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Enhancing Antarctic knowledge through virtual reality: The virtual polar expedition application

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ABSTRACT

Antarctica, due to its extreme environmental conditions, serves as a critical continent for scientific research. In recent years, Turkey has recognized this importance and initiated research activities in Antarctica. Raising awareness about these endeavors and encouraging individuals to pursue careers in this field is crucial. However, it has been observed that some individuals find it challenging to grasp abstract concepts related to Antarctic research. To address this issue, a virtual reality application titled "Virtual Polar Expedition" was developed. Virtual reality technology provides the user with the freedom to move as they wish and the chance to interact with objects, providing a more instructive and memorable experience compared to other applications. At the same time, it is effective in eliminating the abstractness that remains in the mind, giving the user the feeling of being there. Before starting to develop the application, a comprehensive literature review was made, and then the stations and bases established within the scope of the studies of Turkish scientists were modeled using Blender 3.1 software. Then, Horseshoe Island, where Turkish scientists work on Antarctica, was created via the Unity 3D game engine, and application mechanics related to the studies on the island were prepared. After determining the achievements that the application wanted to teach to the user, informative audio recordings about the models were recorded in the studio environment. After the models and sound recordings were transferred to the Unity environment, the output of the application was taken, and the test phase was started. At the test phase, the application was tested in two different virtual reality glasses and the application has been available in Google Play Store. 7 questions, including the achievements, were solved twice, before and after, by 50 people who experienced the application. At the end of the test phase, the instructional nature of the application was proven with numerical data.

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Introduction

In recent years, the impact of climate change has become increasingly evident, posing serious challenges to ecosystems worldwide. One of the most crucial areas for studying these changes is the Antarctic, a unique and pristine environment that offers invaluable insights into global climate patterns and their consequences. However, due to its extreme remoteness, grasping abstract concepts related to Antarctic research can be challenging for the public. To address this knowledge gap, this study investigates whether virtual reality (VR) technology can transform abstract information into concrete experiences for users, enhancing their learning and retention of knowledge about Antarctica.

Climate change and Antarctic

Climate change, which has caused and continues to cause serious problems for the ecosystem as a result of the increasing industrial activities in recent years, has an important place in the world's agenda and offers a

wide research topic for scientists. Antarctica is a very important region for scientific studies on this issue in terms of examining and reducing the climate impacts (Selbesoğlu et al., 2021). The occurrence of many ecosystem events in the world in the Antarctic confirms this argument. Moreover, due to the fact that Antarctica is an untouched geography, it is seen that it provides a suitable environment for scientific research because of factors such as being away from external influences, hosting endemic species, and having a thin atmosphere. This unique environment allows it to serve as a natural laboratory and to provide a working environment for disciplines such as Oceanography, Hydrology, Geology, Meteorology, Geography, Chemistry, and Physics (Şenel & Yavaşoğlu, 2020).

The Antarctic treaty

After realizing how important the polar regions are for global climate change and acknowledging that the past, present and future of the earth are hidden in this natural laboratory, various studies have been started around the world. The Antarctic Treaty, which was the beginning of the officialization of these studies, was signed in 1959 with the participation of 12 countries and entered into force in 1961 (Yirmibeşoğlu, 2018). There are now 30 countries and 100 local stations in Antarctica with the aim of conducting scientific research (Karahilal, 2021). The basis of Turkish studies in Antarctica dates back to the 1960s, but the polar studies of Turkish scientists became official with the signing of the Antarctic Treaty in 1995.

Turkish Antarctic expedition

With the National Antarctic Science Expeditions carried out since 2017, Turkey's polar studies have started to take shape. In 2019, during the 3rd Turkish Antarctic Expedition (TAE-III), the Turkish Scientific Research Camp was temporarily established on Horseshoe Island, which is considered the home of Turkish scientists on the white continent. Horseshoe Island is an island located in western Antarctica, 12 km long and 6 km wide. The reason why it is described as the home of Turkish scientists on the white continent is that it hosts many Turkish research stations as well as the Turkish Scientific Research Camp.

What is virtual reality?

