ORIGINAL ARTICLE

Exploring Middle School Students' Opinions about an Out-of-School Platform: The Case of Space and Aviation Training Center

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***Abstract**: The importance of out-of-school learning environments has been increasing day by day as young learners have the opportunity to gain first-hand experiences with scientific content outside formal science classes. Based on this importance, the aim of this study is to explore middle school students' opinions before and after participating in a space and aviation training center visit. The current study was designed as action research. Data were collected from six sixth-grade students. Nine open-ended questions were administered to the participants before and after participating in a space and aviation training center visit. The participants answered the questions in written form. While most students had never been in an out-of-school environment, they indicated that the visit helped them to recall and learn the subject more easily. In addition, students indicated that out-of-school learning opportunities as they experienced increased their interest and helped to develop more positive attitudes toward the topic.*

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Introduction

OUT-OF-SCHOOL learning environments have gained considerable attention for their effectiveness in enhancing student learning and engagement. These environments encompass a variety of behavioral, social, affective, and cognitive dimensions that can significantly influence learning and facilitate knowledge transfer (Morag & Tal, 2012; Nadelson & Jordan, 2012). Furthermore, they provide opportunities for students to cultivate an interest in science and offer a platform to inspire and engage them, fostering a deeper appreciation and understanding of concepts introduced in the classroom (Bakioğlu & Karamustafaoğlu, 2020; Behrendt & Franklin, 2014). Learning in these natural settings stimulates students' curiosity, offers practical experiences, and enhances the overall relevance of their education (Farmer, Knapp, & Benton, 2007). According to Orion and Hofstein (1994), out-of-school learning activities can help students conceptualize abstract ideas taught in class. Tunnicliffe et al. (1997) further emphasized that environments such as natural history museums and zoological gardens provide richer and more meaningful learning experiences. There are primarily five benefits of out-of-school learning: (1) better development and integration of scientific concepts; (2) extended and authentic practical work; (3) access to non-school material and "big" science; (4) improving attitudes toward science education and encouraging further learning; and (5) social outcomes, collaborative work, and responsibility for learning. Studies focusing on students' gains in out-of-school learning environments reported fruitful outcomes: (a) helping students gain first-hand experience (Ates & Lane, 2019; Armağan, 2015; Braund & Reiss, 2006; Eshach, 2007; Küçük & Yıldırım, 2021), (b) enhancing students' conceptual understanding (Akay, 2019; Bakioğlu & Karamustafaoğlu, 2020; Behrendt & Franklin, 2014; Braund & Reiss, 2006; Yavuz-Topaloğlu & Balkan-Kıyıcı, 2017); (c) eliminating students' misconceptions (Demirel & Özcan, 2020); motivating students to appreciate and understand classroom concepts (Behrendt & Franklin, 2014); (d) increasing students' interest and curiosity (Armağan, 2015; Ates & Lane, 2019; Avan et al., 2019; Behrendt & Franklin, 2014; Nadelson & Jordan, 2012; Soysal, 2019); (e) improving students' attitudes towards the environment (Aydın, 2019; Jarvis & Pell, 2005; Morag & Tal, 2012; Nadelson & Jordan, 2012; Soysal, 2019), (f) enhancing science process skills and critical thinking skills (Avan et al., 2019); (g) enabling permanent learning (İnce & Akanca, 2021; Kubat, 2018; Küçük & Yıldırım, 2021; Sontay et al., 2016); (h) stimulating further learning (Braund & Reiss, 2006), and (i) making abstract concepts more concrete (Demir & Armağan, 2018).

Outdoor learning environments present valuable opportunities to enhance middle school education, though their successful implementation largely depends on teachers' perceptions, preparedness, and experiences. Teachers recognize the educational potential of outdoor learning environments, acknowledging their role in enhancing the curriculum by offering a different viewpoint or creating a deeper connection that can be used to support the curriculum (Eshach, 2007). A recent study reported that most teachers hold positive attitudes toward outdoor learning activities (Demir & Çetin, 2022). Moreover, these activities were perceived as a chance for students to break from routine and get outside of the classroom (Eshach, 2007).

