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Students' Reactions to Virtual Geological Field Trip to Baengnyeong Island, South Korea

Woo-Hee Lee [1], Cheolhong Kim [1], Heejung Kim [2], Hee-Soo Kim [1] and Chungwan Lim [1,*]

[1] Department of Earth Science Education, Kongju National University, Chungnam 32588, Korea; cnssmjm@cne.go.kr (W.-H.L.); cheolhong@smail.kongju.ac.kr (C.K.); heesoo54@kongju.ac.kr (H.-S.K.)
[2] Department of Geology, Kangwon National University, Chuncheon 24341, Korea; hydroqueen@kangwon.ac.kr
* Correspondence: tephra@kongju.ac.kr; Tel.: +82-41-850-8298; Fax: +82-41-850-8299

Abstract: In this study, we evaluated affective components of the learning processes of students after being exposed to a virtual geology field trip of the Baengnyeong Island, South Korea. Changes in students' cognition of and interest in science and scientific attitude were measured before and after exposure to the virtual field trip. We exposed 106 middle school students to the program and our results revealed that this program had a positive impact on their scientific attitude (p value = 0.014) but no significant changes were observed in the students' cognition of and interest in science (p value = 0.166). The significant finding from this study was that the VFT program can bring positive scientific attitude as a component of affective learning process. The affective learning process influences the cognitive learning processes and eventually the academic achievement of the students can be improved. In the students' satisfaction survey, the highest satisfaction level was in the convenience of the program. As access to Baengnyeong Island is limited, though the island is an ideal location for studying geological phenomena, the VFT can be a useful tool for instilling a positive scientific attitude in students via indirect field experience. It can be a good alternative to bridge the education gap between students with special needs who are less mobile and other students.

Keywords: virtual field trip; affective component; Baengnyeong Island; scientific attitude

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1. Introduction

In geosciences, field excursions are important for effective learning; however, suitable locations are often difficult to access, and traveling to such locations can be time-consuming and costly [1,2]. A solution in overcoming such limitations is Virtual Field Trip (VFT) which can actualize the virtual 3D world.

VFTs can not only be applied to geosciences, but also to various fields, such as underwater archaeology, botanical gardens, architectural monuments, and so on [3–5].

Researchers developed VFT programs and offered them to students for several subjects [6–14]. The results showed that students exposed to the VFT exhibited a similar effect to that of the group that attended the actual field trip. This proves that VFTs can provide the real nature of field trips, allow learners to achieve independent learning without time and spatial limitations, and portray various and integral information of science with high accuracy.

For South Korean geoscience students, Baengnyeong Island is a suitable area for geological field excursions, because it contains different geological features suitable for self-led conceptual formation and learning. However, the island's location in the northern West Sea poses an issue for arranging field excursions for students. To address this limitation, we developed an educational program for a VFT to the island and presented it to middle school students. The following study objectives were formulated to identify the educational effects of the VFT: examine the students' reactions to the educational material and determine the implications of the program for science education.

Baengnyeong Island is located in the northern West Sea, 12 km from Jangsan point in western Hwanghae Province of North Korea and 191.4 km northwest of Incheon (Figure 1). In the past, the island was part of the Ongjin Peninsula, and it became an island with an area of 51 km^2 after sea transgression that occurred during the post-glacial age. The geology of Baengnyeong Island mainly comprises of arenite–meta-arenite, quartzite, and pelite–phyllite. Due to long-term weathering, in this region, basalts have limited distribution and have developed into wave-shaped monadnock having slight undulations, with an average height of 50–150 m [15]. Notably, the metasedimentary rock strata, which are part of the Sangwon System, are distributed across the island (to southwestern North Korea). The strata of the system found on the island is ideal for studying the structure and weathering of strata because it contains rocks of a relatively low metamorphic grade (for its age) and preserves abundant sedimentary records.

