THE EFFECT OF AN ONLINE TEACHING MODULE ON THE ACADEMIC ACHIEVEMENT AND CONCEPTUAL LEARNING OF MIDDLE SCHOOL STUDENTS ON SUSTAINABLE DEVELOPMENT[1]

ÇEVRİM İÇİ ORTAMDA UYGULANAN BİR ÖĞRETİM MODÜLÜNÜN ORTAOKUL ÖĞRENCİLERİNİN SÜRDÜRÜLEBİLİR KALKINMA KONULARINDAKİ AKADEMİK BAŞARILARINA VE KAVRAMSAL ÖĞRENMELERİNE ETKİSİ

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Abstract

This study aimed to examine the short and long-term effects of the teaching module, which was developed to include all three dimensions of sustainable development, on the academic achievement and conceptual learning of middle school students. The module, which consists of a total of ten parts, has been applied in the online environment for eighteen hours. In the research conducted with 7th-grade students consisting of 14 students in total, a quantitative research design was used. The data were collected through an achievement test for sustainable development goals and a concept map. They were applied to the students three times, before and after the intervention, and five months after again for retention. Quantitative data collected as a result of this study revealed that the module facilitates students' academic achievement and learning concepts about sustainable development. On the other hand, the fact that the retention test scores of the concept map either remain stable or decrease reveals that there is more to be done to structure the sustainable development concepts, which is a new subject.

Keywords: Sustainable development, teaching module, online, academic achievement

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[1] The data used in this study includes some part of a doctoral thesis completed by the first researcher and under the supervision of the second researcher.

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Özet

Bu araştırmanın amacı, ortaokul öğrencilerine yönelik geliştirilen ve çevrim içi ortamda uygulanan sürdürülebilir kalkınma öğretim modülünün öğrencilerin akademik başarılarına ve kavramsal gelişimlerine olan kısa ve uzun süreli etkisini incelemektir. Toplam 14 öğrenciden oluşan 7. sınıf öğrencileriyle yürütülen araştırmada nicel araştırma yaklaşımı kullanılmıştır. Veriler, süürdürülebilirk kalkınma başarı testi ve kavram haritası yoluyla toplanmıştır. Bu testler, öğrencilere uygulama öncesi ve sonrası ile kalıcılığı ölçek amacıyla uygulamalar tamamlandıktan beş ay sonra olmak üzere üçer kez uygulanmıştır. Bu çalışma sonucunda toplanan nicel veriler modülün öğrencilerin akademik başarılarını ve sürdürülebilir kalkınma konusundaki kavramları öğrenmesini oldukça kolaylaştırdığı ortaya koymuştur. Bununla birlikte, özellikle kavram haritası puanlarının kalıcılık testi puanlarının ya stabil kalması ya da düşmesi yeni bir konu olan sürdürülebilir kalkınma kavramlarının zihinde yapılanabilmesi için yapılacak daha çok şeyin olduğunu ortaya koymaktadır.

Anahtar Kelimeler: Sürdürülebilir kalkınma, öğretim modülü, çevrim içi, akademik başarı

Introduction

Besides the Covid-19 pandemic, which is among the biggest problems of today, and also the economic difficulties caused by it, hunger and poverty, unemployment are among the problems that the whole world has to struggle with. These issues, which can also be described as global problems, can occur in three ways environmental, social and economic. As stated in the Living Planet Report published by the World Wildlife Fund (WWF) in 2010, it can be argued that the problems in question are largely human-induced due to the increase in unconscious consumption of people in recent years (WWF, 2010). The complete elimination of these problems, in which people are mostly at the center, is directly related to the permanence of the measures to be taken. At this point, the importance of the concept of sustainability and sustainable development [SD] emerges. The concept of "sustainable development" was first defined in the report of the World Commission on Environment and Development in 1987, as "development that can meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987; p. 272). What needs to be done today to leave a resource base for future generations, no less than what we have inherited from previous generations, can be shown among the objectives of sustainable development (Yakar, 2005). The most effective solution to be applied for this purpose is undoubtedly through education.