This study was carried out with virtual reality technology, which is also called the "technology of the future", in order to raise awareness about the work of Turkish scientists, to emphasize the importance given to the poles in the eyes of people and to encourage them to work in this field. Virtual reality can be defined as the technology that enables the user to interact with the created 3D pictures and animations to interact with the objects in the environment by giving the feeling of being in a real environment with various technological tools (Çavaş et al., 2004). The biggest advantage of using virtual reality technology compared to other technologies is that it gives the user a sense of reality. Virtual reality, which plays an important role in the examination of places that exist in reality but where students do not have the opportunity to examine, enables the user to feel that they are in control by moving in the direction they want in the computer-created environment, thus making the application more experiential (Bayraktar & Kaleli, 2007).

The problem identified within the scope of this study is that people in Turkey do not have the opportunity to follow the works of Turkish scientists closely, so these studies remain abstract in their minds. The aim of this study is to eliminate the abstract nature of Antarctic research by providing an opportunity for those interested in the subject to virtually observe a close representation of a polar environment. Providing the user with the opportunity to interact with the models in the virtual environment and making them feel like they are on Horseshoe Island increases the retention rate of the information. Some studies have been carried out before in order to find similar solutions. 360-degree video recordings, polar documentaries, and animations can be given as examples of these solutions. However, what makes this study different from other works is that it enhances understanding, thanks to the opportunity to move in any direction and interact with objects, regardless of a source. There are few polar virtual reality applications that host the work of various countries in Antarctica. The parts that distinguish this study from other applications are that it is accessible, easy to use, and specifically showcases the work of Turkish scientists.

Research question and hypothesis

This study aims to investigate whether virtual reality technology can transform abstract information into concrete experiences for users, enhancing their learning and retention of knowledge about Antarctica. The research question is as follows:

- Is a virtual reality application effective in increasing and enhancing users' knowledge about Antarctica?

Hypothesis:

- Users who utilize the virtual reality application will gain more knowledge about Antarctica and retain this information better.

Method

Virtual reality (VR) technology has the potential to revolutionize education and training by providing immersive and interactive learning experiences. This study aimed to develop a VR application to educate users about the Turkish research stations located on Horseshoe Island, Antarctica. The application allows users to virtually explore the island and its surrounding areas, learn about the ongoing scientific research projects, and gain a deeper understanding of Turkey's role in Antarctic exploration. To achieve these goals, the development process followed standard digital product development project steps, with a specific focus on creating a user-friendly and informative VR experience.

Modeling

At the beginning of the modeling phase, first of all, it was decided which software was the most suitable for the study. Based on the opinions received from experts in the field and the past studies examined, among the organic modeling software; Blender 3.1 software was preferred because it is free, compatible with other programs used in the study and useful in organic modeling.

After it was decided to use this software, Horseshoe Island, where Turkish Scientists mostly operate, was modeled. Then, Turkish Scientific Research Camp (Figure 1, Figure 2), Antarctica Turkish Meteorology Station (Figure 3), Aselsan Radio Repeater Station (Figure 4), and TUR1-TUR2 GNSS Stations (Figure 5, Figure 6) were modeled.