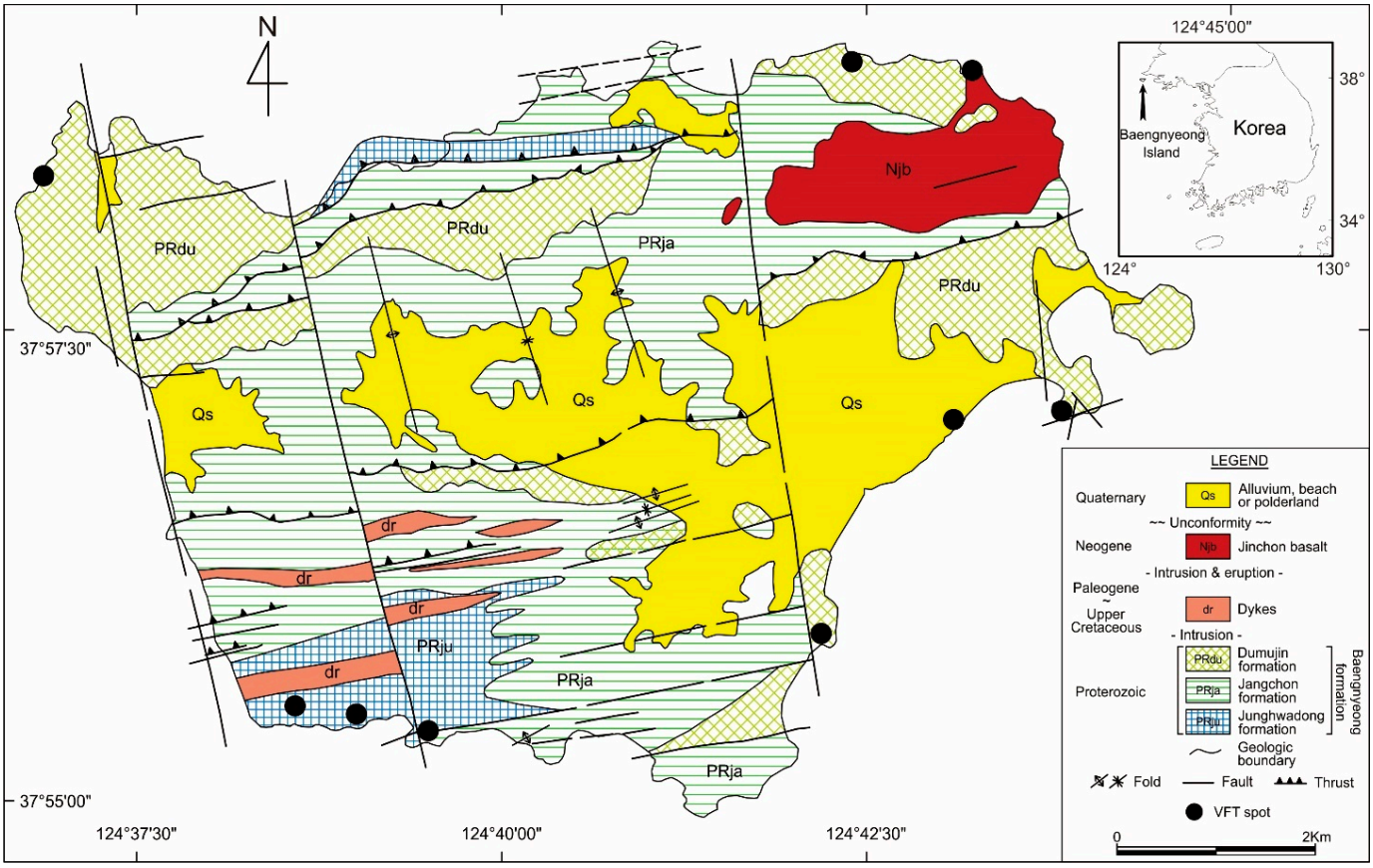

Figure 1. Geologic map of Baengnyeong Island with virtual field trip (VFT) locations [16].

In the 1:1,000,000 scale geological map of the Korea Institute of Geoscience and Mineral Resources (KIGAM), the metasedimentary strata in Baengnyeong Island are indicated as Late Proterozoic (Neoproterozoic) [16]. However, these strata are indicated as Mid to Late Proterozoic in the 1:1,000,000 geological map developed by the Institute of Geology of North Korea [17]. The strata and rocks found in Baengnyeong Island largely fall into 4 categories [15]: (1) Low-grade metamorphic metasedimentary rocks that correlate with part of the Sangwon System (Baengnyeong group), (2) Age-unknown dikes that intrude into those metasedimentary rocks, (3) Cenozoic basalts and (4) Unconsolidated Quaternary sediments.

According to Eiss and Harbeck (1969), learning consists of three interactive processes: cognitive (knowledge, understanding, and conceptualization), affective (emotions, attitudes, and feelings), and psychomotor (practical skills such as operating field instruments) processes [18,19]. Cognitive and psychomotor components are commonly assessed in class-

rooms or during real field trips, whereas affective components are rarely assessed [5,20]. According to Ashby and Isen (1999) and Isen (2008) affective components influence cognitive learning processes [21,22].

Most other research on VR (Virtual Reality) focus on the concept, development, methods, and effectiveness as an alternative of the real field trips [1–14], however, the objective of our study is the evaluation of affective components of learning processes after students' exposure to our VFT program. The evaluation framework consists of the three main categories: cognition, interest and scientific attitude developed by Kim et al. (1998) [23].

2. Methods

2.1. Development of Virtual Geological Field Trip Program

Our VFT program includes igneous, sedimentary, and metamorphic rocks from a part of the Baengnyeong Daecheong Geopark located in the northern West Sea of Korea (Figure 1). Access to the island is limited due to its geographic proximity to Northern Limit Line (NLL) which divides the waters between North and South Korea. Therefore, VFT is more suitable than the real field trip to the island for geoscience education of middle school students.

For our program, panoramic aerial photographs were taken using a drone (MAVIC2 Pro from DJI Corporation, China), and ground photographs were taken using a Nikon D700 camera of Japan equipped with a fish-eye lens and rotator that could turn at 90° angles.

The photographs were stitched using the PTGui software to obtain one panoramic image (Figures 2 and 3). Subsequently, the relevant learning elements, such as audio descriptions or links to online learning content, for the geological characteristics shown in completed panoramic photographs were supplemented to develop the VFT program using the KrPano software (Figure 4).

