

# A trial patch to the extracurricular perspective of sustainable development program in elementary schools of Turkey

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## Research Article

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# Abstract

Sustainable development (SD) and science education have become interwoven categorical issues under the name of science education for sustainable development (SESD). Education can play a crucial role in merging the dimensions of SD as ecology, economy, and energy, along with society in a united holistic goal. Furthermore, it can provide the necessary motivation and self-fulfillment for individuals and communities. Extracurricular activities should also be implemented along with formal ones in courses that are related to socio-scientific issues like SD. In line with this perspective, this study mainly aims to find new means of developing an extracurricular module program based on the principles of SD, in order to address the defects, deficiencies, and needs in science education around the world. For the sake of these, the module program was constructed kneading concepts of energy transformations, biodiversity, and narrating socio-scientific problems that would foster positive student decision-making on SD issues. The study also aims to examine whether the SESD module program would have a significant effect on the academic success and opinions regarding SD of primary school students in science lessons. The study sample comprised 92 Turkish fifth-grade students. A mixed method was handled by allowing qualitative and quantitative research methods in the same context. Qualitative and quantitative data analysis revealed that the SESD module program significantly affected fifth-grade students in terms of their knowledge and opinions to increase their willingness to take action and responsibility.

## 1. Introduction

The ever increased mobility of humankind makes the World as small as village. The surging recent Covid-19 pandemics outbursts this covert reality in narrow time limit. The coronavirus travel all around the world with genetic mutation in come crossing host individuals. The pandemic sometimes is called the revenge of wild life that has been transgressed by human civilization. The wild life wants also necessary place for surviving (Ingrid, 2020). Resultantly, the needed social distancing to block the transmission of virus lessens the available bearing capacity of the Earth as calculated before these pandemics. The anticipated recessions of greatest economies of North America, Europe and Asia is not limited to these geographies but complete globe (Aydınlı, 2019). It is understood that the world will never be same. Therefore, the ever narrowing place and increasing social distance make the sustainable development issues more important than ever. The possible solutions to these problems are collaboration of individuals, foundations and countries hand in hand in collective and individual manner without considering cultural difference including race, ethnicity and beliefs (J.A. Banks & C.A.M. Banks, 2010; Kwatra et al, 2020). Communities and individuals from the perspective of being global citizens need a theoretical framework for self-fulfillment with a positive effect on communities. Self-actualization, realizing personal potential, self-fulfillment, seeking personal growth, and peak experiences are the essential parts of individualism (Realo et al, 2002). Cultural norms are transferred and transformed by individuals in a collective manner (Kim et al, 1994). The renewed concept of sustainability has a controversial impact on individuals and communities. The goal is to unify the impact in contemporary societies by providing advantages in education, physiology and sociology.

The intended change in the normative behavior of individual and community should be based on theoretical perspective which should be based on higher need skill of Maslow which is the self-fulfillment (Maslow, 1943). Otherwise, it cannot be successful in changing behavior. In sociopsychology, the behavior in the circumstances of event can be variant in alone and in community. Therefore, individualism is a subjective perspective and the behavior of individual can be quite variant. But collectivism present a deterministic perspective governed by rules and assumes that behavioral range should be quite limited. Hence, the sustainability issues; duties and rights varies according to structures which are based on individual choices and organizational structures. At this point global citizens and ecological citizenship takes part in sustainable development discussion. The discussion can be based on apparent event in phenomenological perspective or interpretive hermeneutic explanation.

## ***1.1. Sustainability: inferiors, frontiers and paradigmatic change***

The term of "Sustainability" as an English word has been derived the word "sustain" meaning "sustaining life". Furthermore, "sustentation" means the activeness of life through vital processes. People who speak different languages use different words to meet the word sustainability. No one can be sure that all of these words mean the same thing or perceive the same. Also, the word sustainability does not provide an understanding of the same phenomenon all over the world. The understanding of this word can vary naturally or regionally depending on changing conditions in different countries, continents, unions, pact, and even in the northern and southern hemispheres. (Stegall, 2006; Amodu, 2020; Molotokienè, 2020).

In the very beginning, sustainability could not be mentioned. The planet Earth is ever known and justified to be the just one place bearing life in the Universe yet. The planet Earth in the beginning was in a form fluid which is a small part of successive two supernova explosion of a much more giant stars much prior to our stellar star Sun containing mainly Hydrogen and Helium. This means heavier elements such as Carbon responsible for the known life form are not the product of nowadays Sun. The necessary pressure for fusion to reach heaviest element have been accomplished in previous two preceding supernova explosions. Like necessary matter have been ready for complex formation and reaction. The initial formation of Universe has been omitted here. It is understood that there is a continuous transformation with increasing complexity rather than preserving the situations. Later, the Earth becomes solid but not as hard as Iron. The soil formed on it with classical expansion and compression successively with temperature change. Already, all the elements became ready from Nitrogen, Oxygen, Carbon to Iron and Uranium and more. The new atoms with high mass and atomic number are expected to be formed with fantastic properties. Basically, the construction to the next atom is probable with adding one more proton, neutron and electron to the previous atoms. The real situation can be quite burdensome. Come back to original if initial point of beginning of universe and it's all stages are persistent and sustainable we have not could reach the today situation where human exist. The Universe and Earth is stable in comparison with the known human life span. The universe probably has billions or millions of years with lunar or solar calendar account. Human kind is one of latest species in the Earth has some hundred thousands of

years. In our humanitarian account, taking care of the environment means enabling human activity without disturbing the natural cycles. However, it is understood from the previous transformation of the universe, new transformation that transcends the available situation awaits us in certain amount of time that can be short and long relatively with universe and human life spans. Therefore, sustainability is valid only at tangent to the predefined desired position. Otherwise, transformation is sustainable in the universe. In this sense, sustainable transformation seems better than sustainability and sustainable development for the journey story of the universe (Clarke & Mcphie, 2016).

Developing new concepts under similar features of events is a primary struggle in science and technology. Considering, constructing, and communicating about these concepts will improve science in society in a step-by-step manner. The concept of sustainability has drawn attention for several decades and is expanding to cover many issues stemming from the needs of technology-driven communities, such as environmental impact assessments of various processes in civilization, the definition of citizenship, and fair sharing of goods and commodities. This needs understandable models in order for people to envision sustainability (Iwaniec et al, 2014).

The new concepts are perpetually developed abstract ideas that will be outburst and utilized in the future. Some recent examples that unify science and socialites are ecological citizenship as Dobson introduced, sustainable development and citizen science (Dobson & Bell, 2010). Generally, nowadays scientific accomplishment and achievements are at the hands some elitist groups in the societies. The decision made this group is generally not understood by remaining of the society even people experienced in another subjects. Therefore, in order not to be deceit by other construct, every people should have the skills of logical and rational thinking with direct experiencing with science. This is called citizen science (Bonney et al, 2015). Otherwise, the communities can easily be jeopardized and deceived to wrong directions and choices.

The related necessary transformative paradigm shifts in science, technology, the environment, society, economy, and policy education from the contemporary disciplines of science and technology to ensure "sustainability thinking" was given by Zoller (Zoller, 2015). The concept of sustainability is continually associated with different concepts, and accordingly, new fields of study are emerging every day, including tourism, energy, and education. The concept of sustainability is prevalent and is applied across a range, from politics to academia and media to economy, among the different sections of society (Kilinc, 2015). The environment, economics, energy, and society are interrelated concepts in sustainability discussions. These concepts seem somehow contradictory to each other at first glance. That is, while economic and business activities increase welfare and prosperity, they harm the environment in terms of the loss of living and non-living species. The critical concept of education with the right utilization may positively turn the wheels by being part of a merging cogwheel in human processes. The sustainable development (SD) concept has emerged by crosslinking the above concepts in consideration of human behavior. SD takes place at the center of these concepts. The primary aim is to enlarge this cross-sectional area, which is bigger than the decisive addition of function. Education can help this enlarging issue by diffusing to whole systems. Primary anthropogenic effects such as increased waste products, the careless use of

chemicals, inadequate sanitation facilities, a lack of pure drinking water, and continuously depleted natural resources in almost every possible industrial process have turned our attention to efficient green and cleaner production (McGrath & Powell, 2016).

