Turkish Journal of Teacher Education

Volume 14, Issue 2, 2025 e-ISSN:2147-5156

The Effect of Out-of-School Astronomy Education on Students' Views on Science, Technology, Society, and the Environment*

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Keywords

Out-of-School Learning, Astronomy Education, Science-Technology-Society-Environment

Article History

Received June27,2025
Revised Dec24, 2025
Accepted Dec28, 2025
Published Dec 30, 2025

Abstract

This study examined how the "Solar System and Beyond" unit, delivered outside the classroom, affected students' views about science, technology, society, and the environment. A pre-test-post-test control group design, a semi-experimental method, was employed. The data were collected using the "Science-Technology-Society-Environment Scale". The research involved 70 7th-grade students from a public middle school in the Pamukkale district of Denizli during the 2023-2024 academic year. Students in the experimental group participated in out-of-school activities, including a planetarium visit, an observatory trip, and open-air sky observation. The t-test for independent samples was used to analyze the data. Results showed that the experimental group students demonstrated significant gains in the "Science and Technology" and "Technology" sub-dimensions compared with the control group ($p < .05$). No significant differences were observed in the other sub-dimensions or in the overall scale.

Introduction

Out-of-school learning refers to the educational activities students participate in outside the traditional classroom setting (Kucuk, 2020). These activities are often structured and planned but primarily supportive and occur beyond school hours, classified as "non-formal learning" (Eshach, 2007). Such learning experiences are

*This study is based on data from the doctoral thesis conducted by the first author under the supervision of the second author.

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enriched by students' daily life activities, practical tasks, and social interactions. Developing skills related to science, technology, society, and the environment (STSE) is essential, as they foster personal growth and enhance social responsibility. Research suggests a strong connection between the development of these skills and learning outside of school, which provides students with more extensive and meaningful educational opportunities (Kucuk & Yıldırım, 2020).

Recently, out-of-school learning environments have become practical tools for boosting students' interest in science, technology, society, and the environment, as well as deepening their understanding of these subjects. These settings, such as science centers, museums, and botanical gardens, facilitate informal education and offer valuable opportunities for hands-on, experiential learning beyond traditional classroom lessons. The connection between out-of-school learning and STSE skills is complex, as these environments not only promote scientific thinking and technological skills but also raise students' awareness of social and environmental issues. Research indicates that such learning environments can positively influence students' attitudes toward science. For instance, Yılmaz (2024) notes that activities in these settings can improve students' attitudes by increasing motivation and interest in science. Likewise, Chang et al. (2012) emphasize the importance of integrating in-school and out-of-school activities to enhance science education, allowing students to link classroom theories to real-world applications.

The significance of technology in out-of-school learning is growing. With the widespread use of Web 2.0 tools and distance learning platforms, students can easily access information outside of school, even from home. For example, mobile apps like SkyView allow students to observe celestial bodies' positions in real time using their smartphones. Similarly, apps like 'Dark Sky Meter' enable students to measure light pollution around them. These tools exemplify technology-supported out-of-school learning experiences and reflect the connection between science, technology, society, and the environment. Today, places such as science centers, virtual museums, planetariums, aquariums, and traditional museums are vital out-of-school learning environments that combine science and technology. Rapid technological advances have transformed and enriched learning in these settings. Students now leverage online resources, digital experiment kits, remotely accessible courses, and robotics workshops to acquire scientific knowledge and develop skills. These activities foster creative thinking, problem-solving, and technological competence. STEM programs, focusing on science, technology, engineering, and mathematics, offer hands-on experiences in fields like engineering and robotics, boosting both academic and social success. During disruptions such as pandemics and natural disasters, online courses and digital content have been crucial for maintaining continuous learning. Overall, activities both inside and outside school help deepen understanding of how science applies to social life.

Karslı et al. (2019) highlight that out-of-school learning environments enable students to conduct research, sharpen their investigation skills, and understand the interconnectedness of scientific, technological, and social issues. These settings not only promote scientific literacy but also enhance environmental consciousness and sustainable practices. Researchers note that botanical gardens, in particular, serve as effective platforms for teaching socio-scientific issues related to the environment, fostering student interest in sustainability concepts. This approach aligns with the 2018 Science Course Curriculum of Türkiye, which aims to develop individuals who are scientifically literate, environmentally conscious, and responsible.