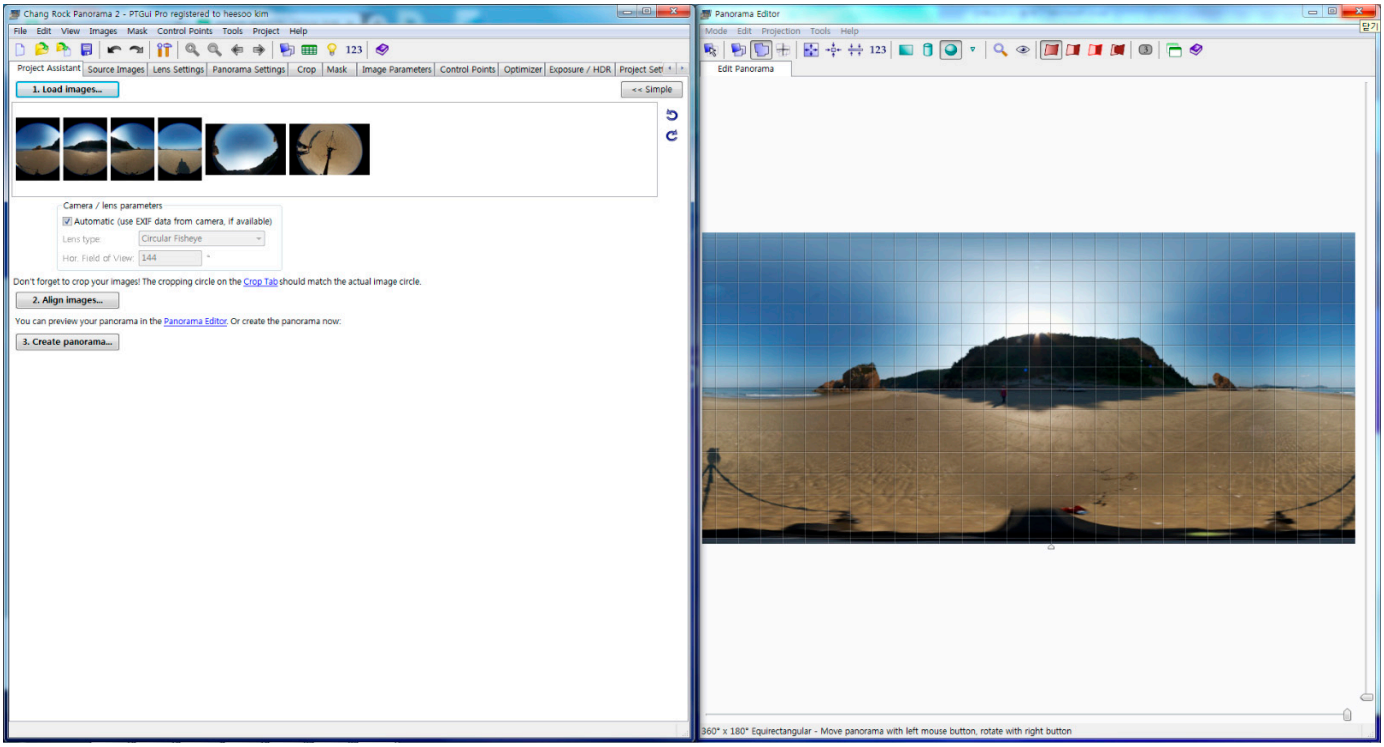

Figure 2. Stitching of aerial and ground photographs using PTGui.

Figure 3. Completed Stitched Image.