Education for sustainable development [ESD] aims to bring knowledge and behaviors to individuals by putting the environment, society, and economy at the center and adopting this behavior as a lifestyle (Engin, 2010). Associating the obtained information with daily life is possible by internalizing the subjects and transforming them into behaviors. Especially middle school 6th, 7th, and 8th-grade students and high school students in the 21st century. Being able to acquire features such as analyzing, comparing, establishing abstract relationships, producing something original, and critical thinking, which is also known as skills, requires activities of this nature to be included in the curriculum (Senemoglu, 2010). At this point, it is very important to raise individuals who are sensitive to their environment in the curriculum. For students to actively participate in the prevention and solution of environmental problems in their country in terms of sustainability, cognitive, affective, and psychomotor areas should be given the required importance as a whole (Derman, 2013). The basis of sustainable development is to create a positive change in the behaviors and attitudes of individuals (Uzun, 2007). In this context, curricula should have educational situations that will provide students with mental and manual skills rather than knowledge. Environmental education for students must be based on sustainable development goals (Ozdemir, 2007; Turer, 2010).

For these reasons, there is a direct reference to the subject of sustainable development in the science curriculum in Turkey (Ministry of National Education [MNE], 2018). There is

some research in which education plays an important role in sustainable development and that educational activities should be reorganized in this context (Ozsoy, 2019; Spiropoulou et al., 2007). In particular, raising individuals with high awareness of the world they lived in, organized changes in behavior and social justice, equality, peace, and economic sustainability can be left as a legacy to future generations (Contini & Pascual, 2010). It has also been explained in the literature that this type of behavior takes more time than cognitive learning because it also includes affective learning (Gomleksiz & Kan, 2012; Koc & Demirel, 2008). The time allocated to environmental issues is very limited (Yilmaz-Yildiz, 2006) reveals that although the subject of sustainable development is included in the curriculum, sufficient importance is not given in the teaching process (Kucuk & Burkaz Ekinci, 2021). In particular, dealing with the subject only at the 8th grade level in the science curriculum is not sufficient for a thorough understanding of the comprehensive nature of the subject. Within the scope of the science course, it is important not only to stay at the conceptual level but also to acquire the skills related to the subject (Kucuk & Burkaz Ekinci, 2021). However, as mentioned above, the acquisitions with this content are not gains that can be observed in a short time, so both teaching and evaluation take a long time.

For this reason, while teaching within the scope of formal education is seen as insufficient in some cases, it is necessary to provide holistic education with the activities provided in informal and non-formal education environments (Kucuk, 2021; Zachariou & Valanides, 2006). In this context, schools should be organized by environmental education, and environmental-based projects should be increased in terms of quality and quantity with different environmental organizations or voluntary organizations (Tanriverdi, 2009). Emphasizing that this renewal generally covers the university level can leave other age groups behind in this regard. However, education is needed to strengthen knowledge, research, and cooperation at all educational levels related to SD and ESD (Spiropoulou et al., 2007; Tuncer, 2008; Wee et al., 2017).

It is noteworthy that while the environmental dimension is emphasized in the studies on the subject area of SD, the theoretical basis of which is constructed in three dimensions, the other two dimensions are not taken into account sufficiently (Kucuk & Burkaz Ekinci, 2021). Demirbas (2011) emphasized in his study that the content of education for SD, unlike environmental education, should include the economic and social effects and results of natural resource use as well as its environmental effects. For these reasons, it is an important problem to examine the short and long-term effects of a teaching module designed to include all dimensions of SD and the details which are included in the method section, on the academic achievement of students in related sustainable development. Academic achievement or academic performance is the extent to which a student, teacher, or institution has attained their short or long-term educational goals (Moore, 2019). In this context, academic success in the current study is related to the extent to which students conceptualize sustainable development goals in the relevant questions and how they define them.

This study aimed to examine the short and long-term effects of the teaching module, which was developed to include all three dimensions of sustainable development, on the academic achievement and conceptual learning of middle school students.

METHOD

This paper is part of a major project designed for sustainable development education based on a mixed research approach that combines qualitative and quantitative research. Due to the Covid-19 outbreak that started at the beginning of 2020, the intervention was carried out through online education and via the zoom application, which the students are also quite familiar with from other formal school courses. In the present study, we measured the academic achievement of the intervention group. For this purpose, an achievement test and also a concept map designed for sustainable development goals were applied to the sample three times before, after, and five months after the intervention.