Out-of-school learning activities that consider individual differences can make education more inclusive and effective by catering to different learning styles. These activities can provide transformative learning experiences—which are often difficult to offer in traditional classrooms—by tailoring them to student interests and needs, thus boosting participation and motivation in science. Such approaches help students make meaningful links between their personal experiences and science, promoting scientific literacy and curiosity (Coşkun et al., 2017; Solis et al., 2021). Introducing real-life problems further supports students' development as lifelong learners.

Students engaging with their peers outside of school gain a better understanding of the significance of collaboration in both academic and social settings (Dere & Çifçi, 2022; Kucuk, 2020). Additionally, family involvement in such activities enhances the learning process by fostering an environment that stimulates curiosity and supports discovery (Pattison & Dierking, 2019). Activities like Science Fairs, Science Festivals, Nature Education, and Science Schools organized by the TÜBİTAK Science and Society Department serve as practical tools for promoting scientific thinking among students and broader community members (Sevim & Kucuk, 2023). These projects enable students to develop solutions to real-world problems actively and often allow them to explore the links between science, technology, society, and the environment through collaborative efforts outside school. Consequently, these activities exemplify the strong connection between out-of-school learning and STSE.

Ancient Egypt's sky observations primarily aimed to determine time, especially to predict Nile flood cycles, leading to the creation of early calendar systems based on celestial movements. This indicates that societal needs drove early research in astronomy. Throughout history, such observational practices, along with technological progress, have prompted humans to consider the possibility of life on other planets. Thus, the relationship between science, technology, society, and the environment (STSE) and astronomy can be traced back to ancient times. Currently, in science education, highlighting STSE relationships through out-of-school learning—discussed in this study—is considered a key research sub-problem. It is expected that engaging students in astronomy activities outside formal settings will enhance their awareness of science, technology, society, and the environment.

One key goal of science education is to cultivate scientific literacy, which involves understanding scientific concepts and the interactions between science, technology, society, and the environment. The Science-Technology-Society-Environment [STSE] framework provides a valuable means for students to connect scientific knowledge to real-world contexts (Bybee, 1997; Cepni et al., 2003; Cinar & Cepni, 2021a,b; Deve & Kucuk, 2016; Kucuk, 2005; National Research Council [NRC], 2012). Astronomy education is particularly well-suited to developing STSE skills due to its abstract nature and its strong ties to daily life. It relates directly to technological tools such as telescopes, satellites, observation software, and mobile apps, helping students understand how these technologies serve scientific needs

(NRC, 2012). Digital sky maps and mobile devices further link astronomy to everyday experiences. The societal aspect is also prominent in astronomy, influencing fields such as calendar-making, navigation, agriculture, and space exploration, shaping societal decisions based on scientific knowledge (Sadler, 2009). Environmental considerations, notably light pollution, are integral to astronomy education. Light pollution hampers observation, wastes energy, harms ecosystems, and affects human health. Addressing it promotes scientific understanding of environmental issues and encourages sustainable practices (Falchi et al., 2016). Ultimately, astronomy education enables a comprehensive understanding of the interconnectedness of science, technology, society, and environment. It helps students question scientific information, use technology responsibly, and recognize their social and environmental responsibilities—aligning well with modern science education goals.

A review of the literature reveals numerous studies examining the link between the STSE approach and out-of-school learning (Kucuk, 2020; Kucuk et al., 2025). This study aims to make a unique contribution by including out-of-school activities that cover all learning outcomes of the "Solar System and Beyond" unit, along with worksheets and student reflective journals that support these activities. It also integrates diverse out-of-school environments, such as planetariums, science centers, observatories, presentations by university experts, and outdoor observations. Moreover, tackling light pollution, which is crucial for astronomy education, through extracurricular activities enhances middle school astronomy teaching. The study also highlights the use of accessible applications like SkyView and Dark Sky Meter, and their integration into classroom activities, which is another significant aspect.

This study investigates the effect of teaching that incorporates out-of-school learning environments on 7th-grade middle school students' views in science, technology, society, and the environment, specifically within the 'Solar System and Beyond' unit in the Turkish science curriculum.

Methods

Since the class groups were predetermined, a quasi-experimental design—specifically, the pretest-posttest control-group model—was employed in this research. In this type of design, random assignment is not utilized. Instead, researchers apply alternative strategies to minimize or manage potential threats to internal validity (Fraenkel et al., 2011). The experimental design used in the study is illustrated in Table 1.