The universe and nature with compromising subjects and objects are assumed to be in balance from the rhetorical beginning to last in execution of any process. It has been understood with experiencing phenomenological ultimate effect of human in nature such as acid rains, plastic pollution and extinction and endangered species, Humans can act and behave contradictory to the condition that allow its existence of body. SD and education may help mankind to grasp its original behavior through historical perspectives. These are higher order thinking and behavioral attitudes that can only be achieved with scientific manner. The attributed responsibility of human in environmental protection cannot be absolved with non-awareness and unconscious. Political attempts, economic subsidies, and technological solutions are not enough to address these problems. Therefore, both scientific methods and practical applications are immediately needed to enable a sustainable society and nature (Luthe, 2017).

## ***1.2. Sustainable development (SD), education for SD (ESD), and science for ESD (SESD)***

Sustainable development still maintains its agenda today, it has been developing from the past to the present. The historical process of the evolution of sustainable development from the past to the present is shown in Figure 1.

The historical evolution of sustainable development can be divided into three periods. These are the period; The first period (embryonic period), before 1972 the second period (molding period) 1972-1987, and the third period (developing period) after 1987 (Shi, Han, Yang, & Gao, 2019). In the embryonic period of sustainable development, the welfare level of individuals has increased with technology and industrialization, and this has led to population growth and naturally increasing consumption of resources, and environmental problems have also increased. In addition, this situation has revealed the danger of depletion of natural resources. Examining whether global economic development is sustainable, Meadows examined the Limits to Growth using population growth, industrial production, consumption and pollution data. He stated that there is a limit to the world's resources and this situation is not sustainable in the future based on past data (Basiago, 1999). Scientists and philosophers have started work on another understanding of human development, which is more in harmony with the world than economic growth. These studies became concrete at the Stockholm conference held in 1972 and sustainable development came to the fore in the international arena (Zharova & Chechel, 2020). Scientists and philosophers have started work on another understanding of human development, which is more in harmony with the world than economic growth. These studies became concrete at the Stockholm Conference held in 1972 and sustainable development came to the fore in the international arena. At the 1972 Stockholm Conference, the carrying capacity of the environment, the consideration of future generations in the use of resources, development and environmental pollution were on the agenda (Yilmaz, 2018). SD was first articulated in 1987 by the World Commission on Environment and

Development (WCED) in the international arena, and it is still in use. SD was then defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs (WCED, 1987). The term SD appears here as an ecological definition based on the problems arising from the unlimited economic development. What is meant by sustainable here is that the benefit of future generations does not decrease and natural resources and ecology are not deteriorated (Gedik, 2020). The definition of this concept appeared for the first time as a definition in the international arena. In the first place, this definition has been generally accepted and in sustainable development; It has been emphasized that social equality, economic growth and environmental development can be at the same time (Du Pisani, 2006). In addition to these three dimensions psychologically, sustainable development is viewed in an effort to increase the welfare level of all people (Di Fabio, 2017). 1992 Rio de Janeiro, UN Conference on Environment and Development (UNCED) linked environment and development. At the Rio conference, it was accepted that human beings have the right to a healthy and productive life in harmony with nature. At the Rio conference, the scope of SD expanded and many disciplines came under the umbrella of SD. Activities to be done in areas such as environment, economy, urbanization and management have been determined to reach SD (Kumar, 2020). The United Nations Conference on Sustainable Development (2012) the Future We Want report was highlighted renewed commitment to sustainable development goals and the global green economy. The 2012 United Nations Conference on SD included renewed plans and targets for SD cooperation. The decision to establish a set of sustainable development goals is recognized as the most concrete outcome of the 2012 United Nations (UN) Rio + 20 Conference on Sustainable Development. The 2012 summit included the process of developing sustainable development goals (Klarin, 2018). The following is the 2015 Transforming Our World Report; It has the distinction of being the latest document defining SD goals and designing the modern platform for sustainable development practice. Agenda for Sustainable Development In September 2015, the UN General Assembly outlines a new framework that forms the cornerstone of the sustainable development agenda to 2030 (Mensah, 2019; United Nations,UN, 2015).

Historical analysis of SD development shows that sustainable development is a dynamic process. In the current conditions shows that sustainable development definitions are evolving and not comprehensive enough, and not compatible with human nature (Boda, & Faran, 2018; Gedik, 2020; Manteaw, 2012; Seker & Aydinli, 2016). Thus, it has many dimensions, called socio-scientific issues, such as global warming, energy resources, water pollution, and poverty. These can affect every living and nonliving being anywhere in the world. Thus, a new definition is required that is valid for everyone in the world. For theoretical and applied purposes, new definitions of SD are required for integration at a global level. SD also directs the system and supports the improvement and reinforcement of generational and intergenerational life standards, social solidarity, and increased equality of opportunity. A module suggestion for SD, showing the relationships between the environment, society, and economy, is given in Figure 2. Here, the figure shows all the dimensions of SD in an interactive and streamlined manner for the well-being of both individuals and communities. This situation causes the dimensions of SD to be interwoven in a dynamic equilibrium state, with the production of new products by the addition of new resources. It explains that SD is possible only if these three dimensions are simultaneously functional.

The module shown in Figure 2 should be implemented to accomplish SD. Otherwise, a catastrophic failure of the systems, and subsequently, the world, will be inevitable after some predefined breakpoint. If the breakpoint is in the reversible zone, the struggle may eventually reverse the failure, and natural balance will again be achieved. Then, the failure will be accelerated, even if the necessary precautions are taken, or if we are lucky enough, we will not go past the breakpoint. That is, SD is a compulsory perspective rather than a luxury model. Then, the SD discussion will continue in order to have an inhabitable world. The SD concept has already been inserted into the fundamental goals of national education programs. However, the transformation of the curriculum has not yet been achieved to meet the requirements of the basic need for SD (Nousheen et al., 2020; Vargas, 2000). Here, for this purpose, the science education for SD (SESD) module program of study was developed, and a theoretical framework is proposed that clarifies the role of SE in SD. The concept of SESD came to the foreground to reach this goal because SE and SD are complementary factors (Correia et al, 2010). This module program can be an example for further studies in other areas of science education.

Science education has a critical role in solving the problems of SD, in transforming anthropogenic behaviors stemming from evolutionary needs into behaviors that are compatible with nature. Science education supports SD, which covers socio-scientific topics and scientific understanding, encompassing the principles, values, and applications that are being taught to individuals. With the increased implementation of SD in education, more individuals will follow a sustainable lifestyle, making our world more inhabitable. Furthermore, international corporations and institutions are joining the challenge to advance learning toward a broader and deeper understanding and practice of sustainability. Studies about education for SD should be increased and deepened to meet the desired level for both Turkey and the whole world. Currently, programs at higher education institutions to educate teacher candidates in Turkey have begun to include related topics on SD. Besides, education practices for SD at the international level have begun (Bürgener & Barth, 2018; Kilinc, 2015). Therefore, for the efficient use of SD in science programs to achieve a sustainable lifestyle, and to make the world more inhabitable, further research and development are needed to bridge the gap between social and scientific issues. Ecological citizenship is another hot spot, stands as a suitable type that encourages individuals, communities, and organizations as citizens of the world to consider environmental rights (Dobson & Bell, 2010). Therefore, it should be insisted that people be raised as ecological citizens through educational activities (Andersson et al, 2013). Many educators emphasize the need to create programs related to SD, to raise citizen awareness, and to encourage sustainable behavior. This can only be made possible by including SD in education programs.