The Sample

The sample of the research consisted of the 7th grade of a public middle school located in the Çayeli district of Rize province in Turkey. 10 girls and 4 boys were determined by purposeful sampling. Purposive sampling allows for in-depth research by selecting information-rich situations depending on the purpose of their studies (Cresswell, 2003). It is preferred when it is desired to work in one or more special cases that meet certain criteria or have certain characteristics. In this context, students who had an informal learning experience in previous years were knowledgeable about environmental issues, were willing to learn, and fully participated in the online classes at the school were selected. These students were informed about the research by both their families and the science teacher, who is the third author of this study. In this way, all of them participated in the study voluntarily.

The process schedule of the research is given in Table 1 below.

Table 1

Process chart of the research

Group	Pre-test	Intervention	Post-Retention tests
7th-grade students	Sustainable Development Achievement Test Sustainable Development Concept Map	Sustainable Development Teaching Module	Sustainable Development Achievement Test Sustainable Development Concept Map

Data Collection

Data were collected through a sustainable development achievement test and a sustainable development concept map developed by the first researcher (Burkaz-Ekinci, 2021).

Sustainable development achievement test

The sustainable development achievement test used in this research consists of twelve open-ended questions. Table 2 shows the relationship between the dimension of sustainable development and the questions.

Table 2

The relationship between the questions in the test and sustainable development

Subject Areas	Dimensions of Sustainable Development			Question Number
	Environment	Social	Economy	
End Hunger and Poverty		X	X	3
Health and Wellbeing	X	X	X	5, 6
Gender Equality, Employment			X	2
Access to Healthy Water/Life in Water	X			5, 8
Accessible Clean Energy	X		X	7
Sustainable Cities	X	X	X	1, 10
Conscious Production and Consumption		X	X	11
Life on Land	X			9
Dimensions of Sustainable Development		X		4

While preparing for the test, firstly the science curriculum (MNE, 2018) was examined and the acquisitions that could be related to the subject were determined. By

determining the achievements that will reflect the objectives of sustainable development, the current gains were arranged in a way that is related to sustainable development and a list of re-acquisitions has been created. To ensure the content validity of the test, an expert who is an expert in the field of sustainable development was asked to conduct a content review. At the same time, a science teacher with seven years of experience examined the test in terms of scope and content. In addition, a Turkish teacher examined the questions in terms of spelling rules and grammar. Necessary corrections were made in line with the opinions determined as a result of these examinations. After the partial corrections, the pilot application of the test was carried out with seven middle school students. Since the meaning of the word "employment" in the second question of the test from the pilot application was asked, it was corrected by giving its meaning in parentheses. In addition, the ecological footprint ranking in question 6 was also changed to "… can you rank them from largest to smallest?". The test time is set to 45 minutes. In addition to the achievement test, a rubric was also prepared that can be used for scoring.

There are some questions that students can comment on through sample scenarios, as well as questions measuring comparison and ranking features. In addition to this, there are also questions about the topics that are frequently mentioned in the visual media, which are up-to-date and can attract the attention of the students while the question content is being prepared. For example, the third question of the achievement test, which includes the achievements designed to eliminate hunger and poverty, can be given. On the other hand, students were asked to interpret by asking a graphic question. In another question designed with a concept cartoon, students were asked to make a choice by seeing different ideas about the subject together and to write their thoughts by justifying them accordingly (Question 4). In another question, two different photographs of the same place, taken one year apart, were included to compare environmental pollution. Here an example of a question (in Turkish) and scoring key used in the achievement test is presented below.

5) Tarım ve Orman Bakanlığının 17.11.2020 tarihinde yaptığı habere göre; İstanbul'a su sağlayan barajların doluluk oranı % 27, Ankara'nın ise % 13 olduğunu belirterek, hiç yağış olmaması durumunda İstanbul'un yaklaşık 3 ay, Ankara'nın da 5 aylık suyunun bulunduğunu açıkladı. Türkiye' nin en çok yağış alan ili olan Rize de ise bu yıl yağışların az olması sebebi ile su sıkıntısının yaşanacağı belirtilmiştir.

Aşağıdaki resimde ise Burdur Gölü' ne ait değişimi görmektesiniz. Su miktarı yıllar içinde azalmakta ve belki de birkaç yıl için de göllerimiz çölleşebilecektir.