However, despite these positive outcomes, both teachers and school administrators had difficulties in implementing out-of-school activities. Teachers report obstacles such as inadequate financial and transportation facilities, timing issues, difficulties in classroom management, unfavorable climatic conditions, safety concerns, risks of danger and accidents, and a lack of parental consent (Ateskan & Lane, 2016; Aydemir & Toker-Gökçe, 2016; Behrendt & Franklin, 2014; Ernst, 2007; İnce & Akcanca, 2021; Michie, 1998; Orion & Hofstein, 1994; Yıldız, 2022). While these barriers can be considered external (Kesaplı Can et al., 2017), there are also internal challenges, including insufficient preparation for outdoor learning, a lack of preparation for the setting, and teachers' limited experience, confidence, motivation, and pedagogical knowledge for conducting out-of-school activities (Ateskan & Lane, 2016; 2019; Tal & Morag, 2009). To overcome these difficulties, teachers need to be prepared for their roles during out-of-school activities. These roles were explained by deWitt and Storksdieck (2008) as: first familiarizing themselves with the location before the visit; then familiarizing students with the agenda and setting; planning pre-visit activities and allowing students to explore and learn in the setting; organizing post-visit activities that are aligned with the curriculum and the purpose of the visit.

In a content analysis on out-of-school learning environments, Sarac (2017) reviewed 133 theses (doctorate and masters) and articles to conclude that the number of studies has increased recently and most of them were descriptive and quantitative in nature. Based on this, it is evident that more implementation-based qualitative studies are needed to explore the effectiveness of out-of-school learning environments on students' learning outcomes. Prior studies were conducted in a variety of out-of-school learning environments such as hydroelectric power plants (Yavuz-Topaloğlu & Balkan-Kıyıcı, 2017), zoos (Yavuz-Topaloğlu & Balkan-Kıyıcı, 2012), planetariums (Demir & Armağan, 2018; Sontay et al., 2016), science camps (Avan et al., 2019), disaster and emergency centers (Nalkıran & Karamustafaoğlu, 2020), museums (Kartal & Şeyhoğlu, 2020; Pedretti & Soren, 2003; Pedretti et al., 2001), science centers (Ertuğrul & Karamustafaoğlu, 2020; Pedretti, 2002; Yolcu & Karamustafaoğlu, 2021), botanic gardens (Karslı et al., 2019), space centers (Jarvis &Pell, 2005), and bird watch sites (Keşaplı et al., 2017). However, to date, we have not encountered any study conducted in a space and aviation training center. Only Aslan (2022) investigated the opinions of the instructors working at the space and aviation center. This study addresses this gap in the literature.

The Turkish middle school science curriculum, released in 2018, highlights the importance of out-of-school learning environments for fostering meaningful and lasting learning. In this context, several informal learning environments—such as school gardens, science centers, museums, planetariums, zoos, botanical gardens, and natural settings—are recommended to support inquiry-based learning (Ministry of National Education [MoNE], 2018, p.11). Furthermore, recent changes to the Turkish education system, set to be introduced in the 2024-2025 academic year, also emphasize the role of out-of-school learning environments through extracurricular activities that offer transdisciplinary experiences for students (MoNE, 2024). Both curricula share a common understanding of the necessity of integrating out-of-school learning environments into science classes. However, they do not provide specific guidance on how to achieve this. As a result, there is an opportunity to explore how a particular out-of-school learning environment, such as a visit to a space and aviation center, can be utilized to support science education. To address the existing gap in the literature, this study explored middle school students' perceptions before and after participating in a space and aviation center. Specifically, we sought answers to the research questions below:

1. *What were the expectations of selected middle school students before participating space and aviation training center visit?*
2. *What were the viewss of selected middle school students after participating space and aviation training center visit?*

Methods

This study adopted an action research paradigm. Action research is a process in which practitioners use research methods to systematically assess and reflect on their own teaching practices (Ferrance, 2000). Typically, it involves researchers investigating their own implementation strategies, either independently or in collaboration with others, to address and resolve practical issues in the classroom (Yildirim & Simsek, 2011). The first author, an experienced science teacher working with sixth-grade students in a public school, encountered challenges while teaching the first theme of the sixth-grade science curriculum: "World and Universe." Specifically, she struggled with teaching concepts related to the solar system, planets, and their positions in the universe. These ideas remained abstract for students, making it difficult for them to grasp the vastness of space and the universe. To address this challenge, she decided to organize a field trip to support her students' understanding of these concepts. The first author collaborated with the second author, an experienced researcher specializing in the design and implementation of outdoor learning environments. This study can thus be considered collaborative action research, in which a school-university partnership was established (Pine, 2009).