The concept of SD was first openly used in Turkey in the 2013 National Education Program, and continuous development is ongoing. The most crucial difference between this program and the former one is that the understanding of such topics changed with the inclusion of SD. With the new perspective, the program includes a road map regarding how to transfer the understanding of SD to the public. This understanding requires solidification of the qualities of SD for education, to increase the interaction among programs, and to reinforce and improve the connections by increasing knowledge and experience, and to make political reforms related to SD (Aydınlı, 2014).

### ***1.3. Extracurricular activities and decision making***

Curriculum and program development for SD in science education is relatively new concept in Turkey also. The construction of related courses for this issue is lack behind the desired level (Aydınlı, 2014). Stemming from the current situation, it can be concluded that further studies should be conducted about SD, and these program development efforts should be extended from higher education to preschool, covering primary and middle school education in Turkey. Program development efforts should have the capacity to cover all items, from the preparation of events and activities of conventional laboratory experiments, to outdoor or extracurricular experiences for sustainability. Along those lines, Pauw et al. (2015) assume that ESD has a positive impact on students' sustainability behavior which can be come out with descriptive analysis. The students' behavioral choices can be affected not only by formal education, but also by outdoor activities with extracurricular experiences which is similar to real life experiences (Post & Meng, 2018). Similarly, in this study, the results and outcomes imply that sustainability consciousness of the study group has been improved which is analyzed and estimate through a series of descriptive analyses and structural equation models. Encouraging the students to solve real-world problems, constructing the courses according to problem-solving and project-based models foster the skills of both trainee and trainer for sustainability (Post & Meng, 2018). These will end harnessing the teaching skill of nature in real life (Beames et al, 2012).

Now, it is understood that SESD is limited and lacking in the educational systems of many countries, just like in Turkey. There should be enough trials and communications to reach common sense of sustainability. The preparation and implementation of module programs at various scope and extent is the very beginning in educational perspective to reach ultimate goal of sustainability. It can be advocated that preparation of model programs for SESD is vital stages to result in an inhabitable environment for societies in the world. At the end, an executional model programs will be gained and hand out. Accordingly, in this study, the prominent purpose is to develop a Science Education program and to test its effectiveness on Sustainable Development. And exposing, displaying and drawing the basic components and building blocks of this subject.

In the end, all inspiring practices should be attributed and selected by individuals and communities. Thus, the basic question is the free will of human being at consequence of choices in determinism and voluntarism (Cohen et al, 2007). Do really bad practices be preferred rather than good ones, that the basic dilemma of ethics? Humans behave both subjectively and objectively in the circumstances, due to their nature. Otherwise, it would not be possible to choose among equal options. Also, if it was compulsory to choose best items in quality and quantity items that is phenomenologically and hermeneutically contradictory to human nature, the basic struggle would be the just disseminations of good practices to the societies. That is, we do not have to come across always choosing practices. Then the value of human being should be enquired. Contrarily, decision-making and choosing are higher-order thinking, which comprises intentions, experiences, and qualities (Siribunnam et al, 2014). Formal classroom education in school does not provide the necessary actions and the right choice of free will. The subjects in the classroom should be extended to the real world, with outside activities, and beneficial activities for

both individuals and communities. Such activities may include transforming wind into energy by lighting a bulb, observing the hazardous effects of waste in nature and biodiversity, and discussing scientific theories (Garrecht et al, 2018). Hence, we need to raise citizens who will make positive decisions and play an active role in decreasing and eliminating these problems. Looking at these problems only from the perspective of the social and pure sciences prevents us from seeing the bigger picture. Therefore, utilizing SE that integrates pure scientific fields with social sciences, and that interprets the topics of social sciences would act as a bridge, and urge individuals to take action. The all of it is called socio-scientific issues.

Now, it is assured that the SD concept fits best into science education under the name of SESD. Since the basic sense of sustainability is endurance, the program developed related with should also be in continuous format both for formal and informal curricular activities. It should perpetually be reconsidered and reconstructed. This enables efficient execution and fair actions on SD. Sustainability has taken gradual attention in the national science education program in Turkey, and should be enhanced with outdoor and extracurricular activities. Here, a module program was developed in order to address the existing shortcomings concerning sustainable development in science education in Turkey. For this purpose, first of all, the problem statement has been constructed with initial interview with the fifth grade students by descriptive analysis. Then the module program was constructed and applied to a pilot group along with literature survey. Later, modified module program was executed in control and experimental groups in experimental research. Finally, semi-structured post-interviews were conducted. This research was executed in three classes of fifth-grade elementary school students. The intended and expected results of the study are more positive attitudes of students in their utterances regarding their sustainable development views, and not decrease in their academic performance due to busying them with extra activities. Therefore, here are two hypotheses. First one is the  $H_1$  alternative hypothesis that the consciousness of experimental student on sustainable development issue becomes significantly greater than control group. There are three dimensions in consciousness; economic, social and ecological. And second one is the  $H_0$  null hypothesis that the academic success of the groups does not change significantly. An academic knowledge test was applied for the examination second hypothesis.

## **2. Methodology**

### ***2.1. Study model***

The socio-scientific topics stemming from the nature of it should be handled in endurance both theoretically and practically at various perspectives. The ultimate result SD will eventually become apparent and achieved with the application of the SE program in formal and lifelong educations. Therefore, the resulting outputs and gains should be assed in "fit to purpose" perspectives. For there is a need to cover all the dimensions results due to nature of targets and results. Resultantly, in this study a mixed method; quantitative and qualitative analysis were applied to accomplish satisfactory measurement and assessment. This mixed method is shown in Figure 3. It has been advocated that,

harnessing both qualitative and quantitative measure results in more reliable and valid output and data in consistency akin to our study (Creswell, 2014).

For due to the complexity of SD, the progress on it can only be scrutinized and assessed evaluated abide by both quantitative and qualitative research that compromise both determinism and individualism. By this general rule sociologically governed by the society and individual physiological preferences such as feelings, values and decisions will have been covered. Therefore, both quantitative research and qualitative research was harnessed and preferred in this study. In general, quantitative research was assumed to measure generalized average score of objects such as academic achievement, and somehow contrary to this, qualitative research was accepted to measure the change in individuals' attributes such as feelings, values, opinions and behaviors in reflective and hermeneutic perspectives. The qualitative dimension of the research aims to gaze answer to the question "what does SESD program have an effect on the opinions of 5th grade students about SD?" The main feature of the qualitative study is the in deep investigation of one or more situations. Factors related to a situation are investigated with a holistic approach and focus on how they affect the situation and how they are affected (Miles & Huberman, 1994). The qualitative analysis supports the efforts to determine an individual's SD awareness, providing more information about human behavior changes. The qualitative analysis goes more deeply into the processes and outcomes in a situation by collecting more naturalistic data. However, it cannot be easily transformed into statistics to measure significant differences in the academic achievement. Quantitative analysis was used to determine academic success that was related to SD and the efficiency of the module program. In the quantitative dimension of this research, it is experimental to determine the effectiveness of SESD application in academic achievement test. Therefore, in the quantitative research pretest-posttest control group pattern was used in the study (Creswell, 2014). The dependent variable of the study is academic success. The independent variable is SESD. While this process was given to the experimental group, the control group was included only according to the current curriculum. Academic achievement of the students was measured before and after the implementation in the both experimental and control groups. The modular courses were harnessed and executed by the same researcher who is also science teacher of the classes.

The necessary ethical permissions were taken in direct written and oral communication with the letter of request through steps of the ministry of national education, province director and school manager. The subjects of experimental group are fully informed consent. And subjects of control group are not informed. The necessary permissions are gained with fully writing to ministry of national education within the control of school directorate. Possible beneficence to participants have been explained to school administration.