Figure 1 Turkish Scientific Research Camp Model, Blender 3.1

Figure 2 Turkish Scientific Research Camp Model Interior View, Blender 3.1

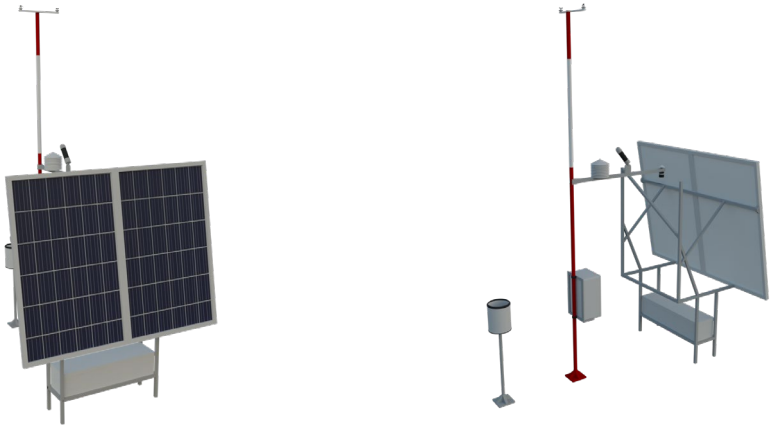

Figure 3 Antarctica Turkish Weather Station Model, Blender 3.1

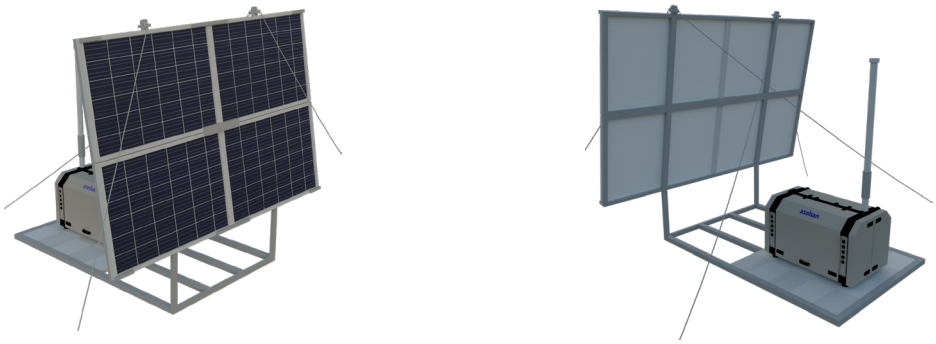

Figure 4 Aselsan Radio Repeater Station Model, Blender 3.1

Figure 5 TUR1 GNSS Station Model, Blender 3.1

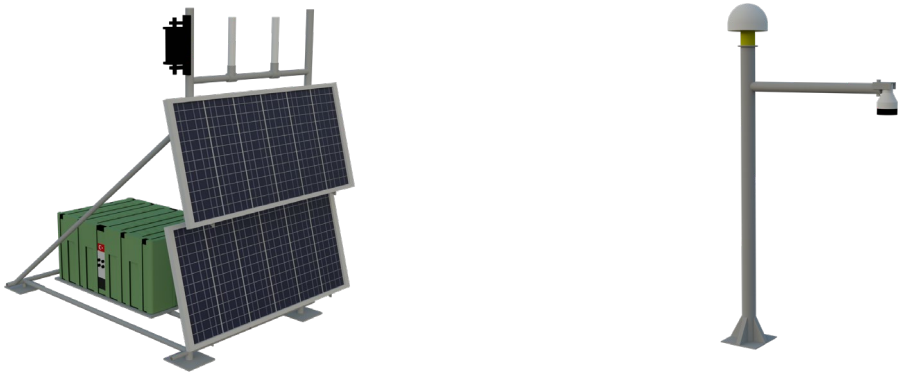

Figure 6 TUR2 GNSS Station Model, Blender 3.1

Creating the virtual environment

First of all, it was determined which game engine was the most suitable for developing a virtual reality application. Unity 3D was preferred among the game engines because it is open source, free, contains a lot of accessible educational content, and because we had experience with it from our previous works. "Google VR SDK" plugin was used based on the research and the information obtained about which plugins to use on Unity.

Then, Horseshoe Island prototypes were created to establish the mechanics and environments to be used in the application on Unity. Based on the prototypes, it was decided how the mechanical and environment design of the application would be. Subsequently, the drawings created in Blender were transferred to the Unity environment, and the environment and mechanics of the application were created.

The application was programmed in C# language using Visual Studio 2021. The fact that it is an easy-to-use language, has a modern language structure, and is among the most preferred languages in Unity programming influenced the preference for the C# language. We decided to create the mechanics for the application using the "gaze-based interaction" method. With this method, it is aimed for the user to interact with the object when holding the cursor on the object for a certain period and clicking with the game controller. The basic algorithm of the application is designed so that when the user enters a specific area, by giving input with the remote, the user experiences informative audio records and animations about that subject.