Participants

The participants were selected from the first author's school, an Imam Hatip school (a type of religious school) where classrooms are gender-specific. The study involved a girls-only classroom. Six female students were chosen using the maximum variation sampling technique to capture a broad range of perspectives (Yildirim & Simsek, 2011). The participants were selected based on their academic achievement levels: two students with high academic achievement, two with moderate achievement, and two with low academic achievement.

The Data Collection Tools

The researchers designed open-ended questions to explore the participants' opinions both before and after visiting the space and aviation training center. These questions were developed based on previous research (Akay, 2019; Cebesoy & Karışan, 2023; Elmas, Aslan & Hakverdi Can, 2021; Küçük & Yıldırım, 2021; Soysal, 2019; Yavuz-Topaloğlu & Balkan-Kıyıcı, 2017). After drafting the questions, the authors reviewed and refined them in alignment with the study's objectives. To ensure validity, the draft was reviewed by a third researcher with expertise in science education and outdoor learning.

The data collection tool included nine questions. The first two questions aimed to determine whether the students had previously visited out-of-school learning environments, and if so, which ones. These questions sought to gather information about the participants' prior experiences with informal learning settings. The remaining questions focused on the space and aviation center visit. Initially, participants were asked if they had ever visited a space and aviation center, and to describe their experiences if applicable. If they had not visited one, additional follow-up questions were posed: "What do you think the space and aviation center would be like?/What do you expect to see there?" "What does the space and aviation center mean to you?" These questions were designed to gauge participants' perceptions of the center. The final set of questions addressed their post-visit experiences, specifically aimed at understanding which science topics were connected to the visit and how the out-of-school learning environment influenced their learning.

The questions were administered to participants both before and after the visit to the space and aviation training center, with participants providing written responses. Following this, the first author conducted semi-structured interviews to further explore and clarify participants' answers.

Field Trip to Space and Aviation Center

The first author initially contacted the authorities at the Space and Aviation Center to arrange the visit. Once the date was set, the author worked with the school principal to obtain the necessary official documentation. Each student was given a consent form, which their parents signed to grant permission for the school trip. During the excursion, a guide from the Space and Aviation Center was assigned to lead the group, with additional staff assisting in explaining the exhibits. The first author accompanied the students, facilitating their questions and guiding their learning.

The Content of the Field Trip

The Space and Aviation Center consists of two main sections: Aviation, Space Technologies, and Astronomy. The students visited both sections during the field trip. In the Aviation section, there were several interactive exhibits. The students explored the evolution of aviation, starting from the wing structure of a bird to a real aircraft. One of the highlights was a full-size A320 aircraft, where the students had the opportunity to closely examine various areas of the plane, including the cockpit, cabin, landing gear, and wing structures. For many of the students, this was their first time boarding a real aircraft. The section also featured an exhibition on flying air balloons, where students engaged in interactive physical activities. Next, the students visited the Space section, which included a lift that simulated the feeling of being in a rocket. This experience led them to a model showing how astronauts live in space, as well as the time changes experienced due to the Earth's shape. The students learned about the working principles of rockets and the history of manned space missions, gaining insight into the lives of astronauts in space. In the Astronomy section, students explored models of the Sun, Moon, and different planets. The exhibits covered various themes, including Galaxies, Stars, the Solar System, the History of Astronomy, Observation Instruments, Mars Research, and Exoplanets. Many of the exhibits were interactive, providing students with hands-on experiences that deepened their understanding of astronomical concepts.

Data Analysis

First, the interview recordings were transcribed verbatim. Both data sources—the students' written responses and interview transcripts—were carefully read by the first author and analyzed using content analysis. To ensure reliability and consistency in the coding process, the first author initially coded half of the data. The same data were then independently reviewed and coded by the second author. Consensus was reached through comparison and discussion of the codes and emerging themes.

To assess the degree of agreement between the two coders, inter-coder reliability was calculated following the guidelines of Miles and Huberman (1994). Among the available methods, the percent agreement approach (Lombard et al., 2002) was chosen for this study. The agreement ratio was calculated by dividing the total number of coding agreements by the sum of agreements and disagreements. This ratio was found to be 90%, indicating a high level of consistency between the coders.