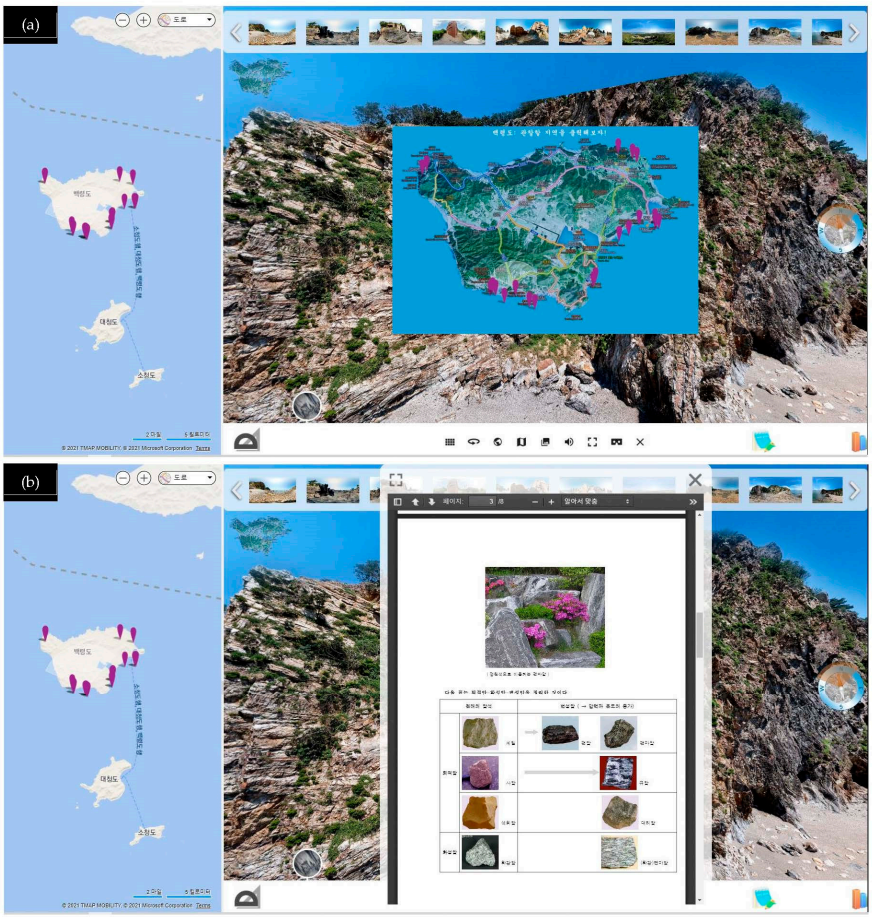

Figure 4. Main Screen of Virtual Field Trip (VFT) Program Developed in our study using KrPano. When clicking the "Show map" menu a map connected to Bing maps appears on the left for geographical information (**a**). The materials for the preparatory study pops up when clicking the notepad icon (**b**).

The VFT program was developed by dividing Baengnyeong Island into 21 sectors in order to configure the tour in a sequential pattern. Sixteen of these sectors comprised of the main observation spots that provided important geological and topographical characteristics. In Figure 4, the upper part of the main screen of the completed VFT program contains thumbnail images; the panoramic image appears in the center, and the

menu appears in the lower part. The thumbnail images show regional panoramic scenes, and users can jump to the desired location by selecting the relevant image. A complete map of Baengnyeong Island appears in the upper left corner of the panoramic screen to indicate the position of the location that the user is observing, and the map is linked to other locations so that users can easily navigate between the desired places. A compass is placed on the right side of the screen to indicate the direction in which the photograph is being viewed. Furthermore, the menu is composed of various convenient functions, such as a rotating panoramic image, the current position on the map, and sound, along with virtual reality mode icons that allow users to experience the environment in 3D on their own smartphones and/or virtual reality devices. A protractor icon appears to the left of the menu so that strata or ground slope can be measured. Users can learn geological and topographical facts of the Baengnyeong island through this geological VFT via the learning icons displayed in the bottom right of the screen. Additionally, by following the "Hot Spot" link for each location, users can learn Supplementary Information about the geological characteristics. Furthermore, links to other relevant learning sites are shown, and voice guidance can be played, enabling users to access relevant knowledge on their own.

The program was introduced in a science class at the computer room of the school. Firstly, a preparatory learning stage was provided, which involved basic contents covered by the regular curriculum, such as rock types and geological structures. Then, the Baengnyeong Island VFT program was demonstrated by a science teacher, showing the students how to operate the program on the main screen in front of the classroom. Then, each student operated the program with his/her usual computer and monitor. Students connected to http://203.253.36.216/hskim/panorama/dron-use/dron.html, accessed on 8 October 2021 and navigated through the program, on 14 November 2019, according to the provided instructions, which include:

(1) Find Jinchon basalt, listen to the explanation on the rock, and write down its characteristics;
(2) Find out three places where ripple marks are observed. Listen to the explanation on ripple marks and write down their characteristics;
(3) Find out a fold and listen to its explanation. Write down its characteristics;
(4) A place in Baengnyeong Island is famous for a Korean folklore. Find the place and write down the story after listening to the explanation of the island's origin.

Notably, the students could listen to the explanations or watch the VR on the geologic phenomena by clicking outcrops or scenes on the screen. Additionally, they could observe close-up pictures of rocks or geologic structures at certain sites. Finally, the students were asked to write and submit a review paper to recapitulate the knowledge acquired through the program.

2.2. Study Subjects and Test Tool

We recruited 106 students for this study—the students in the first and second grades (ages 13–14) of the Inji Middle School in Seosan City, Chungcheongnam Province, South Korea (Table 1).

Table 1. Study Subjects from Inji Middle School, Seosan, South Korea.

	Male	**Female**	**Total**
Pre-test	49	57	106
Post-test	48	55	103

To assess the range of the students' conceptual definitions associated with science, we applied the 48 parameters developed by Kim et al. (1998) [23], which is a widely used questionnaire in South Korea for such analyses (see the English-translated version in the Supplementary Material). The parameters are grouped into 3 categories: cognition, interest,

and scientific attitude. The three categories belong to the science-related affective domain that is considered as a very important domain for achieving students' scientific literacy [23].

The "cognition" category comprises of three sections, namely, cognition of science, scientists and science-related jobs, and the interrelationship between science, technology, and society (STS). The "interest" category is divided into interest in science, science learning, science activities, and science-related careers, as well as interest in and anxiety surrounding science. Finally, the "scientific attitude" category is composed of seven sections, namely, curiosity, open-mindedness, critical mindedness, cooperation, voluntariness, endurance, and creativity (Table 2).

Table 2. Composition of the questionnaire on Cognition of, Interest in, and Scientific Attitude of Kim et al. (1998) [23].