Figure 7 Front View of the Turkish Science Base

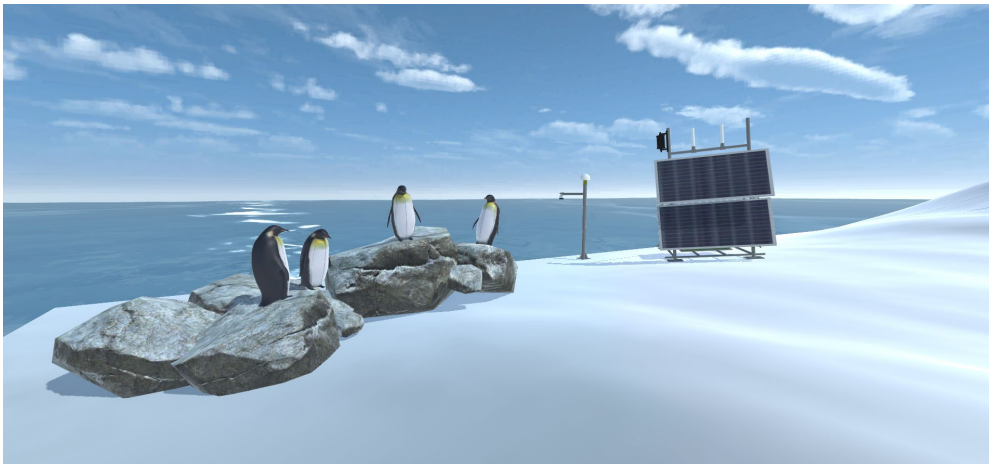

Figure 8 View of the North Side of the Island

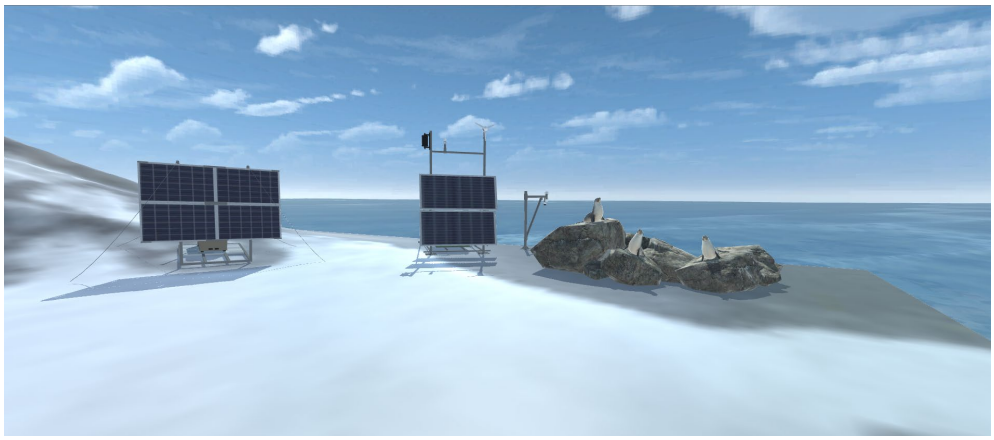

Figure 9 View of the South Side of the Island

Figure 10 Ship and Boat

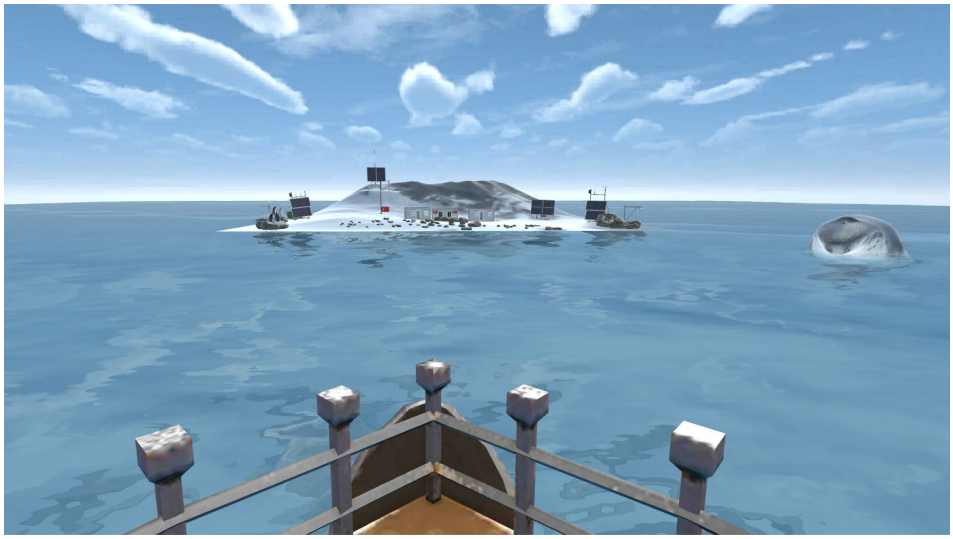

Figure 11 View of the Island from the Ship

When the visual part of the application was completed, the voiceover part was started. Sound recordings for the promotion of the island and the modeled stations were taken in the studio environment and added to the application. All the scripts and assets used in the application are given in a GitHub repository.