After establishing coding reliability, the remaining data were analyzed according to the finalized codes and themes. The findings were organized and presented in tables for clarity. To maintain participant confidentiality, each student was assigned a pseudonym (S1, S2, …). Additionally, square brackets ([…]) were used within the quotations to clarify meaning and prevent potential misunderstandings.

Research Ethics

The study was conducted in accordance with the principles of the Declaration of Helsinki. No form of deception was used with the participants at any stage of the research. Ethical approval was obtained from the University's Science and Engineering Sciences Scientific Research and Publication Ethics Committee (Approval No: E-54749836-050.99-199764). Additionally, informed consent forms, signed by the students' parents, were collected prior to the study to ensure voluntary participation and uphold ethical standards.

Findings

This study aimed to explore students' perceptions of their visit to a space and aviation center. Before examining their views about the visit itself, several questions were posed to identify their prior experiences and expectations. All participants reported having previously visited out-of-school learning environments. When asked to specify these settings, two students mentioned visiting a science center, while one student noted having been to a zoo and a museum. Additionally, three students stated that they had attended mosques for religious education during the summer.

Table 1. Students' Perceptions Before the Visit.

Themes	Codes	Participants
Expectations	Entertaining	S1, S3, S4, S5, S6
	Learning	S2, S3, S4, S5, S6
	Informative	S1, S2, S3
	Enjoyable	S1, S4, S5
	Notable	S4, S5, S6
	Reinforcement	S2, S4
	First-hand experience	S3

Most participants indicated that they had not visited a space and aviation center before. When asked what the term space and aviation center meant to them, the students predominantly associated it with topics related to space and aviation, reflecting their general expectations of the center's focus. For instance, S2 stated, "I think it has something to do with aerospace and aviation." Only one participant indicated that she could not figure it out. Then they were asked about their expectations about this space and aviation center visit. Their perceptions before the visit are presented in **Table 1**:

Table 1 presents students' expectations about the visit. Almost all students projected that the visit would be entertaining. Some excerpts are presented below:

"I think it [the visit] will be an entertaining visit." (S5)

I hope it [the visit] would be an entertaining trip." (S6)

In a similar manner, learning in the space and aviation center was another commonly expressed expectation. For instance, some students expressed this:

"I expect to learn some information by trying informative experiments there." (S3)
"We can learn science concepts outside the classroom." (S5)
"I think it [the visit] will help us to learn the planets and the solar system better." (S5)
I think it [the visit] will help to learn new concepts about the context." (S2)

Besides learning, having an informative and enjoyable experience was another expectation expressed by the participants; some excerpts are presented:

Table 2. Students' Perceptions after the Visit.

Themes	Codes	Participants
Perceptions	Entertaining	S1, S2, S3, S4, S5, S6
	Learning	S1, S2, S3, S4, S5, S6
	İnformative	S1, S2, S3, S4, S5, S6
	Enjoyable	S1, S2, S3, S4, S5, S6
	Notable	S2, S3, S4, S5, S6
	Reinforcement	S1, S2, S4
	First-hand experience	S1, S2, S3, S4, S5, S6
	Memorable	S1, S2, S3, S4, S5, S6

"I am expecting to see informative experiments there." (S3-informative)

"I think this visit will be informative." (S4-informative)
"The visit will be enjoyable." (S6-enjoyable)
"I think the visit will be enjoyable." (S1-enjoyable)

The participants also thought that the visit would be notable. A student indicated that "I think it [the center] would be a remarkable place." (S6).

Reinforcement of what has been learned was expected by the students. For instance, S2 stated: *"I believe that it [the visit] will reinforce what we have learned so far*."

Having first-hand experience was only expected by one participant:
"*We can try out many things in the sections here ourselves.*" (S3)

The second research question explored participants' opinions about the space and aviation center visit after the experience. In this section, additional questions were included to determine whether the visit contributed to a deeper understanding of the Space and World unit, and to what extent the experience supported their learning of related concepts. Students' perceptions after the visit are presented in **Table 2**:

As **Table 2** shows, the participants' views about the visit were more specific than their perceptions before the visit. All students expressed the visit's entertaining and informative role. For instance:

"I think the visit was great, I discovered important things during the visit." (S1)

"There was one activity: It gave us a sense of how astronauts feel when they go into space. It was so much fun." (S2)

"It was very entertaining. I learned a lot during the visit." (S3)

"Planets, airplanes, astronauts, spacecraft... all related to science topics. I learned new things there." (S6)

"If you are interested in science and want to see and learn about science, you can go there. I think it's a very nice place." (S4)

In addition, the students frequently mentioned learning science content and enjoyable moments during the visit.