## ***2.2. Study group***

The study was conducted in a public primary school in İstanbul, Turkey. İstanbul is a metropolitan city with population around 15 million. Therefore, our study group is just geographically located in İstanbul province. Three fifth-grade classes in this school, with a total of 92 students, were all taken completely. The fifth grade is the first grade in the middle school of the K-12, known as lower-secondary level. This

fifth grade is just starting level for the abstract sustainability in national curriculum. Also, it is this ages that the students pass from concrete operational stage to formal operational stage. Yes, the effect of implementing the developed module program at higher grades can be more intrusive and differentiable. However, the fifth-grade students are free from any measurement examination pressure to select schools since they are newly involved the secondary school and also, the subjects related with sustainable development issues, such as biodiversity, clean environment, and energy is firstly introduced in national program. These would have allowed us a better chance for implementing of the research studies in untouched medium.

In order to determine the equivalencies of the experimental and control groups, one-way analysis of variance (ANOVA) was applied based on the students' achievement scores at the end of the previous academic year. The results of this analysis revealed that three groups were equivalent to each other ( $F = 0.085, p > 0.05$ ). From a random selection, pilot (5D), control (5A), and experimental (5D) groups were determined.

### ***2.3. SESD module program***

The SESD module program was created for fifth graders at the elementary school. A diagram explaining the stages of creating the module program is shown in Figure 4. The left side of the figure shows the preparations for developing the program, and the loop on the right side shows the creation and evaluation processes of the program. If the result is not sufficient in the evaluation of the program, it starts over until the result is sufficient, and the program can be implemented. The module program is also open for further development; thus, it can be sustainable.

The socio-scientific issues covered by the SESD program are biological diversity, energy resources, recycling, clean production, and the environment. The content and educational status items of the module, according to these themes, were considered together. In this regard, the contents, activities developed by the contents involving the active participation of the students, educational status, and lesson plans were created and prepared so that the module would reach its goals. The relationship between the activities followed for six weeks, the goals and performance are shown in Appendix A.

### ***2.4. Data collection tool***

#### **2.4.1. The academic achievement test**

The academic achievement test developed by the researcher was used to measure the academic success of the participants concerning SD. The academic achievement test has 23 questions related to sustainable development topics such as biodiversity, energy sources, recycling, and clean environment. Before developed test, researchers had written 23 gains for the target element of the SESD program. A total of 23 items were created, consisting of one item to represent each achievement towards these objectives.

The difficulty index of the test was calculated to be 0.58, and KR20 (alpha) and the reliability indices were 0.913 and 0.906, respectively. If the difficulty index of the test ranges from 0.4 to 0.7, this means the test has normal difficulty. Also, if KR20 (alpha) and the reliability indices are above 0.70, the test is reliable. These indices confirm that the academic achievement test is a well-grounded data collection tool in terms of reliability and validity.

## **2.4.2. A semi-structured interview form**

Interviewing is one of the most widely used data collection tools in the field of social sciences. The interview method is a technique of collecting data by way of verbal communication. An interview form comprising ten items to determine the views of the fifth-grade students regarding SD was prepared. The interview questions were coded as Q1, Q2, ..., Q10, as shown in Table 1. The main aim of these questions was to determine attributes such as feelings, values, opinions, and behaviors that were related to sustainable development.

The interview questions were related to SD (Q1–Q2), the relationship between SD, and the economy (Q3–Q4), the environment (Q5–Q8), and society (Q9–Q10). Each interview lasted around 15 min. The interview questions were developed according to feedback, which ensured validity and reliability by individuals who were experienced in qualitative research.

## **2.5. Process**

This study developed a module program for SESD and determined whether the program was effective. Figure 5 shows a diagram consisting of the steps for the development and implementation of the module program.

The module program was implemented with a pilot group of 30 randomly selected students. The execution of the program was realized by one of the researchers, who is a teacher himself. This was done to see the shortcomings before implementing it with the experimental group. The pilot scheme was used to determine how long it would take to complete the module program, and whether there were any unintelligible, failing, or missing parts. Some necessary changes, such as the period, and some unintelligible, failing, and missing topics were reorganized in the program. Making corrections and clearing up students' misunderstandings increased the reliability and validity of the module program. The module program (experimental group) and the current program (control group) were conducted by same one of the researchers, who is a teacher himself in the same school. The main difference between the experimental group and the control group was that the classes were taught so that all the topics were associated with SD.

The participants were informed about the program before it was implemented. In the classes included in the experiment, the SESD program was implemented for a total of six weeks for four hours a week on the chapter called "Visit and Get to Know the World of Living Beings." The experimental group completed the Engage, Explore, Explain, Elaborate, and Evaluate stages of the 5E model. In the 5E model, based on a constructivist approach, students used their curiosity, their desire to discover, and their prior knowledge in

a process highlighted by learning new information, to enable them to use this information in different situations, and then to evaluate the effectiveness of the information (Chen, Mineweaser, Accetta, & Noonan, 2018). Lessons were presented to the experimental group by using lectures, questions and answers, discussions, and visual techniques, as well as audiovisual teaching technology. Class 5A, the control group, discussed the same chapter following the current program except SEDS program. The control group completed the chapter in four weeks, with classes for four hours a week. While discussing the topics, the

## Table 1

Interview questions used to determine the students' views regarding sustainable development(SD).

Q <sub>1</sub>	<b>Could you please list the words come to your mind when you hear the phrase sustainable development?</b>
Q <sub>2</sub>	How do you think we should use the world's resources so that humans can continue living?
Q <sub>3</sub>	What does it mean to you that while the economy is growing, in other words, when people are making more money, the ecological balance is disturbed?
Q <sub>4</sub>	Does an increase in the number of factories financially contribute to people's lives? Why?
Q <sub>5</sub>	What do you think about the decrease in the number of the variety of species in the world or the extinction of species like dinosaurs and mammoths and the continuing extinction of some other living beings?
Q <sub>6</sub>	What do you think life at the class, school, in public and on earth would be like if billions of people in the world would share the same genetic makeup such as twins?
Q <sub>7</sub>	Are recycling, clean production, and environment essential for living beings on earth? Why?
Q <sub>8</sub>	Would you like to contribute to the solution of the problems around you personally? For example, would you like to participate in the projects of the municipality related to the environment and share your views about it?
Q <sub>9</sub>	Can we improve the living conditions of society by incredibly depleting the resources in the world? Why do you think so?
Q <sub>10</sub>	When we consider our ethical values (equality, solidarity, respect for nature, tolerance, sharing responsibility) and beliefs and how they direct our behaviour, how important do you think they are for the continued survival of living beings such as humans, bugs and plants?

control group was read to from a book on the topic published by the Turkish Ministry of National Education, and they provided examples from daily life. The activities in the course book were completed, and the researchers made the necessary explanations on the topic.

When the topic was completed, short formative assessment techniques, which are comprehension check questions and clarification requested related topic was used whether they understood it or not, and short repetitions were done. Later, there was an activity to discuss the topic again and solve the assessment questions in the course book.

## **2.6. Data analysis**

The levels of academic achievement between the experimental group, who were subjected to the module program prepared to establish SD, and the control group, who followed the current program, were analyzed using analysis of covariance (ANCOVA). Ancova provides great statistical power because it reduces the error difference. When there are differences between groups at the beginning of an experiment, this is a decrease in bias in the experiment. In this study, both the difference between the groups and the academic achievement pre-test results were controlled with ANCOVA (Wright, 2006). The pre-test score is the covariate to determine whether the post-test is significantly different. Before ANCOVA was performed, a Shapiro–Wilks test for normality was performed.

The semi-structured interviews were conducted by the data analysis stages developed by Creswell. These stages are: organizing and preparing the data, gathering general information, determining the codes, making the definitions, and interpreting the results (Creswell, 2014). In the study, the answers given to specific questions were compartmentalized. These units were coded according to some criteria, and the developed codes were presented in tables after being categorized under some subtitles.

## **3. Results**

The developed SESD module program was tested, and its findings and efficiency are discussed qualitatively and quantitatively under two main headings. The findings under the first heading are based on the qualitative research model that was used to determine the effects of the program on the students' views regarding SD. The findings under the second heading are based on the quantitative research model used to determine the effects of the program on the academic success of the fifth graders.

