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Exploration of the Perception of Elementary and Secondary Pre-Service Teachers About "Novelty Space" in Learning in Geological Field Trip — A Secondary Publication

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Abstract: The purpose of this study was to examine the perceptions of novelty space among pre-service elementary and secondary earth science teachers. We conducted a survey to explore the perceptions of 38 pre-service elementary school teachers at the National University of Education and 31 pre-service secondary earth science teachers at the Department of Earth Science Education at B University. Semi-structured interviews were conducted with 12 participants, including three pre-service elementary teachers and nine pre-service secondary science teachers. In addition to the elements of novelty space, prior knowledge (cognition), prior outdoor learning experience (psychology), familiarity (geography) with outdoor field learning, and social and technical elements were added. When classified based on elementary and secondary levels, there were statistically significant differences in cognitive, psychological, geographic, and social areas for the elements of novelty space. Statistical differences indicated that the experience or capital related to outdoor learning may have resulted from more pre-service secondary earth science teachers than pre-service elementary teachers. In additional interviews, both elementary and secondary pre-service teachers reported that competencies in the technical domain would be emphasized in the future owing to the necessity and the technical development of virtual-reality-based outdoor field learning programs. This study emphasizes the academic significance of novelty space that should be considered to conduct geological field learning for elementary and secondary earth science pre-service teachers while considering the current post-pandemic educational context.

Keywords: Novelty space; Learning in virtual geological field trips; Geoscience education

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1. Introduction

In the case of Danyang, the most recently selected National Geopark, the website of the National Geopark provides not only geological sites that the public can observe with the naked eye, but also geological tours using virtual reality (VR) technology, or programs that citizens can participate in, in the form of virtual reality.

Anyone can easily access the website through a variety of media, including mobile phones and personal computers (PCs), and enjoy the experience of being in the field. This is also true for outdoor geology learning for students. From the 2010s to the recent past, there have been a number of Korean studies that have applied virtual reality-based outdoor geology learning [1-6]. The most recent Korean example is Choi [7], who used curriculum content to implement outdoor geology learning in a virtual reality program to implement outdoor geology learning in virtual reality using curriculum content. In the domestic case, there is a lot of interest in outdoor geology learning that can be utilized for educational purposes in a non-face-to-face environment based on virtual spaces rather than real-world spaces. At the university level, Arizona State University and Illinois State University have developed virtual outdoor geology learning programs that can be accessed in a non-face-to-face environment, centered on places and topics that can be studied, and provided to university students. The positive aspects of virtual outdoor geology learning have been proposed as an alternative to overcome the difficulties of conducting real outdoor geological expeditions in a face-to-face environment due to safety concerns, budgetary issues, etc. The development and learning effects of virtual outdoor geology learning programs began to be emphasized [8]. In this process, virtual outdoor geological learning has evolved from a 2D type of data that observes photos through PC access to 3D data that is provided in various forms, such as 360-degree panoramas, 360-degree camera photos, drone photos, Google Tour Creator, VR technology utilization, and voice insertion, so that we can access 3D data and enjoy geological elements as if we were visiting the site [9]. In addition, with the renewed emphasis on post-COVID-19 non-contact environments as learning environments, many new studies have been proposed for virtual outdoor geology expeditions, as well as positive findings in cognitive and definitional domains [10-20]. As such, many cases at home and abroad are currently working on various forms of outdoor geology learning that utilize virtual reality.

The components of outdoor learning for implementing outdoor geology learning can be broadly categorized into three main components: cognitive, psychological, and geographic [21]. Cognitive elements are related to scientific knowledge and concepts. The psychological domain refers to the idea that ensuring that students feel psychologically secure, rather than negatively affected by prior outdoor experiences, or by anxiety, fear, or difficulty with outdoor learning, can help their learning outcomes. The idea is that making students feel psychologically secure, rather than in a negative state of mind, can be beneficial to their learning outcomes. Geography is the familiarity or familiarity with the outdoor learning area, including the sense that the more geographical information students know, the more familiar they are, the better it can help them learn. Reducing the unfamiliar experience space is important for successful outdoor learning, and Orion and Hofstein [22] hypothesized that the larger the size of this space, the more difficult it is to perform outdoor learning tasks.