Main Category	Sub-Category	Question NO.
Cognition (C)	Cognition of science (CS)	1, 4, 8
	Cognition of science learning and teaching (CL)	5, 9, 12
	Cognition of science related careers (CC)	2, 6, 10
	Cognition of importance related to STS problems (CT)	3, 7, 11
Interests (I)	Interests toward science (IS)	13, 18, 24
	Interests toward science learning (IL)	14, 20, 25
	Interests toward science activities (IA)	15, 21, 26
	Interests toward science related careers (IC)	16, 22, 27
	Anxiety (IX)	17, 19, 23
Scientific attitude (A)	Curiosity (AU)	31, 37, 44
	Open-mindedness (AP)	28, 38, 45
	Critical-mindedness (AR)	33, 39, 46
	Cooperation (AO)	29, 32, 40
	Voluntariness (AV)	30, 34, 41
	Endurance (AE)	35, 42, 47
	Creativity (AC)	36, 43, 48

Questions 1–25 included the science cognition and interest domains, and questions 26–48 were related to overall scientific attitude (Table 2). Notably, the reliability of each question was 0.8 or higher. In terms of the reliability coefficient, Cronbach's alpha for the cognition and interest questionnaires was 0.83, and that for the scientific attitude questionnaire was 0.87. The item test correlation coefficient for the first 12 questions ranged from 0.1 to 0.3, and for the next 24 questions it was from 0.3 to 0.5 and for the remaining 12 questions it was from 0.5 to 0.7. The standard deviations of individual questions ranged from 0.8 to 1.2.

A satisfaction survey was performed immediately after applying the VFT program using Lim's (1999) questionnaire, after expert consultation and modifying its contents to suit the purpose of our study [24]; the Cronbach's alpha of this survey was 0.899. This questionnaire aimed to examine the satisfaction level of the students with respect to 11 sub-domains that enabled the verification of questions on curriculum relevance, interest, understanding, aesthetic discernment of nature, convenience, memory, self-directed learning, interactivity, likeness to reality, convergence education, and scalability, which were rated using a five-point Likert scale (Table 3).

Notably, we conducted individual interviews to qualitatively verify the effects of the VFT program developed in this study. Six students were selected per student level and grade, that is, one from each science performance level (high, medium, and low levels) of

the first and second graders. The interviews were conducted using step-by-step questions (Table 4), based on the level of the student.

Table 3. Composition of Questionnaire of the VFT program satisfaction survey.

Question NO.	Area
1	Curriculum relevance
2	Interest
3	Understanding
4	Aesthetic discernment of nature
5	Convenience
6	Memory
7	Self-directed learning
8	Interactivity
9	Likeness to reality
10	Convergence education
11	Scalability

Table 4. Question Configuration for Individual Interviews.

Question NO.	Questions for Interview
1	Was this program interesting?
1-1	Which part of the program was most interesting?
1-2	What can be improved in the program?
2	Have you observed any rock in this program?
2-1	What is the name of the rock you observed?
2-2	Can you explain the characteristics of the rock briefly?
3	Have you observed a geological structure in this program?
3-1	What is the name of the geological structure you observed?
3-2	Can you explain the characteristics of the geological structure?

The detailed overall process of the study is summarized in Figure 5.

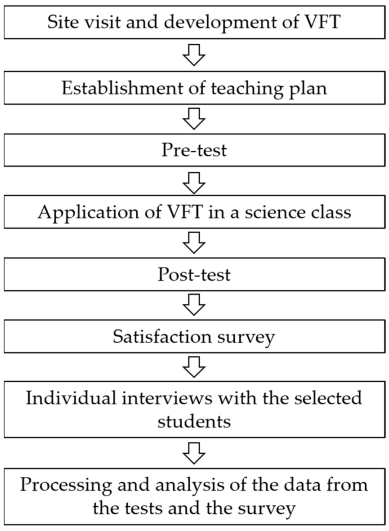

Figure 5. Overall flowchart of the study process on the Bangnyeong Island VFT.

3. Result

3.1. Changes in Cognition of, Interest in, and Scientific Attitudes before and after Virtual Field Trip (VFT)

Normality tests were carried out for the two categories—that is, cognition of and interest in science and scientific attitude—using the Shapiro-Wilk normality test for the pre and post-test. The p values in the normality test for the mean value of the pre-test were 0.287 and 0.352, which indicated normal distribution. Those for the post-test were 0.524 and 0.147, which also indicated normal distribution. Since the p-values of the Shapiro-Wilk normality test were >0.05, t-tests could be conducted to find out significant changes in the students' cognition, interest, and scientific attitude before and after applying the program.

Notably, the results of the pre-test were not disclosed to minimize its influence on the post-test. After the pre-test (September 2019), the VFT program was applied in November 2019; the post-test was conducted in December 2019.

Questionnaires of Kim et al. (1998) were used to examine changes in the students' cognition of and interest in science before and after the VFT program was applied. We found no significant changes ($p > 0.05$; Table 5) after exposure to the program.

Table 5. Results of Independent Sample t-test on the Students' Cognition of and Interest in Science.

	No. of Subjects	Mean	Standard Deviation	t Value	Degrees of Freedom	p Value
Pre-test	103	3.04	10.594	−1.397	102	0.166
Post-test		3.11	9.81			

The questionnaires used to examine the changes in students' scientific attitude before and after VFT program exposure revealed significant changes ($p < 0.05$; Table 6), indicating that our VFT program could improve students' scientific attitudes.