Table 1
The Study's Experimental Design

Group	*Pre-Test*	*Experimental Procedure*	*Post-Test*
Experimental Group [EG]	STSEs	Curriculum supported by out-of-school learning environments	STSEs
Control Group [CG]	STSEs	Science course curriculum	STSEs

STSEs: Science-Techonology-Society-Environment Scale

Participants

Data Collection Procedures

We have provided the STSE as a pre-test to both the experimental and control groups at the beginning of the intervention. Students in the experimental group engaged in out-of-school learning activities designed by the researchers. These activities took place in different informal environments, including a planetarium, an observatory, an open-air telescope session, and a university campus. Each activity was divided into three phases: before, during, and after, with worksheets provided at each stage to guide and reinforce learning based on the out-of-school learning pedagogy. The experimental students were also asked to maintain a science journal after each session, following detailed instructions. The initial researcher has instructed both groups. Another study has also shown that this kind of out-of-school instructional design produces successful outcomes (Kucuk, 2000). Meanwhile, the control group received instructions in accordance with the standard classroom curriculum. After completing the unit, we administered the STSE again as a post-test for both groups to evaluate skill improvement.

Data Analysis

Before starting the experimental procedure, the STSEs scores of students in both groups were examined using an Independent Samples t-test, a parametric statistical method. For this test to be appropriate, several assumptions must hold: (a) the two groups must be independent, (b) the dependent variable should be measured on an interval or ratio scale, (c) the raw scores in each population should be normally distributed, and (d) the variances of the populations should be equal (Buyukozturk et al., 2019). Table 3 presents the descriptive statistics used to determine whether the pre-test STSEs scoresmeet the assumptions for a t-test, and Table 4 presents the post-test scores of students in both the experimental and control groups.

Table 3

Descriptive Statistics for STSEsPre-Test Scores

Factors	*Groups*	*n*	$\bar{x}$	*Median*	*Mode*	*sd*	*Skewness*	*Kurtosis*
Science and Technology	EG	35	12.85	13	13	1.43	-0.050	-0.331
	CG	35	12.97	13	13	1.48	-0.520	1.194
Technology	EG	35	15.62	16	17	2.23	-0.790	0.930
	CG	35	15.88	16	17	1.56	-0.092	-0.911
Impact of Technology on Society	EG	35	19.80	20	22	2.57	-0.127	0.186
	CG	35	20.60	21	20	2.76	-0.052	-0.293
Impact of Science and Technology on Society	EG	35	27.14	28	28	3.38	0.033	-0.770
	CG	35	27.62	27	25	3.67	0.780	0.684
Impact of Society on Science and Technology	EG	35	33.57	34	35	4.27	-0.255	-0.410
	CG	35	32.71	32	32	4.03	-0.007	-0.458
Impact of Science and Technology on the Environment	EG	35	12.85	13	13	1.26	-0.087	-0.350
	CG	35	13.11	13	14	1.72	-0.187	-0.781
Impact of Technology on the Environment	EG	35	14.14	14	16	1.57	-0.250	-1.248
	CG	35	13.31	13	13	1.87	-0.543	0.066
Impact of Society on Environment	EG	35	23.48	23	23	2.24	-0.188	-0.051
	CG	35	22.45	22	22	3.11	0.046	-0.401
STSE Pre-Test Total Scores	EG	35	159.48	159	169	10.82	0.001	-0.187
	CG	35	158.68	158	145	11.42	0.306	-0.508

Table 3 and the STSE scores, including all sub-dimensions, show very similar means, medians, and modes for both groups. The data indicate that, for each group, the skewness and kurtosis coefficients of all sub-dimensions and the overall STSE scores in the pre-test ranged between -2 and +2. According to George and Mallery (2010), skewness and kurtosis values within ±2 of 0 suggest that the data follow a normal distribution. As seen in Table 3, both groups satisfy the assumption of normality. Levene's Test for Equality of Variances checked if the sample variances across the population were consistent. The findings showed that variances were uniform for all sub-dimensions except 'Impact of Science and Technology on the Environment' (F=4.821, p=0.032). However, since the t-test is a robust parametric test, it remains valid even when variances are unequal (Buyukozturk et al., 2019).