Burdur Gölü Uydu Görüntüleri — 1990 — 2000 — 2010

Yakın zamanda bunun benzeri resimleri artık her yerde görebiliriz. Sizce bu duruma neler sebep olmuştur?

....
....

Suların azalması ile birlikte suda yaşayan canlılar hakkında neler söyleyebilirsiniz?

....
....

Figure 1. A sample question of the sustainable development achievement test

This question was evaluated using the scoring key below.

Table 3

Scoring key of the fifth question

Score	Content
3	The student can explain the causes of water scarcity and the effect of this situation on both humans and aquatic creatures.
2	The student can explain the cause of water scarcity, but cannot link its effect on aquatic organisms.
1	The student can construct the causes of water scarcity through just one example.

Item discrimination (rj) and item difficulty (pj) indices for each question in the test are also calculated with Nitko (2004) formulas and given in Table 4. Based on this table, it is revealed that the item difficulty of the questions varies between 0.47 and 0.90, with an average of 0.70 and the item discrimination varies between 0.11 and 0.55 with an average of 0.30.

Table 4

Item analysis (pj,rj) results of the sustainable development achievement test

Question No	pj	rj
1	0,71	0,11
2	0,76	0,33
3	0,71	0,44
4	0,47	0,11
5	0,76	0,44
6	0,71	0,22
7	0,66	0,55
8	0,90	0,22
9	0,61	0,11
10	0,61	0,44
11	0,80	0,33
Mean	0,70	0,30

Sustainable Development Concept Map

Concept maps are diagrams that show concepts and the relationships between them (Novak & Gowin, 1984). Concept maps can be developed hierarchical or non-hierarchical according to the content of the subject (Yin et al., 2005). Concept maps can be used both as a teaching tool and an assessment tool. In this research, a non-hierarchical concept map was prepared considering the criteria determined by the experts. In this study, a concept map was used as an evaluation tool rather than a teaching tool. By Sustainable Development Concept Map, the concepts that the students associated with sustainable development were determined. To measure the content and comprehensibility of the sustainable development concept map, an expert in the field of sustainable development was consulted. Similarly, it was tried to measure whether there was a problem with spelling by having a Turkish teacher read it. There are ten spaces in the concept map. Student scores were calculated by giving 1 point for the correct concept in each blank and 0 points for the wrong concept. The highest possible score was set as "10" and the lowest score as "0". The test time is set to 20 minutes. In this direction, the correct and incorrect concepts written by each student on the concept map were analyzed.

The teaching method and content analysis of the sustainable development module

A total of 10 teaching modules were designed within the scope of sustainable development. The module took a total of eighteen hours. The teaching of the module was done by the first researcher. Each of these is designed for specific sustainable

development goals. For example, the content analysis of the 8th module for "Access to Healthy Water/Life in Water" and the related course learning outcomes are given in table 5.

Table 5

The sample content analysis of the sustainable development module

Course Number	Sustainable Development Goal	Time	Course Outcomes
8	Access to Healthy Water/ Life in Water	40'+40'	8.1. Based on the information that "According to the 2019 World Water Report prepared by UNESCO, which is affiliated to the United Nations, two billion people do not have regular access to clean water resources, 4.3 billion people do not use sanitary facilities", they express the disasters that water waste will bring along.

In the teaching process, the 5E model of constructivist learning was used. As an example, the teaching process within the scope of course number 8 is explained below.

In this module, students are made to realize that access to clean and healthy drinking water is a fundamental human right, how harmful chemicals and garbage affect the quality of water, that water is a rich ecosystem for many species, and that persistent pollution will endanger many species. Instead of the water treatment plant that is planned to be taken for the treatment of dirty water, a video about how the water treatment is carried out is watched because the intervention is made online. Then, an experiment is conducted to show/see how the dirty water is cleaned. Students are expected to fill in the designed V diagram in line with the experiment done in the lesson. In addition, the information note titled "A Little Information About Water" was shared in the lesson and it was presented with striking information about saving water. In the evaluation phase of the course, to encourage students to be careful when using water, they were asked to follow the water meter in their home and tabulate the previous data with the data after tooth brushing. In this way, they are expected to see that the difference in the meter is small if water is used carefully.