Getting application output

After the virtual environment was created, the working output became available. For this, first, a name that would best summarize the work was chosen and a logo of the work was designed. Then, in order to use Unity on Android devices, a printout in .aab file format was made using Android Studio SDK. After this stage, the study became available on an Android device. Therefore, a Google Play Console account was opened, and the

application's Play Store page was created. The application's .aab file was uploaded to the system, and after completing the necessary tests, it was made available on the Google Play Store. In order to test the work, a phone with the application installed, mobile-based virtual reality glasses, and a game controller are sufficient.

In addition to this method, the application can also be used with computer-based virtual reality glasses. In this direction, the application was re-developed by using the "Steam VR SDK", adhering to the game mechanics, and the application was tested with a Windows-based .exe output, and this version also worked successfully. The new version created was tested with HTC Vive virtual reality glasses and feedback about the new mechanics was received from users.

Figure 12 Mobile-Based Virtual Reality Glasses

Figure 13 Computer-Based Virtual Reality Glasses

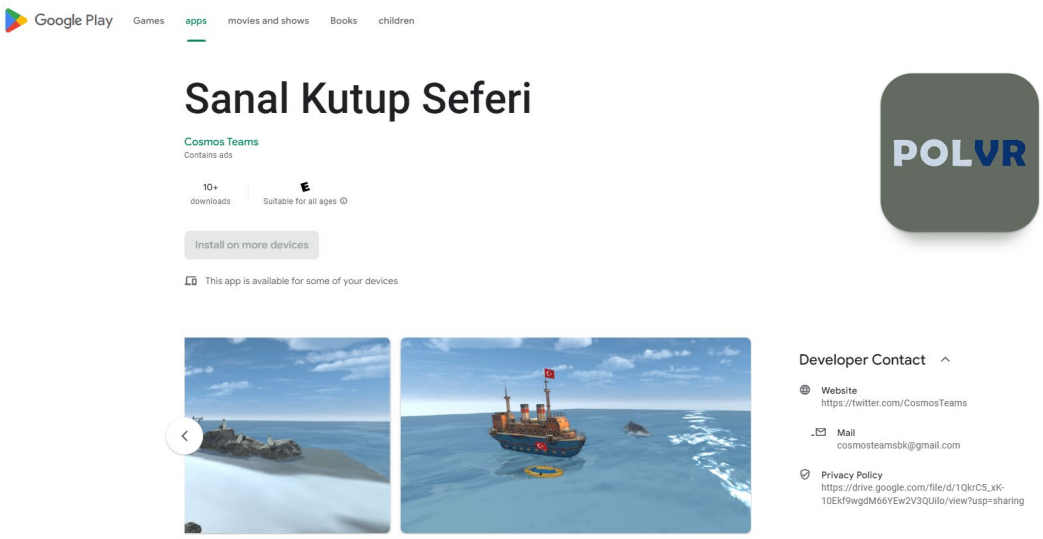

Figure 14 Google Play Store Page of Virtual Pole Expedition

Participant selection

Fifty participants were recruited to participate in this study through an online platform. During the recruitment process, we collected basic demographic information from participants, including their age and educational background.

Data collection

A pre-test and post-test design was employed to evaluate the effectiveness of the VR application in enhancing user knowledge about Antarctica. Participants completed a "Pole Knowledge Adequacy Form" consisting of seven multiple-choice questions before and after experiencing the VR application. This form

assessed participants' understanding of key concepts related to Antarctic geography, climate, research activities, and the role of Turkey in Antarctic research.

Data analysis

Paired-samples t-tests were conducted to analyze the differences in participants' scores on the "Pole Knowledge Adequacy Form" between the pre-test and post-test. This statistical analysis helped determine whether the VR application had a significant impact on user knowledge acquisition.

Results

Application benefits

In this section, the achievements that the Virtual Pole Expedition application aims to bring to the user are listed below.

- Recognizes the Antarctic Treaty signed by our country.
- Recognizes Horseshoe Island, where Turkish scientists operate in Antarctica.
- Explains some of the studies carried out by Turkish scientists within the scope of the Turkish Antarctic Science Expeditions.
- Recognizes the first Turkish scientists who set foot in Antarctica.
- Explain the basic information about Antarctica's living ecosystem.
- Recognizes domestic and national technologies used in Antarctica.