Table 4

Descriptive Statistics for STSEs Post-Test Scores

Factors	*Groups*	*n*	$\bar{x}$	*Median*	*Mode*	*sd*	*Skewness*	*Kurtosis*
Science and Technology	EG	35	12.82	13	12	1.65	0.331	-0.569
	CG	35	11.40	12	12	2.36	-0.383	1.117
Technology	EG	35	16.77	17	18	1.84	-0.414	-0.095
	CG	35	15.82	16	15	1.74	0.137	-0.416
Impact of Technology on Society	EG	35	20.00	19	18	2.97	1.150	1.368
	CG	35	20.28	20	19	2.49	0.851	1.062
Impact of Science and Technology on Society	EG	35	27.42	28	30	3.25	0.080	-0.248
	CG	35	26.34	25	23	3.80	0.549	-0.061
Impact of Society on Science and Technology	EG	35	33.00	33	32	4.28	-0.024	0.277
	CG	35	31.85	32	32	4.22	-0.481	0.239
Impact of Science and Technology on the Environment	EG	35	12.31	12	11	2.06	-0.385	-0.213
	CG	35	12.45	12	12	1.73	-0.013	0.116
Impact of Technology on the Environment	EG	35	12.97	13	12	2.02	-0.593	0.599
	CG	35	12.48	13	14	2.55	-0.714	-0.371
Impact of Society on Environment	EG	35	21.54	22	22	2.77	0.078	0.145
	CG	35	21.80	22	21	2.77	0.079	-0.365
STSEs Post-Test Scores	EG	35	156.85	156	149	13.48	-0.222	-0.386
	CG	35	152.45	151	149	14.41	0.394	0.247

Table 4 and the STSE scores, including all sub-dimensions, show very similar means, medians, and modes for both groups. The data indicate that, for each group, the skewness and kurtosis coefficients of all sub-dimensions and the overall STSE scores in the pre-test ranged between -2 and +2. As seen in Table 4, both groups satisfy the assumption of normality. Levene's Test for Equality of Variances checked if the sample variances across the population were consistent. The findings showed that variances were uniform for all sub-dimensions

We analyzed the STSEs data by using SPSS version 20.00. Initially, descriptive statistics, such as the arithmetic mean and standard deviation, were calculated from the STSE. Subsequently, we conducted an independent-samples t-test at the 0.05 significance level. To assess the effect size, Eta squared, and Cohen’s d (d) values were also reported in the context of the independent samples t-test. Turgut (2009) noted that the independent-samples t-test is a widely used statistical method for determining whether there is a significant difference between group means when measurements are taken with the same assessment tool.

For the analysis of the qualitative data in this study, three students were selected as participants for their science daily journals. In this selection, the students' post-test scores on the STSEs were used. Thus, three students were identified with codes A, B, and C. Student A is male; B and C are female, and all are 13 years old. Student A's science grade is 70, Student B's is 80, and Student C's is 90. Additionally, the post-test scores on the STSEs for students A, B, and C were calculated as 133, 158, and 185, respectively. Excerpts from the daily writings that support these students' STSEs scores were presented to reveal the findings.

Results

Results Obtained from Quantitative Data

Table 5 shows the results of the independent-samples t-test for the pre-test scores of the groups.

Table 5

Results of the Independent Groups t-Test on Pre-Test Scores for STSEs and Its Sub-Factors

Factors	*Groups*	*n*	$\bar{x}$	*sd*	*t*	*p*
Science and Technology	EG	35	12.85	1.43	-0.327	0.745
	CG	35	12.97	1.48		
Technology	EG	35	15.62	2.23	-0.557	0.579
	CG	35	15.88	1.56		
Impact of Technology on Society	EG	35	19.80	2.57	-1.252	0.215
	CG	35	20.60	2.76		
Impact of Science and Technology on Society	EG	35	27.14	3.38	-0.575	0.567
	CG	35	27.62	3.67		
Impact of Society on Science and Technology	EG	35	33.57	4.27	0.863	0.391
	CG	35	32.71	4.03		
Impact of Science and Technology on the Environment	EG	35	12.85	1.26	-0.711	0.480
	CG	35	13.11	1.72		
Impact of Technology on the Environment	EG	35	14.14	1.57	2.218	0.030*
	CG	35	13.31	1.87		
Impact of Society on Environment	EG	35	23.48	2.24	1.585	0.118
	CG	35	22.45	3.11		
STSEs Pre-Test Scores	EG	35	159.48	10.82	0.370	0.712
	CG	35	158.68	11.42		

*p<0.05

Table 5 reveals a significant difference in the experimental group (t=2.218; p<.05) regarding the 'Impact of Technology on the Environment' sub-dimension of the STSEs.

Table 6 shows the results of the independent-samples t-test for the post-test scores of the groups.