Previous studies have emphasized cognitive, psychological, and geographical familiarity and unfamiliarity with the experience space in order to facilitate outdoor geology learning, and have argued that the smaller the size of the unfamiliar experience space, the more successful outdoor geology learning can be [22]. On the other hand, the current virtual outdoor geology learning that can be applied in a non-face-to-face environment is not only limited to the existing unfamiliar experience space, but also raises the need for another dimension of outdoor learning [23]. For example, Lee and Shea's [24] study emphasized teacher expertise in terms of how teachers perceive the technical aspects of facilitating learning for students in a virtual reality-based environment. Teacher expertise is emphasized. We were interested in how proficient teachers are in terms of technology, such as VR and AR, and how they perceive the use of these technologies for educational purposes. Just as we investigated the perceptions of new technological aspects of outdoor geology learning in a contactless environment, we have reached a point where another level of unfamiliar experiential space is needed. Virtual field trips in new environments are not just about how Rather than focusing solely on how teachers perceive

the technological aspects, it should add a new dimension to the unfamiliar experience space suggested by previous research. In addition, in traditional learning environments, such as virtual learning environments, and in different conditions, students need to consider factors in the social area for smooth learning. The social component is an aspect of learning based on Vygotsky's social constructivism, which views the relationships among members of society and the elements of the learning environment as well as the relationships among the members of the learning environment and their relationships with each other as influencing learning [25-27].

The unfamiliar experience space, first proposed by Orion [21], did not take into account learning contexts such as virtual reality, contactless environments, etc. When a pandemic or similar situation involves a change in the learning environment from other variables outdoor learning components and conditions for enabling outdoor geology learning may need to be modified. The unfamiliar experiential space of outdoor geology learning needs to be approached anew in the context of the times and circumstances. As pre-service teachers acquire both content knowledge and pedagogical knowledge before entering the field, much of the knowledge they acquire in pre-service teacher education programs may have a significant impact on the formation of their identity as teachers. In this regard, we aimed to create an unfamiliar experience space for virtual reality-based outdoor geology learning for pre-service elementary and secondary geoscience pre-service teachers to investigate how they perceive the pre-service elementary and secondary geoscience teachers. Investigating pre-service teachers' perceptions of the unfamiliar experience space of virtual outdoor geology learning will provide a foundation for future pre-service teacher education.

Furthermore, as pre-service teachers' perceptions are likely to be projected onto the school site, it is necessary to explore how pre-service teachers perceive the components of virtual reality-based outdoor geology learning in the current context.

The purpose of this study is to explore pre-service primary and secondary geoscience teachers' perceptions of unfamiliar experiential spaces to facilitate outdoor geology learning in a time of shifting perspectives toward new learning environments, such as virtual environments. geoscience pre-service teachers.

2. Research methods

2.1. Research procedures and participants

2.1.1. Research procedures

The procedure for this study consisted of five steps. Firstly, a literature review and literature analysis were conducted to investigate pre-service primary and secondary teachers' perceptions of the unfamiliar experience space. Developed a questionnaire to explore the second unfamiliar experience space. The finalized questionnaire was validated and revised by a third researcher and in-service teachers. In this process, inaccuracies and unclear statements were corrected, and the finalized questionnaire was finalized. Fourthly, based on the developed questionnaire, surveys, semi-structured interviews, and data collection were conducted with primary pre-service teachers enrolled in University of Education A and secondary geoscience pre-service teachers enrolled in University of Education B. Fifthly, after all data collection was completed, the results of the survey and interviews were analyzed together to explore the perceptions of elementary and secondary pre-service teachers.