### ***3.1. Development of the SESD module program and students' views regarding SD***

The semi-structured interviews were conducted to determine the students' views regarding SD. According to students' academic achievement test results, three groups (low-middle-high) have been formed, each group consisting four members and were coded as S1 to S12. The participants were selected by basic random sampling method from groups. The answers obtained through the interviews were evaluated and analyzed according to SD and its economic, environmental, and social subcategories. Table 2 shows the frequencies of the students regarding the concept of SD and the economic, environmental, and social subcategories of SD.

When general views on SD were examined, it was found that before the program was implemented, the students were unable to explain SD and could not associate it with its different dimensions, but after it was implemented, they were able to understand the concept and associate it with the different dimensions. After the implementation, it was observed that the students were able to internalize SD and its dimensions, as well as topics such as energy resources, biological cleanliness, and clean environment.

During the interviews, students declared that they were willing to participate in projects to solve environmental problems; however, they were reluctant to have any relevant responsibilities. This finding shows that the students may not have participated in an environmental project, and even if they were willing to participate, they did not have the self-confidence or self-sufficiency to take responsibility. After the program implementation, all of the students wanted to participate in environmental projects and take responsibility. It was discovered that this program helped to improve motivation, self-confidence, and self-sufficiency among the elementary school students. When the views of the students regarding the economics and dimensions of SD are examined, it can be deduced that the SESD module program can be considered as a requirement for SD. Table 3 shows the students' views regarding the concept of SD and its' economic, ecologic, and social subcategories before and after program implementation.

This finding agrees with the direct quotes, as well as the frequencies of the subcategories of SD, which shows that the SESD module program positively affected the comprehension and explanation of SD, as well as its economic, environmental, and societal dimensions. This finding supports the argument that the SESD module program is effective. As an intermediate result the first hypothesis that the consciousness of experimental student on sustainable development issue becomes significantly greater than control group is confirmed with three dimensions.

## **3.2. Effects of the SESD module program on academic success**

The module program was developed and designed in such a way that it leaves it open for further development. The mean scores of the pre- and post-tests of academic success and the result of the ANCOVA are presented in Table 4.

The results of ANCOVA show that the most significant score increase from pretest to post-test occurred in the experimental group and that the smallest increase occurred in the control group, and the effectiveness of the module program between the groups was significantly statistically different ( $F(1, 59) = 58.1; p = 0.00$ ). The results also show that the pretest results affected the post-test gain ( $p < 0.00$ ). This indicates that the SESD module program had a significant effect on the academic success of the students. As a second immediate result, second null hypothesis that the academic success of the groups does not change significantly is not confirmed. This means that the academic success of the experimental is also improved with possible attitudinal positive effect of the module program.

Findings of the qualitative and quantitative analyses indicate that the SESD module program had a significant positive effect that would make the fifth-graders establish SD. The individuals in the grades

where the module program was implemented will be able to develop positive attitudes and values, in addition to making decisions and establishing SD. The individuals who internalize SD will make it possible to make the world more sustainable.

## **Table 2**

Frequency of students regarding the concept of sustainable development and its' economic, ecologic and social subcategories.

<b>SD and Its Economic, Environment and Society Subcategories</b>		<b>FBI</b>	<b>FAI</b>
SD	I have never heard of the concept of SD.	10	–
	SD means continuity.	1	10
	SD is a coordination of its economic, environmental, and social dimensions.	–	9
	We need to economize resources.	3	12
	We need to produce new resources increasingly	–	8
Economic	The environment should not be polluted to earn money.	8	11
	The use and processing of natural resources would help the economy to grow and support development.	–	7
	An increase in the number of environmentally friendly factories would financially improve humans.	2	8
	If the number of environmental pollutions increases, the general welfare of the public would decrease.	5	9
Ecologic	In terms of biodiversity, there is no problem in the extinction of species of living beings that are dangerous for humans.	4	–
	Nothing would happen if living beings became extinct.	4	–
	An increase in biodiversity would be beneficial to all living beings.	2	12
	There are conclusions about the undesirable outcomes of identical genetic characteristics.	4	11
	It is possible that if one of the living beings sharing identical genetic characteristics gets sick, the others might get sick too. Therefore, the species might become extinct.	–	6
	Recycling is related to the economic, social, and environmental dimensions of sustainable development.	–	8
	I would participate in projects to solve environmental problems, but I would not want to have any responsibility.	3	–
I would participate in projects to solve environmental problems, and I would want to have responsibility.	8	12	
Social	Depletion of resources is disadvantageous for society.	7	12
	New resources should be created and produced.	–	8
	Our moral values are unimportant for living beings.	2	–
	Our moral values are essential for living beings.	3	12
FBI, frequency before implementation; FAI, frequency after implementation.			

SD and Its Economic, Environment and Society Subcategories	FBI	FAI
Our moral values are essential for living beings, but I do not know why.	7	-
FBI, frequency before implementation; FAI, frequency after implementation.		

**Table 3**

Students' views regarding SD and its economic, environmental, and social subcategories before and after program implementation.

Subcategory	Student Question	View before Implementation	View after Implementation
Sustainable Development	S2-Q1	“When I hear about sustainable development, I do not think of anything. This is the first time I heard about it.”	“When someone talks about sustainable development, there are social dimensions, economic dimensions, environmental dimensions. Also, the event should continue without damaging the environment. All three things that I mentioned should be realized.”
	S6-Q2	“We might extremely deplete the resources. In this way, we will make more money.”	“Resources in the world are limited. Because one-day fossil fuels such as coal will be depleted, it would be better if we used renewable energy resources instead. We need to produce new resources increasingly.”
Economic dimension	S12-Q3	“Earning money is more important. The environment can be polluted.”	“We should not pollute the environment to make money, and we cannot develop; to the contrary, we might go back because we meet everything from nature. Animals, humans. Because economic growth is done by nature”.
	S5-Q4	“It would increase. But fishes can die due to waste left to the sea. As a result, dirty smoke from factories negatively affects people. Earning money is more important. The environment can be polluted.”	“It would increase. It would be better if we encircled industrial areas with flowers, animals, and other living beings. We can thus prevent dangerous wastes in the environment.”
Environmental dimension	S9-Q6	“God did not create us that way. What if he did? The stronger people could have been cruelled to us and use us as slaves. But you have the same strength? Then I would teach him a lesson. How would we live? It is nonsense, but what would happen if it did? Everyone would be powerful.”	“If someone gets sick, everyone else would also get sick. They all would vanish. Therefore, diversity is a good thing.”
Societal dimension	S11-Q9	“For example, if we cut a lot of trees, we would not be able to breathe. We should plant.”	“We can improve the living conditions by using the resources, but we need to reproduce the resources. We need to work very hard.”

Subcategory	Student Question	View before Implementation	View after Implementation
	S8-Q10	"I can say it is important. But I do not know why."	"It is important. Everybody has the right to live, and no one can intervene in that. Everyone should be treated justly."

**Table 4**

Mean scores of the pre- and post-tests of academic success and result of the ANCOVA.

Group	N	Pre Test	Post Test	Mean Corrected	Source	df	Mean square	F	Sig
Experiment	31	8.3	15.2	15.3	Pre-test	1	316.5	36.9	.00
Control	31	8.6	9.7	9.6	Group (Experiment/Control)	1	49.2	58.1	.00

## 4. Discussion And Conclusions

The success of the social transformation is seen not only in political initiatives but especially in social learning processes. As a result, education and teacher training, in particular, have to play a critical role in any change toward a more sustainable future. What is needed is a professional action movement that involves education for sustainable development (Bürgener & Barth, 2018; Vargas, 2000). SESD here is a trial conceptual framework to succeed this issue with the aid socio-scientific character of extracurricular and somehow outdoor activities. Hence, this module program was constructed on this framework for sustainability.