Table 6
Results of the Independent Groups t-Test on Post-Test Scores for STSEs and Its Sub-Factors

Factors	*Groups*	*n*	$\bar{x}$	*sd*	*t*	*p*
Science and Technology	EG	35	12.82	1.65		
	CG	35	11.40	2.36	2.928	0.005*
Technology	EG	35	16.77	1.84		
	CG	35	15.82	1.74	2.197	0.031*
Impact of Technology on Society	EG	35	20.00	2.97		
	CG	35	20.28	2.49	- 0.436	0.664
Impact of Science and Technology on Society	EG	35	27.42	3.25		
	CG	35	26.34	3.80	1.283	0.204
Impact of Society on Science and Technology	EG	35	33.00	4.28		
	CG	35	31.85	4.22	1.123	0.265
Impact of Science and Technology on the Environment	EG	35	12.31	2.06		
	CG	35	12.45	1.73	- 0.313	0.755
Impact of Technology on the Environment	EG	35	12.97	2.02		
	CG	35	12.48	2.55	0.881	0.381
Impact of Society on Environment	EG	35	21.54	2.77		
	CG	35	21.80	2.77	- 0.387	0.700
STSEs Post-Test Scores	EG	35	156.85	13.48		
	CG	35	152.45	14.41	1.318	0.192

*p<0.05

Table 6 reveals notable differences in the 'Science and Technology' sub-dimension of the STSEs, with the experimental group performing better (t=2.928; p<.05). Additionally, the 'Technology' sub-dimension also shows a preference for the experimental group (t=2.19; p<.05). When the effect size of the obtained results was calculated, d=0.69; eta squared=0.112 was found for the 'Science and Technology' sub-dimension.

This indicates that the difference between the means is 0.69 standard deviations, and that 11% of the scale scores are affected by the application. The effect sizes suggest a medium effect. For the 'Technology' sub-dimension, d=0.53 and eta squared=0.066 were observed. This means the mean difference is 0.53 standard deviations, and 6% of the variance in scale scores is due to the application. The effect sizes for this sub-dimension indicate a low effect.

Results Obtained from Qualitative Data

We also examined the science journals of three students and found statements that aligned with the quantitative measurement tool's results. Student A remained quiet during class throughout the internship. His journal notes that he didn't particularly enjoy keeping a journal, but he did so because he liked his teacher and didn't want to upset him. However, after the "Observatory Activity," he correctly compared the observatory he visited to the ideal observatory criteria.

Figure 1 displays Student A’s diary following the “Observation Activity.”

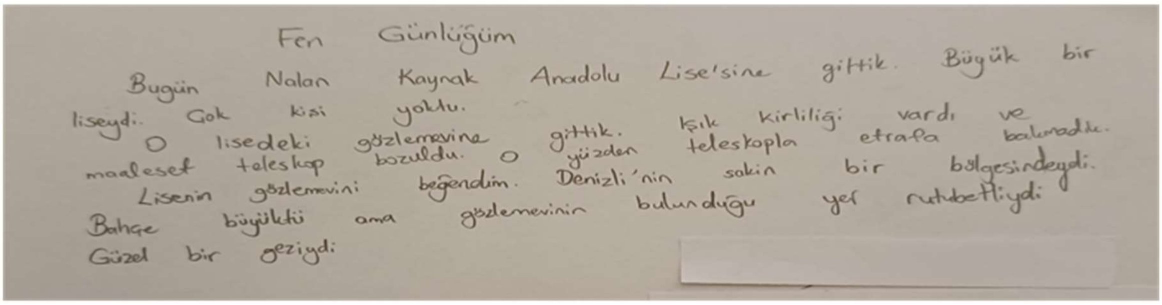

Fen Günlüğüm
Bugün Nalan Kaynak Anadolu Lise'sine gittik. Büyük bir liseydi. Çok kişi yoktu.
O lisedeki gözlemevine gittik. Işık kirliliği vardı ve etrafa baksmadık.
maalesef teleskop bozuldu. O yüzden teleskopla
Lisenin gözlemevini beğendim. Denizli'nin sakin bir bölgesindeydi.
Bahçe büyüktü ama gözlemevinin bulunduğu yer rutubetliydi
Güzel bir geziydi

Figure 1. *The student A's diary after the 'Observation Activity.'*

In his diary, A wrote,

"Today we went to Nalan Kaynak Anatolian High School. It was a large high school. We went to the high school's observatory. There was light pollution. Also, the place where the observatory was located was humid."