2.1.2. Research participants

This study explored the perceptions of primary and secondary pre-service teachers and was conducted among 38 primary pre-service teachers enrolled at University of Education A and 31 secondary geoscience pre-service teachers enrolled in the Department of Earth Science Education at University of B. The participants were 44 women and 25 men. The gender of the pre-service teachers was 44 females and 25 males. Of the pre-service

teachers who responded to the survey, 12 (nine secondary and three primary) were asked if they would like to participate in a follow-up interview and agreed to participate in a semi-structured, face-to-face interview.

2.2. Data collection

2.2.1. Questionnaire

For the survey of unfamiliar experience spaces, this study drew on elements presented in the literature [22,28], case studies and surveys conducted to explore elements of unfamiliar experience spaces in outdoor learning [25-27], a conceptual exploration of unfamiliar experience spaces in outdoor contexts [23], and a study that explored the relevance of unfamiliar experience spaces to learning [29-31]. The questionnaire was translated and adapted from a survey study [32] that explored the association between motivation and unfamiliar experiential spaces in outdoor geology exploration. One Ph.D. in science education, one doctoral candidate in science education, Two middle and high school field teachers in the metropolitan area majoring in geology, and one elementary school field teacher in the metropolitan area participated in the face validity process.

A previously developed survey questionnaire on unfamiliar experience spaces [32] was first translated into Korean. Afterward, the questions were modified to suit the Korean situation and context. In addition, the social component of unfamiliar experience space [23,25-27,30]. To add a technical component to the study, a question from previous study questions was translated and added to this [23,24]. In other words, there are five unfamiliar experience spaces that have been suggested in the literature, but no survey questions have been developed to investigate them. We translated, modified, and added questions about social and technological factors to this survey. The survey items were first translated and revised by the researcher, and then face validated with one middle school geoscience teacher, one high school geoscience teacher, one elementary school field teacher, one Ph.D. in geoscience education, and one Ph.D. candidate in science education (specializing in geoscience). Consensus was achieved through the process of modifying the sentences when there were differences in the interpretation of the survey questions in Korean, and the development of the survey questions was completed by pointing out the ambiguous or difficult-to-understand terms in consideration of the readability of the questions and supplementing the questionnaire based on this. The internal reliability coefficient (Cronbach's α) obtained in this study is 0.83.

The survey consisted of a total of 40 questions, which were answered on a Likert scale (1–5). The 40 questions were categorized into five components of outdoor learning proposed in previous studies: cognitive, geographic, psychological, social, and technological, and the order of the questions was randomly distributed. Furthermore, additional interviews were conducted to co-interpret the participants' responses and to explore their perceptions of unfamiliar experiential spaces as building blocks for outdoor geology learning through semi-structured interviews about their needs in new learning contexts such as virtual outdoor geology learning in a contactless context.

2.2.2. Semi-structured, non-face-to-face interview

Twelve pre-service teachers participated in a semi-structured, face-to-face interview. The interviews were conducted virtually using zoom due to the coronavirus situation in Korea. The semi-structured interviews started with a light conversation, including individual explanations of the survey questions, and were based on two previous studies: a study of secondary pre-service geoscience teachers' perceptions of outdoor geology learning [7] and a study of elementary teachers' perceptions of virtual outdoor geology learning [33]. Based on the two previous studies, a semi-structured interview list was developed (**Table 1**). The semi-structured interviews were categorized into three areas: "Importance and value of virtual outdoor geography learning," "Experiences of virtual outdoor geography learning," and "Strategies and training for virtual outdoor geography learning." In addition, additional

questions and answers and member-checking of the written content were conducted between the researcher and study participants. The semi-structured interviews took an average of 64 minutes each.