"*The assembly and instruments are very impressive. The hall about the solar system was the most interesting one. I learned a lot during the visit." (S3)*

"This trip was very effective in understanding space subject." (S6)

First-hand experience was only mentioned by one student before the visit. In contrast, all the students expressed that the activities they participated in helped them to learn the content or make the visit more entertaining/interesting. Sample excerpts are provided below:

"We, ourselves participated in the activities live. It helped us to learn the subject more easily." (S5)

"We boarded Turkey's own airplane. It was very fun." (S1)

"The first place we went was inside of an airplane. This place was very interesting for me." (S4)

Students rarely expected the visit's reinforcement role in their learning. However, all students emphasized the visit's supporting role in learning the science content. For instance:

"The visit provided a review of the topics we learned in class." (S1)

"This visit allowed us to learn the subject in depth." (S6)

One more code that appeared in the post-visit was "being memorable." All students said the visit was an unforgettable experience for them. S4 stated, "In my opinion, doing lessons outside of school is memorable."; another student (S2) said, "The visit was unforgettable. I could forget what I ate yesterday. However, I cannot forget what I have experienced, so far."

Discussion and Conclusion

The present study explored sixth-grade students' perceptions before and after participating in a space and aviation center visit, as captured through their written reflections. The findings revealed that participants' responses prior to the visit were generally brief and limited in scope. While all students acknowledged the visit's potential to be both entertaining and informative, few mentioned other possible outcomes or learning opportunities. In contrast, post-visit responses were noticeably more detailed. Beyond reiterating the entertaining and informative aspects, students described specific learning experiences, moments of enjoyment, and the value of engaging in first-hand activities. An additional theme that emerged was the role of the visit in reinforcing classroom learning, with students explicitly stating how the experience supported their understanding of related science topics.

One prominent outcome of this study was students' frequent emphasis on the visit's entertaining dimension. This finding is consistent with previous research highlighting the importance of enjoyment in out-of-school learning environments (e.g., Armağan, 2015; Kartal & Şeyhoğlu, 2020). Teachers in other studies have similarly emphasized the entertaining nature of such activities, suggesting that this affective dimension is a valuable contributor to student engagement and learning (Ertuğrul & Karamustafaoğlu, 2020; Morag & Tal, 2012). In addition to its entertaining value, the informative role of the visit was also strongly reflected in students' post-visit reflections. Participants frequently noted how the visit complemented and reinforced the content of their science lessons. This aligns with findings from earlier studies (e.g., Akay, 2019; Bakioğlu & Karamustafaoğlu, 2020; Behrendt & Franklin, 2014). For example, Behrendt and Franklin (2014) emphasized that well-designed out-of-school learning experiences can enhance students' motivation and comprehension of classroom concepts. Although the present study did not include a formal assessment of conceptual understanding — a limitation to be acknowledged — the students' detailed descriptions of how the visit related to their coursework suggest that their conceptual grasp of space-related topics may have improved, as supported by previous literature (Akay, 2019; Bakioğlu & Karamustafaoğlu, 2020; Behrendt & Franklin, 2014; Braund & Reiss, 2006; Yavuz-Topaloğlu & Balkan-Kıyıcı, 2017).

While the notion of the visit being memorable was mentioned by only three students before the trip, all participants identified notable and interesting moments in their post-visit reflections. This finding is consistent with previous research highlighting the memorable and engaging nature of out-of-school learning experiences (Armağan, 2015; Demir & Armağan, 2018; Ates & Lane, 2019; Avan et al., 2019; Behrendt & Franklin, 2014; Demirel & Özcan, 2020; Nadelson & Jordan, 2012; Soysal, 2019). The themes of notability and interest frequently appear in studies involving students (e.g., Bakioğlu & Karamustafaoğlu, 2020; Demirel & Özcan, 2020; Jarvis & Pell, 2005; Soysal, 2019), pre-service teachers (Gürsoy, 2018), and in-service teachers (Demir & Armağan, 2018). For example, Jarvis and Pell (2005) noted that a thoughtfully designed visit to a space center could leave a lasting impression on students, enhancing their engagement with science concepts. Similarly, studies with teachers have echoed these findings. In Ates and Lane's (2019) research, the teachers emphasized that field trips created new learning opportunities for students, enabling them to meaningfully connect in-class content with real-world experiences. The present study's findings align well with this body of literature, reinforcing the idea that out-of-school learning environments can both capture students' interest and leave memorable educational impressions.