His observations, especially regarding light pollution, were accurate. Significant differences were observed between this student's pre-test and post-test scores on the environmental questions titled "The impact of science and technology on the environment," "The impact of technology on the environment," and "The impact of society on the environment" in the STSES exam.

Figure 2 displays Student B's diary following the"Planetarium Activity".

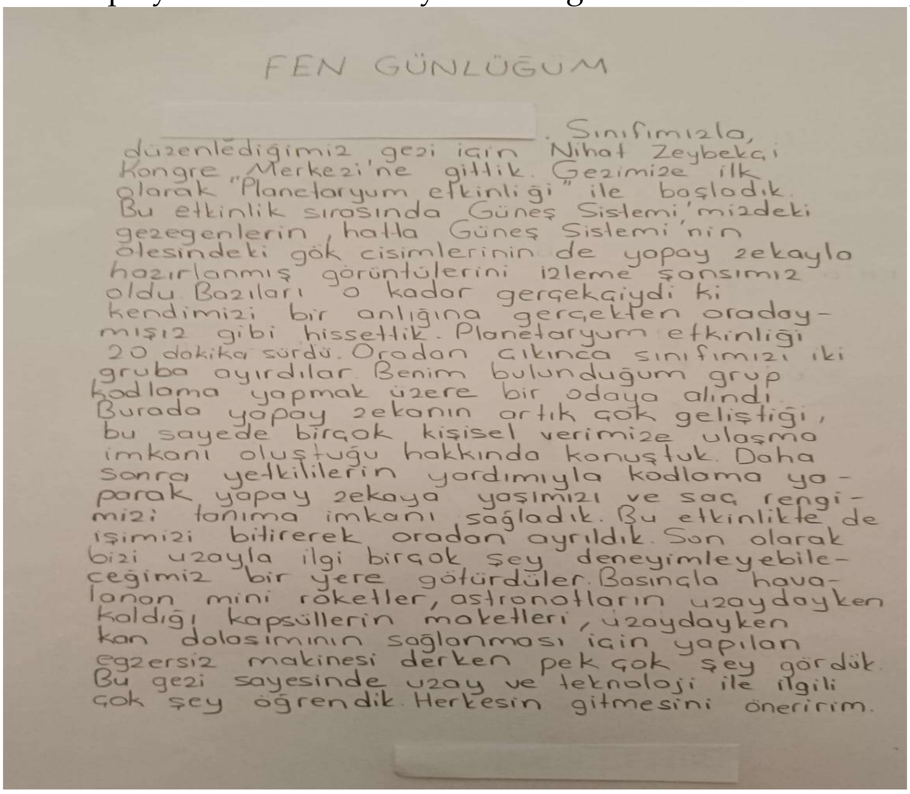

FEN GÜNLÜĞÜM
. Sınıfımızla,
düzenlediğimiz gezi için Nihat Zeybekçi
Kongre Merkezi'ne gittik. Gezimize ilk
olarak "Planetaryum etkinliği" ile başladık.
Bu etkinlik sırasında Güneş Sistemi'mizdeki
gezegenlerin, hatta Güneş Sistemi'nin
ötesindeki gök cisimlerinin de yapay zekayla
hazırlanmış görüntülerini izleme şansımız
oldu. Bazıları o kadar gerçekçiydi ki
kendimizi bir anlığına gerçekten oraday-
mışız gibi hissettik. Planetaryum etkinliği
20 dakika sürdü. Oradan çıkınca sınıfımızı iki
gruba ayırdılar. Benim bulunduğum grup
kodlama yapmak üzere bir odaya alındı.
Burada yapay zekanın artık çok geliştiği,
bu sayede birçok kişisel verimize ulaşma
imkanı oluştuğu hakkında konuştuk. Daha
sonra yetkililerin yardımıyla kodlama ya-
parak yapay zekaya yaşımızı ve saç rengi-
mizi tanıma imkanı sağladık. Bu etkinlikte de
işimizi bitirerek oradan ayrıldık. Son olarak
bizi uzayla ilgi birçok şey deneyimleyebile-
ceğimiz bir yere götürdüler. Basınçla hava-
lanan mini roketler, astronotların uzaydayken
kaldığı kapsüllerin maketleri, uzaydayken
kan dolaşımının sağlanması için yapılan
egzersiz makinesi derken pek çok şey gördük.
Bu gezi sayesinde uzay ve teknoloji ile ilgili
çok şey öğrendik. Herkesin gitmesini öneririm.