Table 1. Semi-structured questionnaire list

Categorization	Question number	Question
The importance of virtual outdoor geology learning and its	1	What do you think is the most important component of virtual outdoor geology learning, and why do you think so?
	2	What do you see as the benefits and need for virtual outdoor geology learning?
Virtual outdoor geology learning experience	3	Have you experienced any of the emerging virtual outdoor geology learning methods (and if so, how many and examples)
	4	What skills do you think are necessary to participate in virtual outdoor geology learning, and why?
	5	What skills do I need to create a virtual outdoor geology lesson?
Strategies for virtual outdoor geology learning experience	6	What training do you think pre-service teachers need to create virtual outdoor geology lessons, and would you be interested in participating in such training if it were offered?
	7	As an in-service teacher, what teaching strategies would you use to implement virtual outdoor geology learning and why?
	8	How do you think virtual outdoor geology learning can impact student learning?

2.2.3. Data collection

Data collection was conducted among elementary pre-service teachers enrolled in University of Education A and secondary geoscience pre-service teachers enrolled in University of Education B in the academic year 2021. We are grateful to the 38 elementary geoscience pre-service students who agreed to participate in the study students (38 elementary pre-service teachers and 31 secondary geoscience pre-service teachers) who agreed to participate in the study. Of the 69 pre-service teachers who participated in the survey, 12 participants agreed to participate in semi-structured interviews (three elementary pre-service teachers and nine secondary geoscience pre-service teachers) were interviewed (**Table 2**). The researchers and study participants met face-to-face via Zoom and conducted semi-structured interviews between December 2021 and January 2022.

Table 2. The average and standard deviation of pre-service teachers for cognitive domain questions

Question number	Question	Mean (standard deviation [SD])
2	I know a lot about geology.	2.46(0.778)
6	I understand the geologic processes that can create different landscapes and landscapes.	3.28(0.922)
10	I understand how different kinds of rocks are made.	3.33(0.934)
12	I know what my task is while participating in an outdoor geology expedition.	3.78(0.802)
13	I can read a geologic map of the area where I am participating in an outdoor geology expedition.	3.42(0.944)
19	I understand how the landscape was formed, such as rivers and streams.	3.61(0.771)
20	I know how the places I visit on my field trips relate to the content I am learning in my field trips.	3.94(0.705)
23	I know why geologic disasters (geohazards) can happen.	3.68(0.883)
27	I understand geologic phenomena and their relationship to artifacts (non-human).	3.41(0.960)

2.3. Data analysis

The analysis of the survey data in this study was conducted using SPSS26.0 for descriptive statistics. The survey items were categorized by each item and the frequency and percentage of each item corresponding to each learning element were calculated to identify the characteristics of elementary and secondary pre-service teachers. Frequency and percentage analyses were used to identify trends by factor, and t-tests were conducted for each question by elementary and secondary pre-service teachers. Qualitatively analyze research-based questions about the perceptions of K-12 pre-service teachers in semi-structured interviews This study is a qualitative analysis of questions based on previous research [34,35] to explore how pre-service elementary and secondary geoscience teachers perceive unfamiliar experience spaces. The author conducted the primary statistical processing and data analysis, and the interview data were transcribed and categorized into keywords by question and then used an inductive approach [34]. After the author completed the analysis, the data were cross-checked with three people: one in-service elementary school teacher and two secondary school teachers (one middle school and one high school) majoring in geoscience, along with member-checking of the research participants who participated in the interviews.

3. Research results

3.1. Survey results

3.1.1. Pre-service teachers' perceptions of cognitive domains

The results of pre-service teachers' perceptions of the first cognitive domain. *T*-tests were conducted on the distribution of scores by item and by elementary and secondary schools. From this, the tendency of the cognitive domains perceived by pre-service teachers was identified.