Globalization makes the underlying problems faced by humans more difficult and cumbersome, instead of accumulated human knowledge making things easier. As has often been mentioned at the United Nations General Assembly, the main problems of the modern world and society are sustainable development, protection of the natural environment, the fight against hunger and poverty, prevention of terror and anarchy, productive energy supply and recently pandemics. These political debates generally continue around the axis of the countries' level of development, the historical structuring of cultures and beliefs, and the prevention of possible natural disasters (Post & Meng, 2018). However, whether it is uttered explicitly or remains in implicit articulation, the leading term in all the debates is sustainability. New concepts were derived from well-known terms, and they began to be used with the concept of sustainability. Some of these are SD, sustainable agriculture, and tourism, etc. This study can be considered to have a connection with the 3Es of international literature: economy, ecology, and energy.

Our study was founded on a broad conceptual framework based on energy policies (Jain & Sachdeva, 2017). Our SD module is a trial for an appropriate conceptual framework amid many research studies. The solution is at the intersection of ecology, economy, and energy. We can call it SD, to increase this intersection and overlap, and to keep it at a certain level (Chen et al., 2018).

SD is such an emerging call and honest invitation for universal action to protect the unique Earth in order to make it possible for people to comfortably live in a just and peaceful world with our stakeholders of other species in wild life. This study prepared a SESD module program, aimed at realizing the universal call and urging people to take action and responsibility. SESD supports raising present and future generations as responsible citizens. Therefore, it has to be taken into account throughout the world (Onwu & Kyle, 2011).

It was previously determined that SD in the science education program in Turkey is limited (Aydınlı, 2014). This developed and implemented a module program for SESD is considered to be appropriate to solve this problem and fill this gap for fifth graders at an elementary school. At first glance the topics covered in this study seems inappropriate to teach fifth graders such as biodiversity, energy resources, recycling, clean production, and the environment. However, the module program covered them in such a way that the issues are internalized with the power semi outdoor extracurricular activities. It was also stated in the literature that these topics are appropriate for individuals who are in the final grades of elementary school (Commons et al, 1982). Probably, the reasons behind this semi suitability is the teachers' lack of preparation for teaching topics, which require higher levels of thinking skills, such as socio-scientific studies for SD, and some other conditions beyond the students' readiness (Eilam & Trop, 2013). Even some resources suggest starting to introduce socio-scientific issues to the preschool age group. With the implementation of the SESD module program for preschoolers, children will be able to think about the components of SD at a basic level and will behave accordingly (Raikes, 2017).

The SESD module program can contribute to the development of students' understanding of SD, growing up as science-literate individuals, and developing scientific process skills and life skills (Correia et al., 2010). In this way, individuals will may have the ability of taking critical decisions about biodiversity, recycling, clean production, and the environment, energy, and water consumption, and will act accordingly. These facts are in agreement with the findings of this study. The affirmative frequencies of students' views on socio-scientific issues on SD becomes higher after the implementation of this study. It can be revealed that the students' views on SD and its economic, environmental, and social dimensions have been improved (Kieu et al, 2016). Other studies are supporting these findings (Kieu et al., 2016; Sewilam et al, 2015). It can be expected that the developed module program will help elementary school students to have a higher level of awareness and understanding of SD and its environmental, social, and economic dimensions. The program as aforementioned includes and unifies extracurricular activities such as transforming wind power, biodiversity, and discussing science in social implementations. This can foster sustainable lifestyles, and thus, the world can become more sustainable. With the help of this program and its extracurricular activities, students become more aware of biodiversity, renewable energies, recycling, and sustainable development, with adapted narratives, models, scenarios, and

practical activities. These developed skills can be assumed as higher order thinking skills. Moreover, studies on SD conducted at the university level indicate that there is a need for the concept and dimensions of SD to be mentioned more often in higher education programs (Kagawa, 2007).

It may be revealed that the SESD module program would have a positive effect to some extent on the academic success of the fifth graders at the elementary school. Some other studies are partially supporting this result (Burmeister & Eilks, 2012; Dymont et al., 2014; Gustafsson et al, 2015). Also, studies are indicating that programs developed to increase the efficiency of SD are useful in obtaining SD outcomes (Kieu et al., 2016). Merely, increasing the work time for any subject eventually results in some positive deviations and attitudes of that subject. Since human nature develops positive attitudes towards things that he has struggled for. Thus, it can be assumed that SESD may affect the attitude resulting in some behavioral change only if the three dimensions of SD are addressed simultaneously (Gagnidze, 2018). Therefore, it is thought that the module program may have facilitated these outcomes in this study. This can be a local and cultural example for dissemination of education for sustainable development for world-wide.

## **4.1. Limitations and future research directions**

The research has some limitations. The research reported here is limited to fifth grade students with a science course. Therefore, research data is limited to students' academic achievement and their views on the SD. Although the same chapters (Visit and Get to Know the World of Living Beings) are applied in the experimental and control groups, the lack of sustainable development in the control group is the limit of the research. Here, the independent variable is the SESD module program associated with the chapter, and the dependent variable is the academic achievement test related to SD. Actually, there is not much increase in the academic achievement of the control group students due to the fact that the subject of sustainable development is not covered in science course. This is another limit of this research. It is known that more than one factor is effective in an individual's behavior. It is uncertain whether the students will actually apply the principles and values of sustainable development in daily life after this study. However, the research results reveal the positive effect of the SESD module program. Despite its limitations, we highly recommended that other studies should carry out similar studies that will increase the effectiveness of sustainable development. It is recommended to apply this program or similar module programs in different places and cultures.

Now, ESD takes some level priority in proximate education policy all around the world. It is suggested that Turkey like all countries should pay more attention on formal and extracurricular outdoor activities on SD in all level even at preschool and universities. Thus, one of the cliché is allocating enough time and course in the programs. This study resulted in an artefact of an alternative module program to diminish this need. The program is sufficiently flexible to updating and upgrading trials. The training of the teachers and trainers about this issue is subject and object of further improvement. (Bürgener & Barth, 2018).

In this state, the sustainability concept is about a socio-scientific goal because it consists of both natural and social sciences. Hence, it is under consideration for inclusion in social programs, in addition to science programs. The best method would be to discuss this topic with a holistic and integrated approach. The concept of sustainability is based on the relationships between several scientific concepts such as energy, entropy, sociology, citizenship, and entrepreneurship. We can deduce and obtain more tips on how to create a world where we can live in peace, thanks to such studies focusing on socio-scientific issues. The concept of “sustainability,” the same word as the journal title, though under investigation for several decades, has not been comprehended in various dimensions regarding the dependent and independent variables.

## Declarations

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# Figures

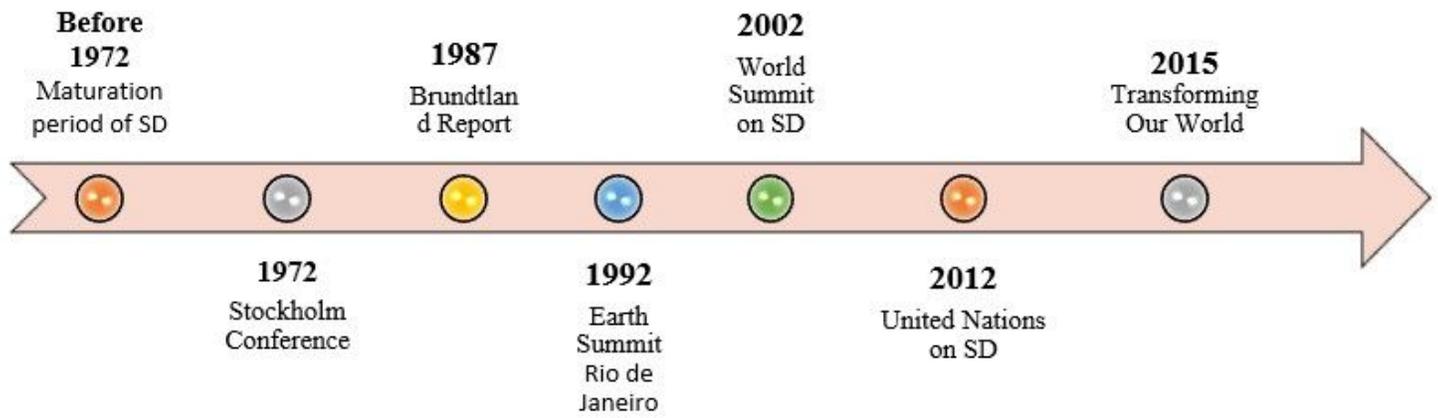


Figure 1

Historical Aspect of Sustainable Development (HSD)