Table 6. Results of Independent Sample t-test on Students' scientific attitude.

	No of Subjects	Mean	Standard Deviation	t Value	Degrees of Freedom	p Value
Pre-test	103	3.13	10.686	−2.505	102	0.014
Post-test		3.29	11.783			

3.2. Satisfaction Level for Virtual Field Trip (VFT) Program

The satisfaction level for the VFT program proposed in this study involved 11 questions corresponding to the 11 sub-domains mentioned above (Table 3). The participating students rated each question using a five-point Likert scale (with 5 denoting the highest level; Table 7). Immediately after the VFT program, we investigated the satisfaction level of the students. The mean score was 3.74, indicating that, in general, the students were satisfied with the content of the program.

The most positive result was found for "convenience" (4.21 points). Similarity between "self-directed learning" and "likeness to reality" (3.99 points), as well as the "scalability" of the program to other disciplines (3.87 points) also yielded positive results. Other responses indicated that the beauty of the environment (aesthetic discernment of nature) was well-executed (3.8 points), learning method was interesting (3.73 points), the program was suitable for self-directed learning (3.73 points) and interaction was well-programmed (3.50 points), confirming that, overall, the students were satisfied with all the domains of the program. These results verified that the program could not increase a students' cognition of and interest in science, but it could cultivate a positive scientific attitude by promoting learning and achievement.

Table 7. Students' Satisfaction Level with Virtual Field Trip (VFT) Program using 5-point Likert Scale.

Question NO.	Test Area	Total Score	Mean	Rank
1	Curriculum relevance	383	3.72	7
2	Interest	384	3.73	5
3	Understanding	372	3.61	9
4	Aesthetic discernment of nature	391	3.8	4
5	Convenience	434	4.21	1
6	Memory	350	3.4	11
7	Self-directed learning	384	3.73	5
8	Interactivity	361	3.5	10
9	Likeness to reality	411	3.99	2
10	Convergence education	377	3.66	8
11	Scalability	399	3.87	3

3.3. Individual Interview Results

To identify the students' perceptions of our program, we conducted measurements according to three stages after separating the categories into two sections. The questionnaire included a section on interest, consisting of one question related to why students were interested in the class using the VFT program, and the other on academic achievement, which comprised of two questions related to knowledge on rocks and geological structures. Immediately after the program, six students per student level and grade were selected, based on their overall learning abilities, and individual interviews were conducted.

Notably, the students gave similar responses to all questions regardless of their grade and learning ability (Table 8). Regarding the questions on interest, all six students responded that the program was interesting, because they enjoyed the vivid virtual experience of being in the field without visiting the study region physically. Additionally, the program enabled students to learn on their own. Regarding academic achievement, all students gained knowledge on the rocks and geological structure developed in the VFT. In particular, they focused on basalt and peridotite rocks and on fold and ripple marks of the geological structures according to the provided instructions in the class. All of the students could explain their observations. One student suggested the use of subtitles on the screen in the program, because some content was difficult to understand due to inaccurate pronunciation or wind noise in a few videos that were linked to hot spots.

Table 8. Responses obtained in Individual Interviews (Refer to questions in Table 4).

Question NO.			1	2	3
Test area			Interest	Achievement (Rocks)	Achievement (Geological structures)
Response	Grade	Learning ability			
	1	Low	Terrific.	Got to know about basalt.	Observed folds.
		Medium	Interesting as in the real field site.	Found peridotite in basalts.	Got to know about fold.
		High	It was convenient for self-study.	Basalt and peridotite occur together.	Ripple marks were observed in many places.

Table 8. *Cont.*

Question NO.		1	2	3
2	Low	It was convenient to connect to the site using a mobile phone.	Found that peridotite is green.	Observed ripple marks.
	Medium	Explanation voice was not clear due to wind noise.	Observed basalts and peridotites.	Found big-scale folds.
	High	It would have been better to have subtitles.	Got to know appearance of basalts.	Got to know the mechanism of folding.

4. Discussion

The students expressed satisfaction with the VFT program in various areas and specially in "convenience" (Table 7). This is a positive signal that the VFT can be an alternative to a real field trip in terms of students' satisfaction.

The convenience of VFTs is especially highlighted when they are applied to students with special needs who have difficulties in accessing the real field sites and usually visit fewer places than more advantaged students [25,26]. For those students, VFTs can be a good alternative to bridge the education gap between students with special needs and other students.

An interview with the 6 selected students revealed that the program is effective in students' interest and virtual site observations regardless of the grade and learning ability.

Sriarunrasmee et al. (2015) found significant increases in scores of students' post-test in comparison to the pre-test for all the measured skills (science concepts, searching, meaningful communicating, and critical thinking) which are related to the cognitive learning process by using a VFT program [27]. However, our study found no significant changes ($p > 0.05$; Table 5) in cognition of and interest in science before and after the VFT program, whereas significant improvement in the scientific attitude which belongs to the affective component of the learning process has been detected. To find the reason why our program was uneffective in the cognitive area further studies are required to determine whether longer-term or other ways of exposure of the program are needed.