Table 2 summarizes the items in the cognitive domain. The item with the lowest score per item in the cognitive domain is the question asking if the pre-service teacher knows a lot about geology. This item had the same mean value of 2 for both elementary and secondary geoscience pre-service teachers, indicating that they tended to disagree that they knew a lot about geology. The item with the highest score was "I know how the places I visit on my outdoor geology field trips relate to the content I learn on my outdoor geology field trips." This can be interpreted as pre-service teachers recognizing the relevance of what they learn on outdoor geology field trips to the content. This means that pre-service teachers can interpret what they learn from fieldwork as part of the learning process, rather than viewing it in isolation from the curriculum.

Table 3 summarizes the *t*-test results for primary and secondary schools. All but one of the questions were statistically significant. Secondary geoscience pre-service teachers scored higher than elementary pre-service teachers on knowledge of geology, geologic processes that create natural landscapes, rock formation, literacy in fieldwork and geologic maps, relevance of fieldwork to curriculum content, explanations of natural disasters, and relationships between geologic phenomena and artifacts, with statistically significant differences.

Secondary geoscience pre-service teachers interpreted that they were relatively better equipped to learn about geology than their elementary counterparts because they were given the opportunity to learn about geological content or to take courses offered by their departments in specific disciplines (mineralogy, petrology, sedimentology, geophysics, structural geology, etc. On the other hand, elementary pre-service teachers interpreted that the requirement to learn all science subjects in general within the university of education curriculum meant that they had fewer opportunities to have a variety of experiences related to geology.

The cognitive domain is a component of the pre-service teachers' perceived acquisition of geological knowledge and is the result of an overall questionnaire that addressed the process of how much pre-service teachers know about geological elements or what and how they learn. The results are for the overall

questionnaire. In the cognitive domain, pre-service teachers' perceptions are that they do not think they know much about geology, but other than that, they know about geological elements and things related to nature and things related to our lives (natural disasters). Applications of geologic knowledge, such as the relationship to non-living objects that are encountered when learning geology, and pre-service teachers' attitudes toward outdoor geology learning positive ratings.

Table 3. The result of the *t*-test in which the questionnaire on the cognitive domain was classified based on elementary and secondary

Question number	Pre-service teachers			
	Elementary (*N* = 38) Mean (SD)	Secondary (*N* = 31) Mean (SD)	*t*	*P*
2	2.18 (0.766)	2.81 (0.654)	3.580	0.001**
6	2.84 (0.789)	3.81 (0.792)	5.039	0.000***
10	3.05 (0.899)	3.68 (0.871)	2.912	0.005**
12	3.50 (0.830)	4.13 (0.619)	3.498	0.001**
13	3.28 (0.812)	4.07 (0.688)	4.983	0.001***
19	3.47 (0.797)	3.77 (0.717)	1.630	0.108
20	3.74 (0.724)	4.19 (0.601)	2.810	0.006**
23	3.26 (0.860)	4.19 (0.601)	5.274	0.000***
27	2.97 (0.972)	3.98 (0.629)	4.958	0.000***

3.1.2. Pre-service teachers' perceptions of the psychological domain

Results of pre-service teachers' perceptions of the second psychological domain. The distribution of scores for each question on the psychological domain and the results of the *t*-test based on elementary and secondary schools were used to determine the tendency of pre-service teachers' perceptions of the psychological domain.

Table 4 summarizes the scores by question. The lowest distribution of scores among the psychological domain questions was for the question about experience in outdoor geology fieldwork. The mean value of 2.38 indicates that the pre-service teachers surveyed did not have much experience. This indicates that many pre-service teachers do not have much experience with outdoor geology fieldwork. On the other hand, the two items with the highest average scores were the ones that asked "if I know the content I need to learn before I go on an outdoor geology field trip" and "if I like new places to visit for outdoor geology field trips. I like to visit new places for outdoor geology learning." The former question reflects the aspect of providing peace of mind or comfort through familiarization with the learning content, while the latter question considers the psychological discomfort or comfort of visiting an unfamiliar environment. The high mean values for both items suggest that pre-service teachers prefer to explore new places or environments for outdoor geology learning and may seek psychological comfort by exploring what they do beforehand in preparation for learning.