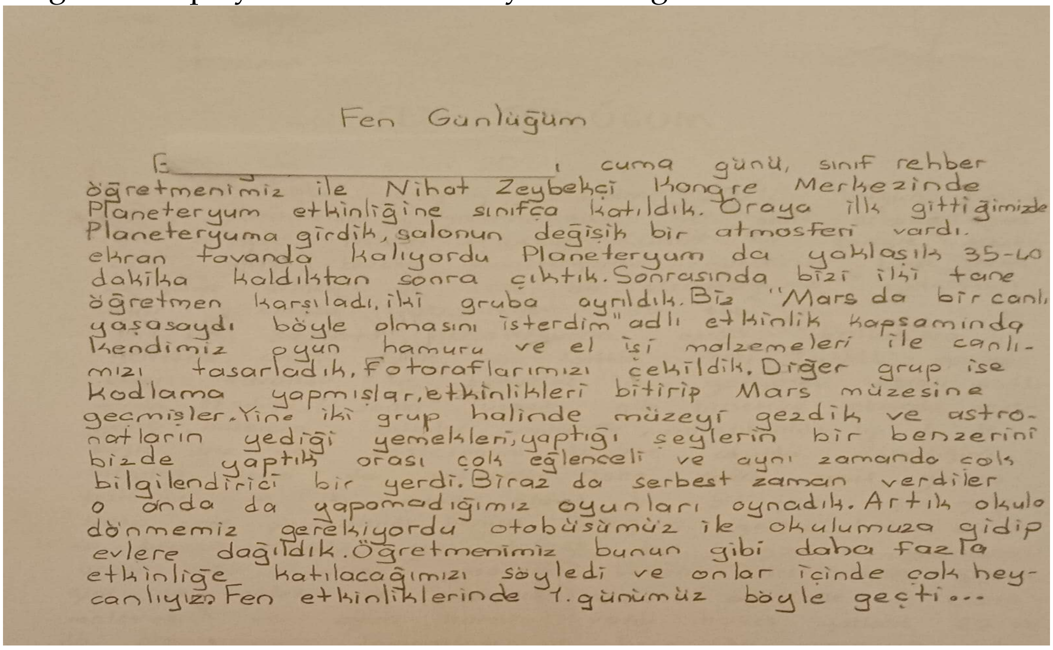
Figure 2. *Student B's journal of '' Planetarium Activity''*

Reviewing student B's journal revealed a more structured schedule. The student detailed their activities with greater precision and articulated their experiences clearly. Notably, they eloquently summarized how technology and science intersect during the "Planetarium Activity." Throughout the experiment, the student actively engaged with the researcher's observations. An important excerpt from the diary is:

> *"...They took us to a place where we could experience many things related to space. We learned many things about space and technology by observing tools such as mini rockets that take off under pressure, models of the capsules where astronauts stay in space, and exercise machines used by astronauts..."*

As a result, the student awarded higher scores on the "Science and Technology" and "Technology" sub-dimensions of the STSEs.

Figure 3 displays Student C's diary following the "Science Center Activity."



Fen Günlüğüm

E______________, cuma günü, sınıf rehber öğretmenimiz ile Nihat Zeybekçi Kongre Merkezinde Planeteryum etkinliğine sınıfça katıldık. Oraya ilk gittiğimizde Planeteryuma girdik, salonun değişik bir atmosferi vardı. ekran tavanda kalıyordu Planeteryum da yaklaşık 35-40 dakika kaldıktan sonra çıktık. Sonrasında bizi iki tane öğretmen karşıladı, iki gruba ayrıldık. Biz "Mars da bir canlı yaşasaydı böyle olmasını isterdim" adlı etkinlik kapsamında kendimiz oyun hamuru ve el işi malzemeleri ile canlımızı tasarladık, Fotoraflarımızı çekildik. Diğer grup ise kodlama yapmışlar, etkinlikleri bitirip Mars müzesine gecmişler. Yine iki grup halinde müzeyi gezdik ve astronatların yediği yemekleri, yaptığı şeylerin bir benzerini bizde yaptık orası çok eğlenceli ve aynı zamanda çok bilgilendirici bir yerdi. Biraz da serbest zaman verdiler o anda da yapamadığımız oyunları oynadık. Artık okula dönmemiz gerekiyordu otobüsümüz ile okulumuza gidip evlere dağıldık. Öğretmenimiz bunun gibi daha fazla etkinliğe katılacağımızı söyledi ve onlar içinde çok heycanlıyız. Fen etkinliklerinde 1. günümüz böyle geçti...