Researchers found no difference in the basic knowledge or cognitive learning outcomes of students who had taken the virtual field trip compared to those who had taken the real field trip [28–30]. They observed that the students who participated in the real field trip have greater qualitative appreciation and positive attitude about the natural environment, or more successful affective learning outcomes. It would be meaningful to compare the cognitive and affective outcomes between our VFT program and a real field trip to Baengnyeong island in the future.

5. Conclusions

Since practical field excursions, which are useful educational tools, cannot always be carried out in geoscience education because of time and distance constraints, we developed a 3D geological VFT program and presented it to first and second grade middle school students. Their cognition of, interest in, and scientific attitude before and after the program were determined. Furthermore, we conducted individual interviews to establish the students' satisfaction with the program and analyze their improvement in academic achievements. Suggestions for how the program can be improved for future implementation were also considered.

Changes in the students' cognition of, interest in, and scientific attitude due to the VFT program can be summarized as follows:

Firstly, no significant changes were observed in the students' cognition of and interest in science. Therefore, further studies are required to determine whether longer-term or other ways of exposure are needed for the program to be effective.

Secondly, the students' scientific attitude significantly differed before and after the program, indicating that the program positively impacted the students' attitudes.

Thirdly, the questionnaires revealed a relatively high satisfaction level with respect to the 11 domains, with a mean score of 3.75 out of 5 points. The students felt the most satisfaction with the program's convenience. They also exhibited high satisfaction with the similarity between the VFT and a real-world geological field excursion, scalability of the program to other subjects, and aesthetic aspects of the program, which enabled them to perceive the beauty of the environment.

Fourth, individual interviews verified the students' understanding of the content, as well as the suggestions for its improvement. The students indicated that they were interested in this technology because they experience self-directed learning realistically and interactively through the program. The students also exhibited high achievement regardless of their grades or knowledge level. The results were similar to those of the satisfaction survey, indicating that the program could enhance students' interest and achievement in geosciences.

The most significant finding of this study was that the VFT program can bring positive scientific attitude as a component of affective learning process. As the affective learning process influence the cognitive learning processes, eventually the academic achievement of the students can be improved by the VFT program.

Even though this study indicated the effectiveness of a VFT program as an alternative to inaccessible, costly, or time-consuming real field trips in geoscience education for middle school students, our program can be extended to other grade students, such as, elementary, high school, or university students. In particular, VFTs can be a good alternative to bridge the education gap between students with special needs and other students.

We plan to apply our VFT to the students with special needs and verify improvements in their academic achievements. In addition, during the periods of health crisis such as COVID19 pandemic, the VFT will be a good tool of pedagogy.

Further studies are needed to find the reason why our program was not effective in the cognitive area. Moreover, a comparison between our VFT program and a real field trip to Baengnyeong island will be studied in the cognitive and affective outcomes. Additionally, as our study was limited to 106 students of first and second grades of a middle school in a small city of Korea, whether the application of VFT to students in other schools or cities would bring about different results from this paper needs to be studied.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/ijgi10120799/s1, Table S1: Science-Related Attitude Test.