In addition, the results of the questions about transportation for outdoor geology learning, learning attitudes, and preference for outdoor geology questions had relatively higher mean values than other questions. In other words, pre-service teachers interpreted that they would be less psychologically uncomfortable with outdoor geology fieldwork. On the other hand, the items with relatively low scores were those related to dealing with accommodation in a different environment from home when participating in an outdoor geology field trip, time planning, etc. These findings suggest that there may be some discomfort experienced by pre-service teachers in the process of participating in outdoor geology fieldwork.

Table 4. The mean and standard deviation of pre-service teachers for psychological domain questions

Question number	Question	Mean (SD)
1	Most students love field trips as much as I do.	3.67 (0.869)
4	I know when it's time to eat while participating in a field geology study.	3.42 (1.020)
7	I have extensive experience with outdoor geology expeditions.	2.38 (0.941)
8	I am familiar with the field trip timeline.	2.99 (1.131)
15	I know how to behave in terms of learning attitude in the outdoor geology learning I participate in.	3.68 (0.831)
17	I have never been to the area visited in the field geology study before.	3.12 (1.065)
21	I am aware of the time spent traveling when participating in outdoor geology learning.	3.35 (1.027)
29	I easily adapt to uncertain situations and new challenging tasks in outdoor geology learning.	3.16 (0.994)
32	I am familiar with transportation to participate in outdoor geology learning.	3.75 (0.961)
34	I love new places to visit for outdoor geology learning.	3.78 (1.096)
35	I can handle critical and urgent situations that may be encountered in outdoor geology learning.	3.33 (0.902)
36	I am uncomfortable sleeping and eating in an environment different from my home.	2.68 (1.194)
37	I familiarize myself with the content to be covered before the field trip begins.	3.80 (0.867)

Table 5 shows the results of a *t*-test between primary and secondary schools for the psychological domain. Eight of the 13 questions were statistically significant. The overall result of the eight questions is that the secondary geoscience pre-service teachers' results are statistically significantly higher than the elementary pre-service teachers. Each of these questions asks about when you eat while participating in an outdoor geology field trip, your experience with outdoor field trips, whether you know the time schedule for an outdoor field trip, your attitudes toward outdoor geology field trips, whether you have visited the field trip site beforehand, how long you spend traveling during the field trip, whether you like new field trip sites, and whether you deal with critical or urgent situations on outdoor field trips. The questions are about practical things that are commonly experienced on field trips and reflect what students familiar with field trips are likely to have experienced at least once. From these results, it can be interpreted that secondary geoscience pre-service teachers may have had relatively more experience with outdoor geology learning than elementary pre-service teachers. In particular, the question about dealing with critical or urgent situations when conducting outdoor geoscience learning is emphasized as one of the attitudes that teachers should have when conducting outdoor geoscience learning. It was interpreted that pre-service secondary geoscience teachers would be relatively more prepared. However, both secondary and elementary pre-service teachers did not have relatively high scores on this question, suggesting the need for training to handle such situations in light of safety concerns in the future.

Table 5. The result of the *t*-test in which the questionnaire on the psychological domain was classified based on elementary and secondary

Question number	Pre-service teachers			
	Elementary (*N* = 38) Mean (SD)	Secondary (*N* = 31) Mean (SD)	*t*	*P*
1	3.58 (0.948)	3.77 (0.762)	0.928	0.357
4	3.08 (0.997)	3.84 (0.898)	3.291	0.002**
7	2.03 (0.885)	2.81 (0.833)	3.738	0.000***
8	2.03 (0.885)	3.58 (1.025)	4.463	0.000***
15	3.45 (0.921)	3.97 (0.605)	2.817	0.006**
17	2.87 (0.935)	3.42 (1.148)	2.198	0.031*
21	3.08 (1.075)	3.68 (1.077)	2.500	0.015*
29	3.03 (1.052)	3.32 (0.909)	1.236	0.221
32	3.63 (0.998)	3.90 (0.908)	1.171	0.246
34	3.47 (1.179)	4.16 (0.860)	2.796	0.007**
35	3.05 (0.957)	3.68 (0.702)	3.029	0.003**
36	2.87 (1.189)	2.45 (1.179)	-1.454	0.151
37	3.92 (0.818)	3.65 (0.915)	-1.321	0.191