Figure 3. *Student C's journal of '' Science Center''*

In her journal, Student C focused on the workshops held at the "Science Center." She mentioned that during the workshop, they designed a living creature on Mars using playdough and craft materials, under the theme "If a living creature lived on Mars, what would I want it to look like?" She also expressed her enjoyment of these extracurricular activities and suggested that more of them should be offered. She also asked the researcher what it takes to become an astronaut and requested recommendations for resource books on the subject. Accordingly, the student scored higher on the sub-dimensions "Impact of Science and Technology on Society" and "Impact of Society on Science and Technology" in the STSEs, which explore the relationship between science and society.

Discussion

This study primarily aimed to assess how activities in out-of-school learning environments influence students' views on Science, Technology, Society, and Environment (STSE). Results indicated a positive impact, notably with the experimental group showing significant improvements in the "Science and Technology" and "Technology" sub-dimensions. This highlights the potential of out-of-school environments to enhance learning. An increased awareness of science and technology suggests that students' interest in scientific processes and their scientific literacy have improved. Braund and Reiss (2006) noted that out-of-school science activities help students understand abstract concepts and achieve meaningful, lasting learning. These findings align with the study's theoretical framework and support previous research, such as Kucuk (2020), which also emphasizes the value of out-of-school learning in this context.

The significant improvement observed in the experimental group in terms of technology is consistent with results showing that students' perceptions of technology increased in STEM-based projects conducted by Venville et al. (2011). The application of technology-based tasks in out-of-school environments supports students' skills in critical thinking, problem-solving, and decision-making. This is also consistent with the findings of Bevan et al. (2010), who found that technology-based activities are more effective in informal environments. However, the lack of meaningful progress in environmental and social dimensions may be due to the activities not being sufficiently inclusive of these dimensions. Rennie (2007) emphasizes that environmental education will be effective not only through the transfer of information but also through participatory, experience-based learning grounded in local social problems. In this context, the study's findings reveal that the content, including the environmental and social dimensions, should be more structured and student-centered.

In the control group, there were notable reductions in certain sub-dimensions, such as "Science and Technology" and "Impact of Technology on the Environment." This indicates that students struggle to sustain their STSE skills solely through classroom learning. Eshach (2007) pointed out that the absence of informal learning opportunities can hinder both cognitive and emotional growth. The lack of significant changes in some dimensions within the experimental group implies that factors such as students' individual differences, activity duration, instructor expertise, and contextual influences (Hofstein & Rosenfeld, 1996) might be affecting the outcomes.

The magnitude analyses indicated medium effects ($d=0.69$; $\eta^2=0.112$) in the "Science and Technology" sub-dimension and smaller effects ($d=0.53$; $\eta^2=0.066$) in the "Technology" dimension. Based on Cohen's (1988) classifications, these results are statistically significant and have educational relevance.

Research indicates that activities in out-of-school learning settings can enhance students' awareness and views related to STSE. Notable improvements are mainly seen in the 'Science and Technology' and 'Technology' sub-dimensions, suggesting that structured activities in these areas positively influence student growth. Conversely, the limited impact on environmental and social dimensions suggests these areas may not have been adequately supported. However, Kucuk (2000) conducted a study in which the human and environment unit was taught outside of school, and it revealed that differences also exist at this level. Consequently, there is a need to develop these learning environments in multiple dimensions and diversify their applications.

Conclusion

When the qualitative and quantitative data analyzed in this study are evaluated together, it is clear that there is still much work to be done to enrich students' perspectives on the environmental and societal aspects of STSE.

Research findings indicate little progress in environmental and social awareness. Therefore, there is a need to develop activities that address local environmental issues, incorporate sustainability-focused field studies, and promote social responsibility initiatives. Besides this, it is also curious how permanent the gains of the experimental group students will be. Kucuk (2020) obtained positive results when measuring the retention of lessons conducted outside of school and lasting for a unit, six months after the applications. To ensure lasting behavioral changes in students, out-of-school activities need to be regularly scheduled and carried out throughout the school year, rather than being limited to short-term projects. This aligns well with the NRC's "lifelong learning" view (NRC, 2009). In conclusion, the out-of-school instructional design implemented in this study contributed to increases in pre-test scores in some areas, although not across all dimensions of the STES. Future studies indicate the need for new pedagogical designs to achieve the targeted goals across all dimensions.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

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