of another person or situation, self-government) and consent considering all pillars of sustainable development goals

Ethical Reasoning	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
ERiA 6: Empathy	No ability to identify the empathy with people and living things facing problems in different parts of the world	The ability to identify the empathy with people and living things facing problems in different parts of the world considering one pillar of sustainable development goals (e.g. people)	The ability to identify the empathy with people and living things facing problems in different parts of the world considering two pillars of sustainable development goals (e.g. people, planet)	The ability to identify the empathy with people and living things facing problems in different parts of the world considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify the empathy with people and living things facing problems in different parts of the world considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

Ethical Reasoning	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
ERiA 7: Authority	No ability to identify the expectation of the legitimate authorities (e.g. experts, law) for protecting the world	The ability to identify the expectation of the legitimate authorities (e.g. experts, law) for protecting the world considering one pillar of sustainable development goals (e.g. people)	The ability to identify the expectation of the legitimate authorities (e.g. experts, law) for protecting the world considering two pillars of sustainable development goals (e.g. people, planet)	The ability to identify the expectation of the legitimate authorities (e.g. experts, law) for protecting the world considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify the expectation of the legitimate authorities (e.g. experts, law) for protecting the world considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

Ethical Reasoning	Insufficient (0)	Marginal (1)	Good (2)	Excellent (3)	Extraordinary (4)
ERiA 8: Rights	No ability to identify the rights (e.g. innate, legal, social) apply for protecting the world	The ability to identify the rights (e.g. innate, legal, social) apply for protecting the world considering one pillar of sustainable development goals (e.g. people)	The ability to identify the rights (e.g. innate, legal, social) apply for protecting the world considering two pillars of sustainable development goals (e.g. people, planet)	The ability to identify the rights (e.g. innate, legal, social) apply for protecting the world considering three pillars of sustainable development goals (e.g. people, planet, prosperity)	The ability to identify the rights (e.g. innate, legal, social) apply for protecting the world considering all pillars of sustainable development goals (e.g. people, planet, prosperity, peace, partnership)

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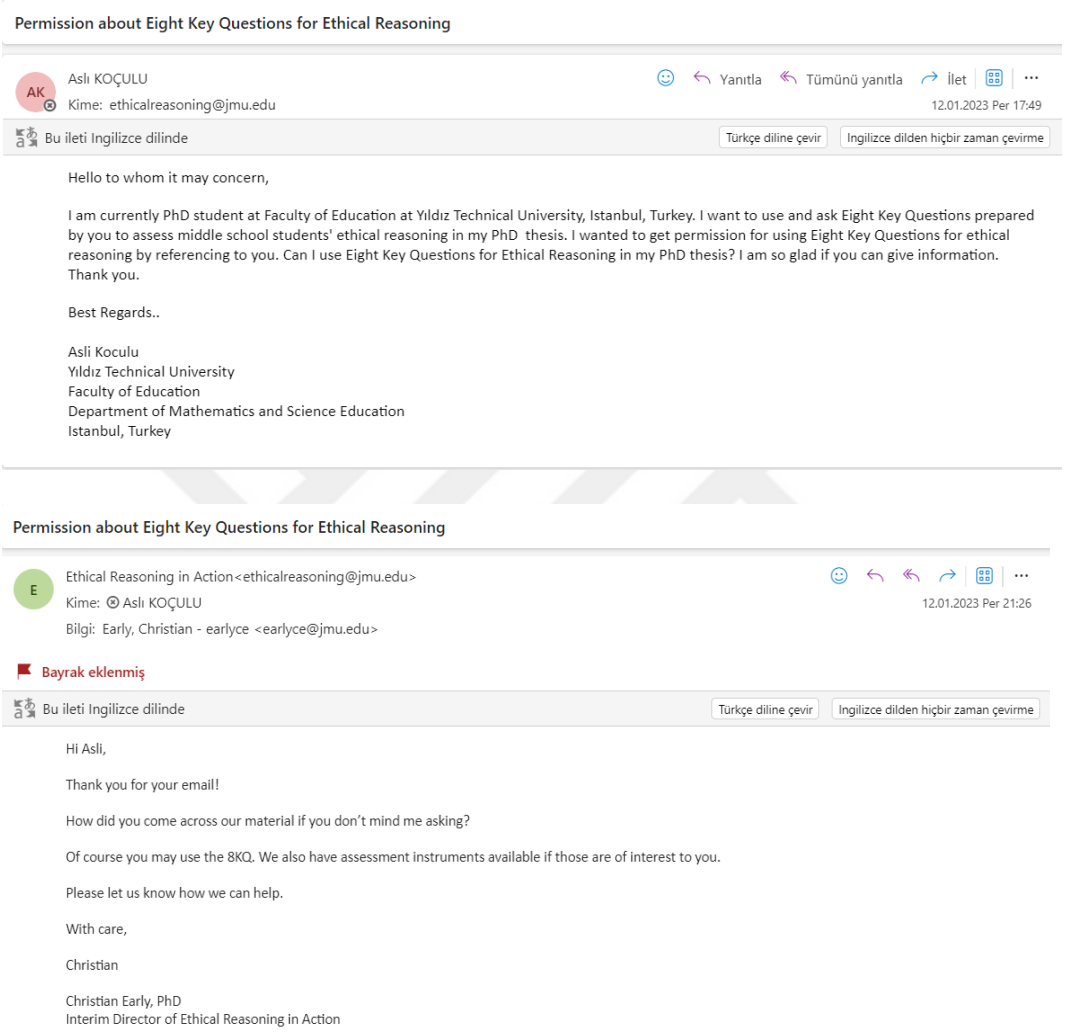