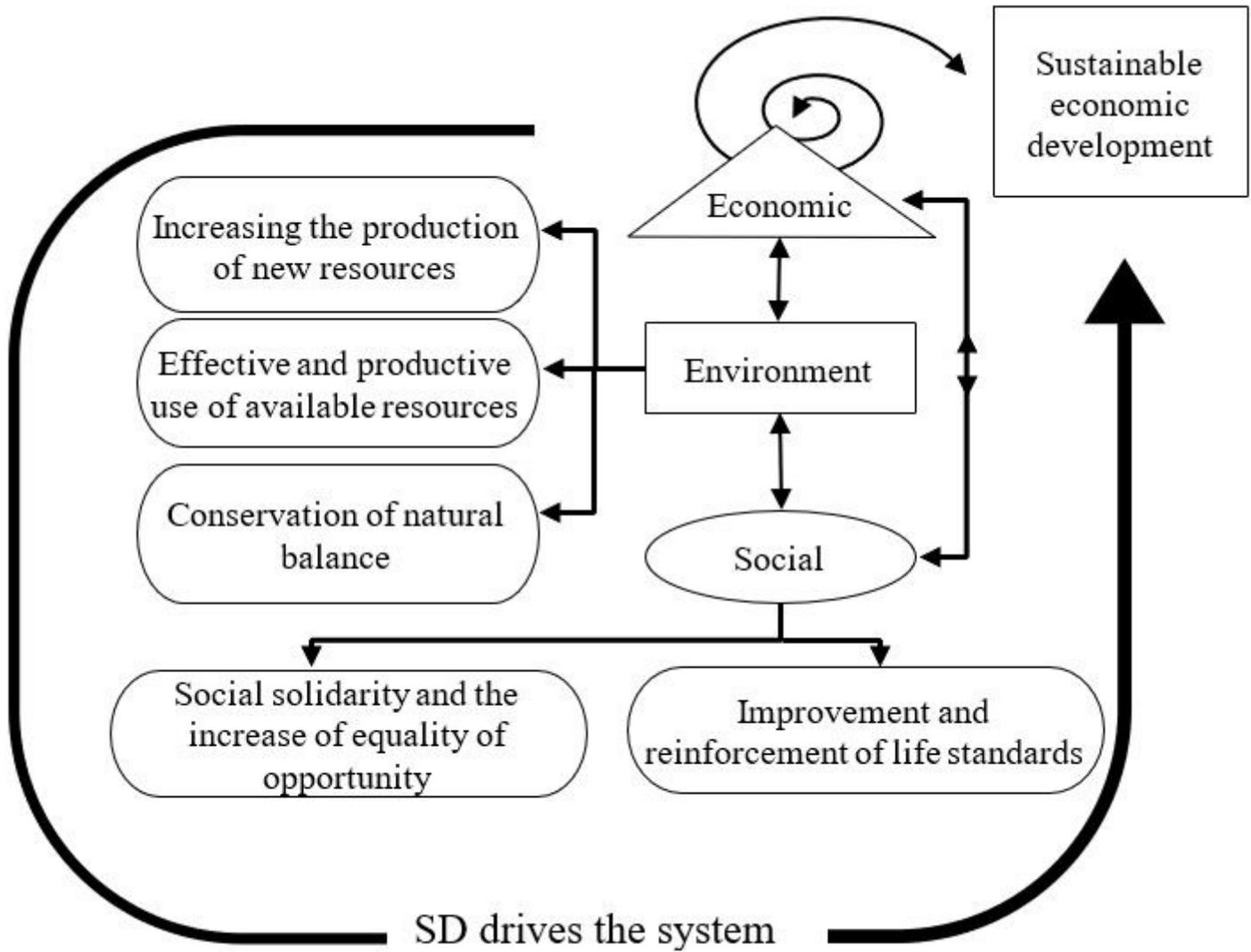


Figure 2

The relations between sustainable development (SD) and the environment, society, and economy.