Data Analysis

The Sustainable Development Achievement Test consists of 11 questions. The lowest score that can be obtained from this test is 11 and the highest score is 33. The normality test was applied to the pre-test, post-test, and retention test scores filled in by the sample group online. After confirming that the scores were normally distributed, the related t-test was used in pairwise comparisons in the SPSS program. The Sustainable Development Concept Map was organized to include 10 gaps (concept and relationship). This measurement tool, which was filled in online on the sample was applied three times before, after, and five months after the intervention was completed. While the lowest score that the students who filled the concept map could get was 0, the highest score was determined as 10. While examining the students' answers, the concepts and relationship levels that can be included in the correct answer category were determined before the analysis and scoring were made. All analyzes in this process were repeated by the third researcher in an independent environment, and consistency checks were made. Partial analysis differences that emerged in this process resulted in a consensus in a meeting moderated by the second researcher. After confirming that the scores were normally distributed, the related t-test was used in pairwise comparisons in the SPSS program.

<div align="center">

RESULTS

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The results obtained from both tests were presented below. Table 6 shows the data for the comparison of all three-time scores of the sustainable development achievement test.
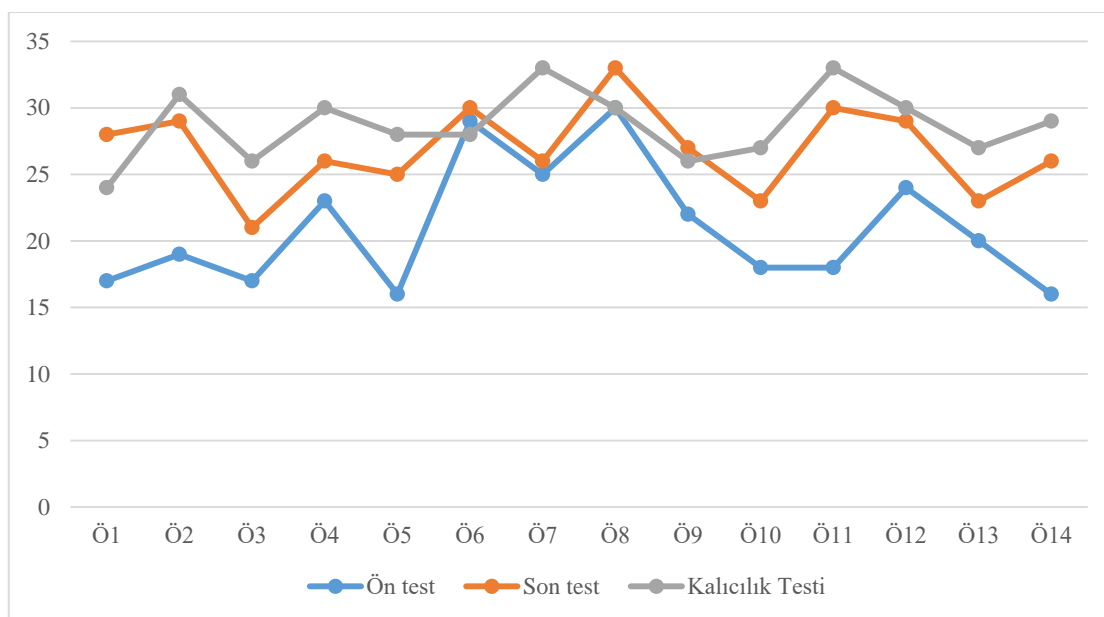
Table 6

Related t-test analysis results of the sustainable development achievement test

	$\bar{x}$	N	s	Std. Error
Pretest-Posttest	21,0		4,64	1,24
	26,86	14	3,25	,87
Posttest-Retention test	28,71		2,64	,71

Table 6 shows that the achievement test results of the students were $\bar{X}$ (pre)=21.00 and increased to $\bar{X}$ (post)=26.86. The mean score obtained from the retention test was calculated as $\bar{X}$ (permanence)=28.71. The dependent t-test results indicate a significant difference in favor of post-test scores ($p < .05$). On the other hand, the pairwise comparison between the retention test scores and the posttest scores indicates that there is no significant difference in terms of decrease or increase (p=,051).