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References

1. Çalışkan, O. Virtual field trips in education of earth and environmental sciences. *Procedia-Soc. Behav. Sci.* **2011**, *15*, 3239–3243. [CrossRef]
2. Meezan, K.A.L.; Cuffey, K. Virtual field trips for introductory Geoscience classes. *Calif. Geogr.* **2012**, *52*, 71–88.
3. Milosz, M.; Kęsik, J.; Montusiewicz, J. 3D Scanning and Visualization of Large Monuments of Timurid Architecture in Central Asia–A Methodical Approach. *J. Comput. Cult. Herit. (JOCCH)* **2020**, *14*, 1–31. [CrossRef]
4. Harrington, M.C.; Bledsoe, Z.; Jones, C.; Miller, J.; Pring, T. Designing a Virtual Arboretum as an Immersive, Multimodal, Interactive, Data Visualization Virtual Field Trip. *Multimodal Technol. Interact.* **2021**, *5*, 18. [CrossRef]
5. Pydyn, A.; Popek, M.; Kubacka, M.; Janowski, Ł. Exploration and reconstruction of a medieval harbour using hydroacoustics, 3-D shallow seismic and underwater photogrammetry: A case study from Puck, southern Baltic Sea. *Archaeol. Prospect.* **2021**. [CrossRef]
6. Kim, G.W.; Lee, K.Y. Developing web-based virtual geological field trip by using flash panorama and exploring the ways of utilization: A case of Jeju Island in Korea. *J. Korean Earth Sci. Soc.* **2011**, *32*, 212–224. [CrossRef]
7. Kim, H.S. Development and application of virtual geological field trip program using 3D panorama virtual reality technique. *Korean Earth Sci. Soc. J.* **2014**, *35*, 180–191. [CrossRef]
8. Philips, A.; Walz, A.; Bergner, A.; Graeff, T.; Heistermann, M.; Kienzler, S.; Korup, O.; Lipp, T.; Schwanghart, W.; Zeilinger, G. Immersive 3D geovisualization in higher education. *J. Geogr. High. Educ.* **2015**, *39*, 437–449. [CrossRef]
9. Cheon, J.B.; Kim, H.S. Comparison of class effect of real field trip and virtual field trip. *Sch. Sci. J.* **2018**, *12*, 331–340.
10. Kim, H.S.; Lim, C. Developing a geologic 3D panoramic virtual geological field trip for Mudeung UNESCO global geopark, South Korea. *Epis. J. Int. Geosci.* **2019**, *42*, 235–244. [CrossRef]
11. Klippel, A.; Zhao, J.; Oprean, D.; Wallgrün, J.O.; Chang, J.S.K. Research framework for immersive virtual field trips. In Proceedings of the 2019 IEEE Conference on Virtual Reality and 3D User Interfaces (VR), Osaka, Japan, 23–27 March 2019; pp. 1612–1617.
12. Šašinka, Č.; Stachoň, Z.; Sedlák, M.; Chmelík, J.; Herman, L.; Šašinková, A.; Doležal, M.; Tejkl, H.; Urbánek, T.; Svatoňová, H.; et al. Collaborative immersive virtual environments for education in Geography. *ISPRS Int. J. Geo-Inf.* **2019**, *8*, 3. [CrossRef]
13. Çöltekin, A.; Lochhead, I.; Madden, M.; Christophe, S.; Devaux, A.; Pettit, C.; Lock, O.; Shukla, S.; Herman, L.; Stachoň, Z.; et al. Extended reality in spatial sciences: A review of research challenges and future directions. *ISPRS Int. J. Geo-Inf.* **2020**, *9*, 439. [CrossRef]
14. Han, I. Immersive virtual field trips in education: A mixed-methods study on elementary students' presence and perceived learning. *Br. J. Educ. Technol.* **2020**, *51*, 420–435. [CrossRef]
15. Lim, S.B.; Choi, H.I.; Kim, B.C.; Koh, H.J. Depositional system and geological structures of the Proterozoic Paegryeong Group. *J. Geol. Soc. Korea* **1999**, *54*, 1. (In Korean)
16. Choi, W.C.; Kim, K.B.; Hong, S.H.; Lee, B.J.; Hwang, J.H.; Park, K.H.; Hwang, S.K.; Choi, B.Y.; Song, K.Y.; Jin, M.S. *Geologic Map of Korea (Scale 1:1,000,000)*; Korea Institute of Geoscience and Mineral Resources: Daejeon, Korea, 1995.
17. Paek, R.J.; Ri, S.R.; Kim, S.J.; Im, M.G. *Geological Map of Korea, Institute of Geology*; State Academy of Sciences: Pyongyang, Democratic People's Republic of Korea, 1996.
18. Eiss, A.F.; Harbeck, M.B. *Learning Objectives in the Affective Domain*; National Science Teachers Association: Washington, DC, USA, 1969.
19. Casper, K. Affective feelings as feedback: Some cognitive consequences. In *Theories of Mood and Cognition: A User's Guidebook*; Psychology Press: Hove, UK, 2001; Volume 27.
20. Stokes, A.; Boyle, A.P. The undergraduate geoscience fieldwork experience: Influencing factors and implications for learning. *Field Geol. Educ. Hist. Perspect. Mod. Approaches* **2009**, *461*, 291.
21. Ashby, F.G.; Isen, A.M. A neuropsychological theory of positive affect and its influence on cognition. *Psychol. Rev.* **1999**, *106*, 529. [CrossRef] [PubMed]
22. Isen, A.M. Some ways in which positive affect influences decision making and problem solving. *Handb. Emot.* **2008**, *3*, 548–573.
23. Kim, H.N.; Chung, W.H.; Jeong, J.W. National assessment system development of science-related affective domain. *J. Korean Assoc. Res. Sci. Educ.* **1998**, *18*, 357–369.
24. Lim, K. Factors Related to the Learner Participation, Achievement, Satisfaction in the Web-Based Online Discussion. Ph.D. Thesis, Ewha Woman's University, Seoul, Korea, 1999.
25. Elleven, R.; Wircenski, M.; Wircenski, J.; Nimon, K. Curriculum-based virtual field trips: Career development opportunities for students with disabilities. *J. Vocat. Spec. Needs Educ.* **2006**, *28*, 4–11.
26. Morgan, H. Focus on technology: Virtual field trips: Going on a journey to learn without leaving school. *Child. Educ.* **2015**, *91*, 220–222. [CrossRef]
27. Sriarunrasmee, J.; Suwannatthachote, P.; Dachakupt, P. Virtual field trips with inquiry learning and critical thinking process: A learning model to enhance students' science learning outcomes. *Procedia-Soc. Behav. Sci.* **2015**, *197*, 1721–1726. [CrossRef]

28. Stumpf, R.J.; Douglass, J.; Dorn, R.I. Learning desert geomorphology virtually versus in the field. *J. Geogr. High. Educ.* **2008**, *32*, 387–399. [CrossRef]
29. Kolivras, K.N.; Luebbering, C.R.; Resler, L.M. Evaluating differences in landscape interpretation between webcam and field-based experiences. *J. Geogr. High. Educ.* **2012**, *36*, 277–291. [CrossRef]
30. Stokes, A.; Collins, T.; Maskall, J.; Lea, J.; Lunt, P.; Davies, S. Enabling remote access to fieldwork: Gaining insight into the pedagogic effectiveness of 'direct' and 'remote' field activities. *J. Geogr. High. Educ.* **2012**, *36*, 197–222. [CrossRef]