Application sections and durations

The average durations of the process from the beginning of the application to the last activity are shown in Table 1. Since these periods depend on the user's initiative, they do not have a definite experience period.

Table 1 Application sections and average durations

Application sections	Average durations
Entry - Getting to the Island by Ship	2 Minutes
Arrival and Introduction of Horseshoe Island	45 Seconds
Turkish Scientific Research Camp Introduction	2 Minutes
Aselsan Radio Repeater Introduction	45 Seconds
TUR1 GNSS Introduction	45 Seconds
TUR2 GNSS Introduction	30 Seconds
Biodiversity Introduction	30 Seconds
Flag Raising Mission	15 Seconds
Weather Station Introduction	30 Seconds
All sections	8 Minutes

Test results

According to the Pole Knowledge Adequacy Form results, the rate of correct answers by the users before and after trying the application is as in Table 2.

Table 2 Rates of answering the questions correctly

Item	1	2	3	4	5	6	7	Average
Before experienced	%52	%38	%26	%56	%30	%44	%26	%38.8
After experienced	%92	%94	%90	%98	%92	%90	%76	%90.2
Increase in accuracy	%40	%56	%64	%42	%62	%46	%50	%51.4

The results of the "Pole Knowledge Adequacy Form" supported the hypothesis that the VR application could effectively enhance user knowledge about Antarctica. Compared to their pre-test scores, participants demonstrated a significant increase in accuracy rates on the post-test. On average, participants' scores improved by 51.4% after experiencing the VR application. These findings suggest that the VR experience successfully transformed abstract information into a more concrete and engaging learning experience, leading to improved knowledge retention.

Discussion and conclusion

The problem identified in this study was that some facts remained abstract in the minds of those who were interested in the subject and wanted to do research, due to the distance between the poles and the low possibility of going. It is seen that the virtual reality application developed to solve this problem offers the user an alternative observation environment.

It has been verified by people who have experienced the application that they feel like they are at the poles for reasons such as the fact that the prepared environment is realistic, and the user has control while observing in the virtual environment without the need for any time or expense.

According to the response rates of the "Polar Knowledge Adequacy Form" applied to users who have experienced the application, the fact that each question has an increase rate of 40% to 64% proves that the application teaches the targeted gains.

The findings of this study demonstrate the potential of VR technology to enhance user learning and knowledge retention in the context of Antarctic research. Participants who interacted with the "Virtual Polar Expedition" application displayed a significant increase in their understanding of key concepts related to Antarctica compared to the pre-test scores. This suggests that VR can be a valuable tool for science education by providing immersive and interactive experiences that make abstract information more relatable and memorable.

This study investigated the potential of VR technology to enhance user knowledge about Antarctica. The findings demonstrated that the "Virtual Polar Expedition" application effectively addressed the challenge of abstract information by providing an immersive and interactive learning experience. Participants showed a significant increase in their knowledge about Antarctica after using the VR application. Future research with larger and more diverse samples can further explore the long-term effects of VR on knowledge retention and user engagement in the field of Antarctic research. By utilizing VR technology, educational institutions and scientific organizations can create engaging learning experiences that raise awareness about the importance of Antarctic research and inspire future generations of scientists.

Further research

This study opens doors for further exploration of VR technology in educational settings, particularly related to science education. Future research could investigate the following:

- The long-term effects of VR on knowledge retention in Antarctic research compared to traditional learning methods.
- The effectiveness of VR applications in fostering interest and motivation among students to pursue careers in science and research.
- The development of VR experiences that focus on specific scientific disciplines within Antarctic research, such as glaciology or meteorology.
- The usability and accessibility of VR applications for diverse user groups, including individuals with disabilities.

By continuing to explore the potential of VR technology, educators and researchers can create innovative learning experiences that engage students, enhance knowledge retention, and inspire future generations of scientists to explore the wonders of Antarctica.

Limitations

This study has certain limitations that need to be acknowledged. Firstly, the sample size of fifty participants is relatively small. Future studies with larger and more diverse samples could provide more robust and generalizable results. Secondly, the potential for self-selection bias exists. Participants who volunteered for the study might have had a pre-existing interest in Antarctica, potentially leading to higher baseline scores on the knowledge test. Future research could employ recruitment strategies that minimize this bias.

Disclosure statement

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

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