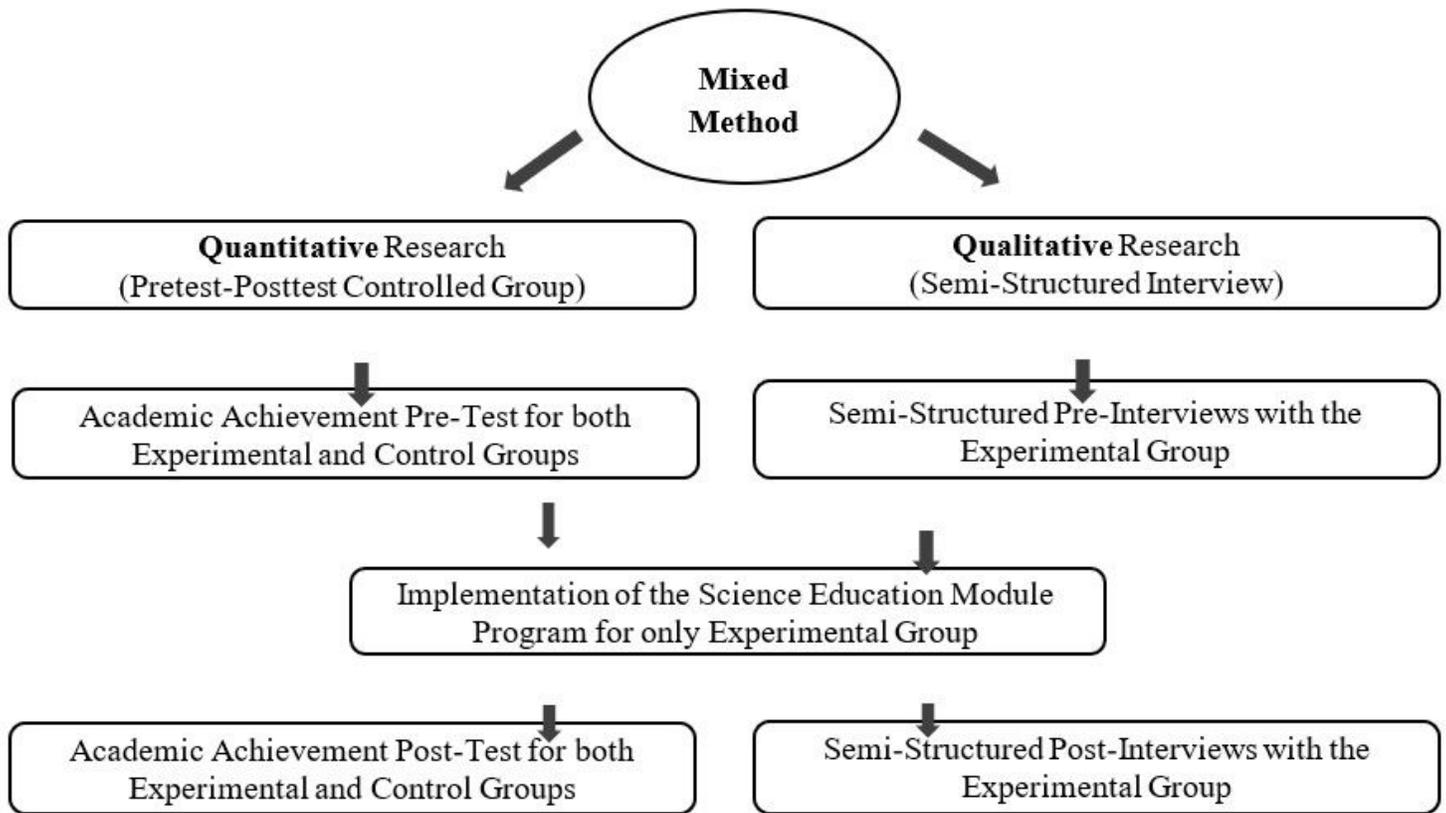
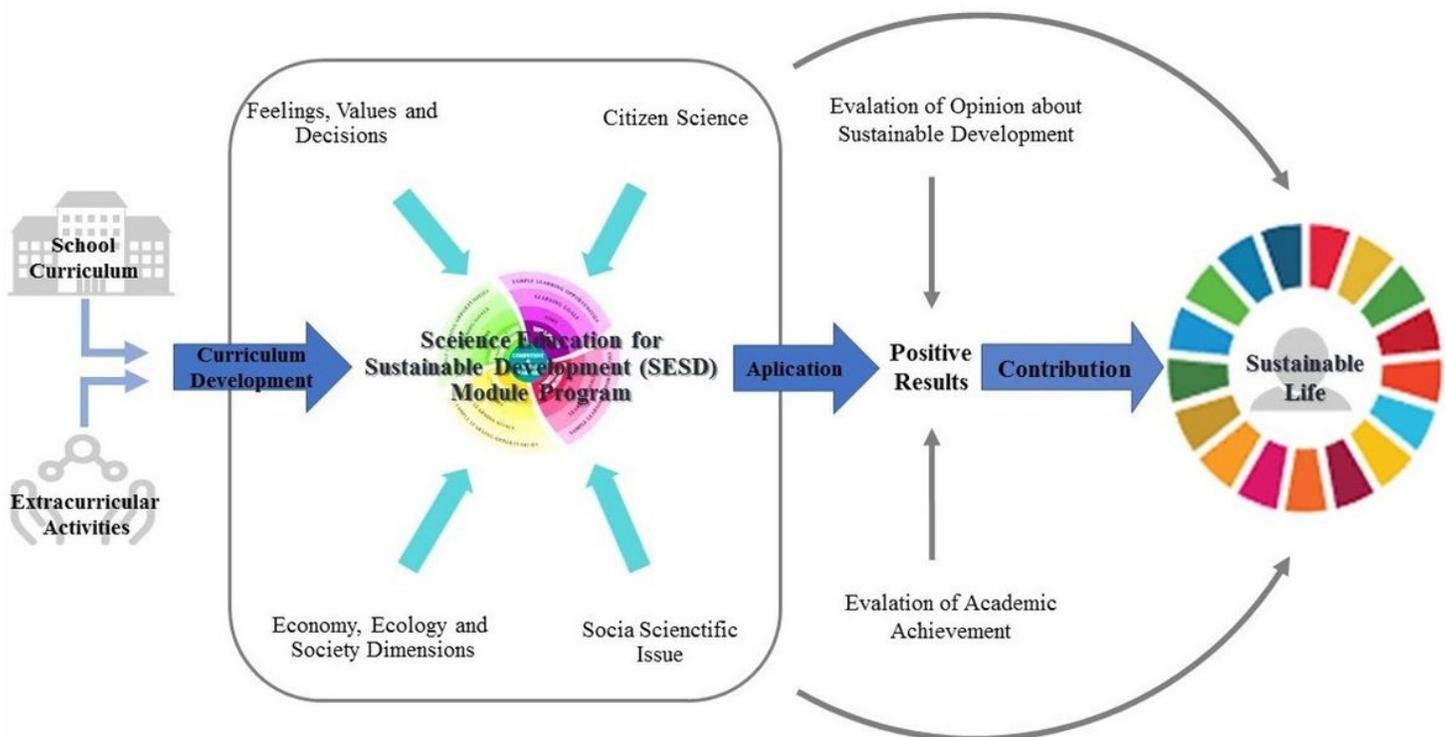


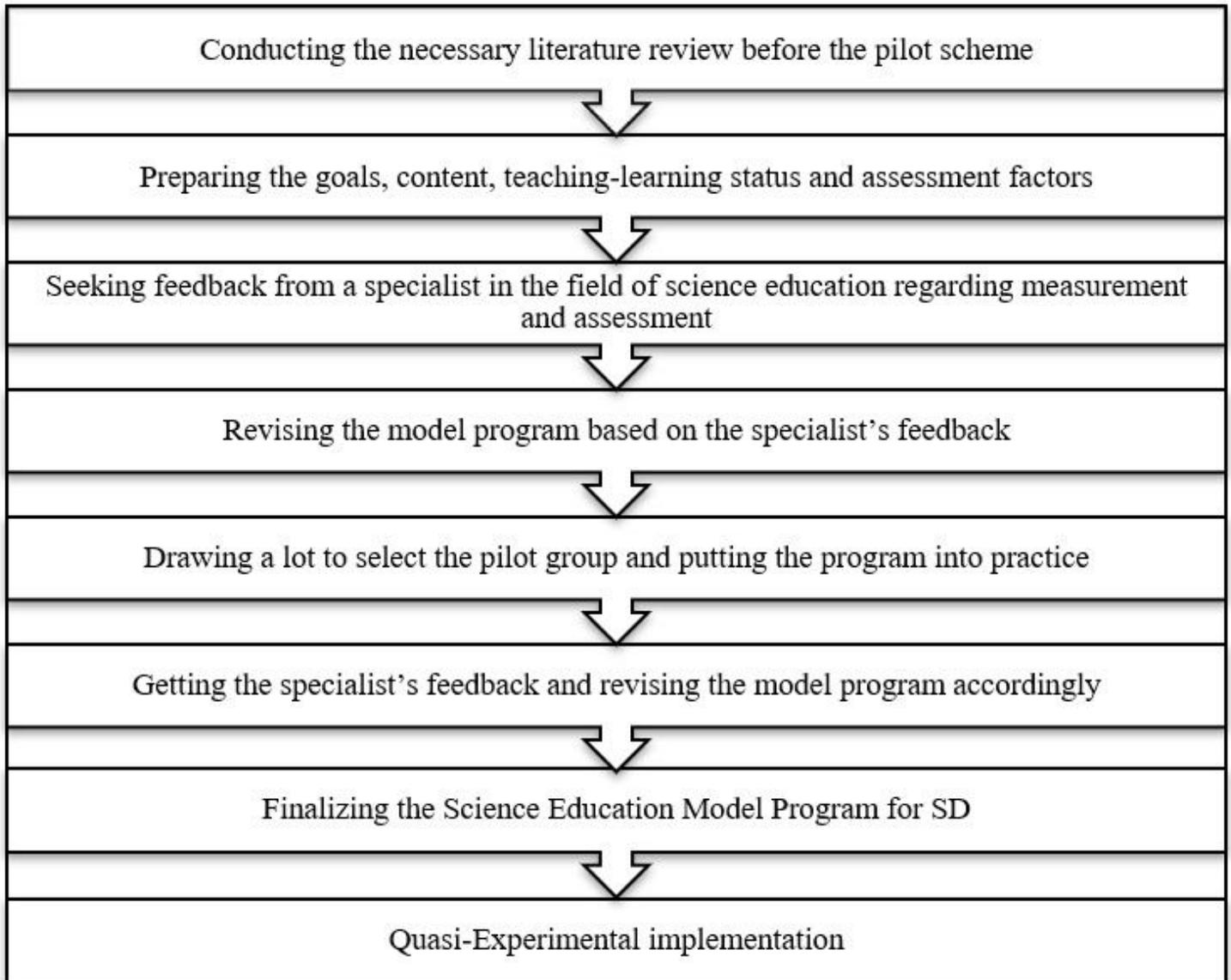
Figure 3

Mixed methods used in the study.



**Figure 4**

Development of the science education for sustainable development (SESD) module program.



**Figure 5**

Operational steps for the preparation and implementation of the module program.