Our study revealed that all participating students emphasized the value of the first-hand experiences they gained during the visit. This finding aligns with existing literature that underscores the importance of direct, hands-on experiences in educational settings (Ates & Lane, 2019; Bell et al., 2009; Demir & Armağan, 2018; Farmer et al., 2007; Orion & Hofstein, 1994). Such experiences are particularly valuable for helping learners grasp abstract scientific concepts (Bell et al., 2009; Demir & Armağan, 2018; Orion & Hofstein, 1994). In this study, students frequently mentioned specific experiences, such as boarding Türkiye's airplane, touring its interior, and actively participating in interactive activities, which demonstrated how impactful these first-hand experiences were for them. Given that topics related to space often involve inherently abstract ideas, such as the vastness of the universe or planetary systems, the visit played an important role in making these concepts more tangible and accessible to students. Additionally, several students noted that the visit reinforced (coded as reinforcement) what they had previously learned in their science lessons, suggesting that the field trip helped consolidate and contextualize classroom knowledge. From this perspective, the teacher's motivation to supplement her instruction with an out-of-school learning experience, specifically designed to support students in grasping complex scientific ideas, can be considered a successful and pedagogically sound decision. As highlighted in the literature, teacher motivation is a critical factor in the effective design and implementation of out-of-school learning environments (Behrendt & Franklin, 2014; Eshach, 2007; Nadelson & Jordan, 2012). However, prior research has also identified several factors that can hinder teachers' willingness and ability to organize such experiences, including time constraints, financial limitations, insufficient preparation, a lack of familiarity with outdoor learning strategies, and curriculum overload (Ates & Lane, 2019; Ateşkan & Lane, 2016; Anderson & Zhang, 2003; Behrendt & Franklin, 2014; Mitchie, 1998; Yıldız, 2022). Moreover, student-related challenges, such as low interest and engagement (Aydemir & Toker-Gökçe, 2016; Tal & Morag, 2009), can also affect the effectiveness of out-of-school learning opportunities intended to support classroom teaching.

Our findings also indicated that all participating students, regardless of their academic achievement level, were able to deepen their opinions about the visit. Since the participants were purposefully selected from different achievement levels, this outcome suggests that a well-designed out-of-school learning experience can engage and benefit a diverse range of learners. Even students with lower academic achievement were able to actively participate, connect with the visit's themes, and relate what they experienced to the science concepts they had previously encountered in their classes. This finding aligns with the broader literature, which consistently emphasizes that thoughtfully planned out-of-school learning environments can ignite students' interest, curiosity, and motivation to engage with science (Ateşkan & Lane, 2016; Behrendt & Franklin, 2014; Eshach, 2007; Nadelson & Jordan, 2012; Tal & Morag, 2009). For instance, Eshach (2007) noted that a well-structured field trip can cultivate students' curiosity and foster sustained interest in scientific topics, making abstract or challenging concepts more accessible to all learners, regardless of their academic standing.

Limitations and Future Research

The present study possesses several unique characteristics. Notably, the teacher (also the first author) recognized that the World and Universe theme was abstract and challenging for her students to grasp and identified a need to complement classroom instruction with concrete, experiential learning opportunities. In response, she organized a field trip to a space and aviation center to enrich the students' understanding. In this respect, the study successfully deepened students' understanding of topics related to space and the universe. However, several limitations should be acknowledged, which also offer directions for future research. First, the study involved only six students from varying academic achievement levels. While the findings demonstrated that all students—regardless of their academic standing—showed increased interest and elaborated on their opinions after the visit, future studies with larger and more diverse samples would provide a broader range of perspectives and experiences. Second, the study primarily relied on written responses to gather student views. Incorporating additional data collection tools, such as semi-structured interviews, Likert-type attitude scales, and observational data during the visit itself, could yield richer and more comprehensive insights. Furthermore, designing an intervention study with a control group could help assess the effectiveness of out-of-school learning environments more rigorously. Despite these limitations, the study offers a valuable example of how a motivated teacher can thoughtfully design a school trip to meaningfully support science instruction and foster students' engagement with abstract scientific concepts.

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