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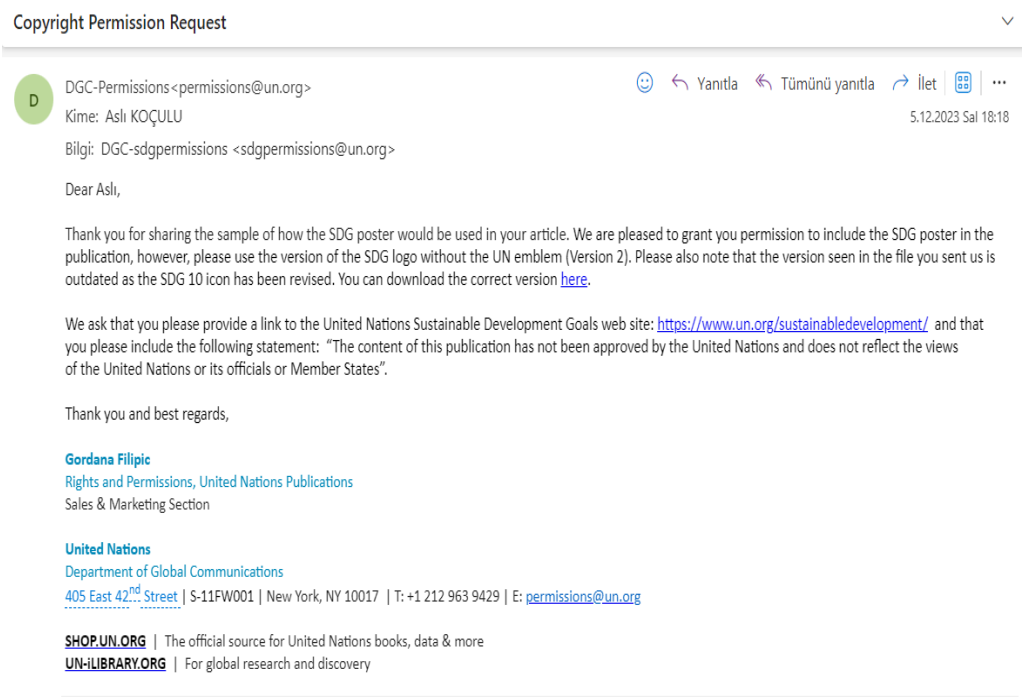

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Yürütücülüğünü Üniversitemiz Eğitim Fakültesi öğretim üyelerinden Prof. Dr. Mustafa Sami TOPÇU danışmanlığında lisansüstü öğrencisi Arş. Gör. Aslı KOÇULU' nun yapacağı **"Sürdürülebilir Kalkınma Hedefleri Ünitesinin Geliştirilmesi ve Uygulanması: Öğrencilerin Sistemsel Düşünme Becerilerinin ve Etik Muhakemelerinin İncelenmesi "** adlı çalışma ve bu çalışmada kullanılacak veri toplama araçları ve yöntemlerine ilişkin bilgilerde etiğe aykırı herhangi bir bulguya rastlanmamıştır.

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PUBLICATIONS FROM THE THESIS

Papers

1. Koçulu, A. & Topçu, M.S. (2024). Development and Implementation of a Sustainable Development Goals (SDGs) Unit: Exploration of Middle School Students' SDG Knowledge. *Sustainability,* 16, 581. https://doi.org/10.3390/su16020581

Conference Papers

1. Koçulu, A. & Topçu, M.S. (2023). Development of the Sustainable Development Goals Unit for Middle School Students. [Paper presentation]. 10. International Eurasian Educational Research Congress (EJER), Ankara, Türkiye, 8- 11 Haziran 2023, ss.621-622.

2. Koçulu, A. & Topçu, M.S. (2023). Developing Students' Systems Thinking with Education for Sustainable Development Goals. [Paper presentation]. NAAEE 2023-North American Association for Environmental Education-52th Annual Conference, United States of America, 18 -20 Ekim 2023, ss.1-2.