Figure 2 includes the pre-post and retention tests of the sustainable development achievement test for each student. It is seen that there is an increase in the scores of all students. For example, while the S8's pre-test score was 17 at the beginning, it increased to 28 at the post-test. Similarly, while S6's pre-test score was 18, it also increased to 30 in the post-test. The maximum and minimum score increases from the achievement test can also be seen clearly in Figure 2. While the highest score increase was observed in S6 with 12 points, the least score increase was observed in S5 at just 1 point (pretest=25, posttest=26).

*The blue line represents the pretest, the orange line the posttest and the gray line the retention test data.

Figure 2. Pre, post, and retention test results of the sustainable development achievement test for each student

Table 7 shows the data for the comparison of all three-time scores of the sustainable development concept map.

Table 7
Related t-test analysis results of the sustainable development concept map

	$\bar{x}$	N	s	Std. Error
Pretest-Posttest	5,93		2, 34	,62

	8,43	14	1,74	,46
Posttest-Retention test	8,79		1,12	,30

The scores obtained from the concept map, which can get a maximum of 10 points, were analyzed according to the pre-test and post-test and presented in table 6. Based on this table, it is observed with the concept map that the students knew which concepts about sustainable development before intervention and how they related them to each other. The concept map test results of the students were X́ (pre)=5,93 and increased to X́ (post)=8,43. The mean score obtained from the retention test was calculated as X́ (retention)=8,79. The dependent t-test results indicate a significant difference in favor of post-test scores (p < .05). On the other hand, the pairwise comparison between the retention test scores and the post-test scores indicates that there is no significant difference in terms of decrease or increase (p=,208).

Figure 3 includes the pre-post and retention tests of the sustainable development concept map for each student. It is seen that there is an increase in the scores of almost all students. The increase is between 1 point and 5 points. While the highest increase in conceptual understanding was observed in S1 (5 points), the least increase in scores was observed in S3 and S13 (1 point). In addition, only one student had a full score (10) in the pre-test, while this number increased to 9 in the post-test. There was a one-point decrease in the post-test scores of two students compared to the pre-test (S4 and S14).
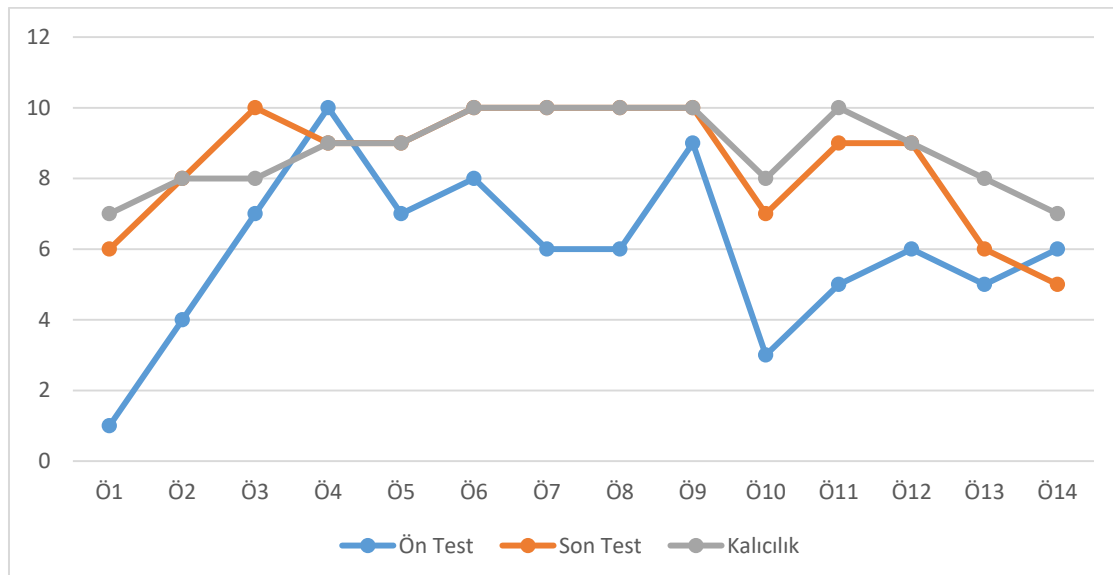

Figure 3. Pre, post, and retention test results of the sustainable development concept map for each student

DISCUSSION AND CONCLUSION

This research, it was aimed to examine the effect of a sustainable development teaching module designed for middle school students and implemented in an online environment on students' academic achievements towards sustainable development goals and their conceptual understanding of sustainable development. It is noteworthy that almost all of the studies in the literature measure characteristics such as attitudes towards sustainable development and awareness rather than success as learning outcomes (Al-Naqbi & Alshannag, 2018; Balakrishnan et al., 2020; Zainordin et al., 2017). These learning outcomes, on the other hand, are far from being the outcomes of a program that will adequately cover all dimensions of sustainable development, including environmental, social, and economic. At this point, first of all, there is a need for a design for sustainable development education in a theoretical sense, which includes the dimensions of the subject in a sufficient and balanced way. In this context, it is clear that the module employed in the current research is sufficient because it focused on all the

objectives of the sustainable development issue and receives the approval of experts in the field. On the other hand, when measuring the effect of the module on academic achievement, there was a need to use a new test consisting of inclusive and open-ended questions instead of using multiple-choice or another measurement tool in which students could not express themselves fully (Kucuk & Yildirim, 2021).

In this study, an open-ended achievement test designed by the first researcher on sustainable development was used. The questions in this test have been prepared in such a way as to reflect the content of each module in the instructional design. In this way, both the short-term and long-term effects of the recruited module are explained. For this purpose, the test was applied three times at the beginning and end of the intervention and five months after the intervention to measure the retention. To provide scoring objectivity, a newly designed scoring rubric was used by the first researcher. The data obtained in this way revealed that the academic achievement averages of the students on sustainable development increased in the posttest. In the analysis made at this point, it was concluded that the increase was statistically significant. Similarly, the decrease in the standard deviation values in the post-test revealed that the student scores became homogeneous in terms of academic achievement in sustainable development, which is the measured quality. One of the most striking results of this study emerged in the retention test. Retention scores of the test were higher than the post-test scores. This situation means that students do not forget the teaching achievements they have gained with the sustainable development teaching module and they develop them. In short, by the nature of the sustainable development issue, it has been achieved to some extent that the achievements can be sustained.

Even if the increase in academic achievement in sustainable development as a learning outcome has been identified, there is a need to examine the awe that triggers this and the content of the module and the teaching process. In another study, in which the qualitative data collected for this purpose will be used, these issues will be discussed. In this section, secondly, the findings of the concept maps developed by the first researcher, which prove the conceptual development of the students on sustainable development, are discussed. In this study, a concept map was used as an evaluation tool rather than a teaching tool. With this concept map, it is explained to what extent the students can learn the relations between the concept or concepts in the subject of sustainable development. Considering the scores obtained from the pre-and post-implementations of the concept map, it was concluded that the pre-scores were quite low and increased in the post-test. This increase is statistically significant as well. This result can be accepted as an indication that the module has increased the conceptual development of students on sustainable development. In short, with the intervention, the students learned the concepts of sustainable development that they did not know before and the relationships between these concepts. In a limited number of studies supporting this result, it has been shared that concept maps make it easier for students to realize the social, economic, and environmental dimensions of sustainable development and the relationship between them (Karaarslan-Semiz & Teksoz, 2019).

The fact that the academic achievement scores on sustainable development and the change in concept map scores in the pre-and post-tests support each other reveal that the measured qualifications serve their purpose. In short, while the concept map scores of those whose achievement test scores increased in the last application increased (for example, S4, and S14), the concept map scores of those whose test scores decreased (for example, S4, and S14). On the other hand, there is a difference in the retention test scores of the concept map when compared to the achievement test. While there was a general increase in the retention scores in the achievement test, the concept map scores either remained the same or partially decreased. This situation revealed that the students learned the new concepts about sustainable development during the teaching of the module and tended to forget them later on. In this context, it turns out that extra efforts are needed in order not to forget the concepts in question. Similarly, concept map scores showing students' recognizing and associating sustainable development concepts reveal that their achievements also differ. At this point, it is also necessary to look at which students gain higher earnings depending on their behaviors of entering the teaching

module and their performance in the teaching process. Now, the qualitative data of the research, which was carried out as a comprehensive project to explain these gaps, will be critical in future studies.

In short, the quantitative data collected to measure the impact of the teaching module for sustainable development goals designed and employed in this research explains the success. However, it still needs to be questioned how the structure, content, the teaching style of the module, and the student participation status affect the way to success.

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