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

3.1.3. Pre-service teachers' perceptions of geographic areas

Results of pre-service teachers' perceptions of the third geographic domain. The distribution of scores for each question about geographical areas and the results of a *t*-test based on elementary and secondary schools.

Table 6 summarizes the average values for the geographic region questions. The two questions with the highest results are being able to locate the places you visited on the field trip on a map and recognizing most of the field trip locations as unfamiliar. This means that pre-service teachers are not geographically familiar with the locations of the field trips, but they are geographically familiar with the locations where they have experienced field trips. On the other hand, the lowest result was "I get disoriented in new places." This means that pre-service teachers interpreted that they do not have a high frequency of geographically disoriented or lost behaviors.

Table 6. The average and standard deviation of pre-service teachers for geographic area questions

Question number	Question	Mean (SD)
3	I am unfamiliar with most outdoor geology locations.	3.67 (0.902)
11	I know the places and areas I will visit on my field trip.	3.46 (1.092)
14	I can find places I've visited on my field trips on the map.	3.84 (0.885)
24	I know where the north is when I'm outdoors.	3.20 (1.079)
28	I get disoriented in new places.	2.97 (1.188)

Table 7 summarizes the results of the *t*-test, categorized by primary and secondary schools. The two questions that had statistically significant results were the one that asked students if they knew the places and areas they had visited on an outdoor geography field trip, and the one that asked students if they could

navigate to the North Iditarod outdoors. For both questions, secondary geoscience pre-service teachers scored significantly and statistically higher than elementary pre-service teachers.

Interpretation of these results is that pre-service secondary geoscience teachers have a better sense of direction in the outdoors and know the locations and areas they will visit on field trips, which may indicate that they are more familiar with outdoor geology field trips or are better prepared geographically for the locations they will visit. geographically prepared for the fieldwork. We interpreted this to mean that secondary geoscience pre-service teachers may be more familiar with or experienced in outdoor geology exploration. Being able to determine orientation in the outdoors requires prior training or at least one outdoor experience. In this respect, it can be assumed that secondary geoscience pre-service teachers will have more experience and resources for outdoor geology learning than elementary pre-service teachers.

Table 7. The result of the *t*-test in which the questionnaire on the geographic area was classified based on elementary and secondary

Question number	Pre-service teachers			
	Elementary (*N* = 38) Mean (SD)	Secondary (*N* = 31) Mean (SD)	*t*	*P*
3	3.71 (0.732)	3.61 (1.086)	-0.428	0.671
11	2.97 (1.078)	4.06 (0.772)	4.889	0.000***
14	3.68 (0.962)	4.03 (0.752)	1.645	0.105
24	2.82 (0.926)	3.68 (1.077)	3.857	0.000***
28	2.97 (1.127)	2.97 (0.972)	-0.021	0.984

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

3.l.4. Pre-service teachers' perceptions of the social domain

The fourth result of the pre-service teachers' perceptions of the social domain is the distribution of scores for each item on the social domain and the results of the *t*-test between primary and secondary schools. The social domain refers to the interpersonal elements of the outdoor learning experience, such as relationships with peers and friends, relationships with people with whom you share a sociocultural group affiliation, and relationships with family members, where you may share positive or negative feelings about the outdoor learning experience [27,36-40].

Table 8 summarizes the results for the social domain questions. The item with the highest mean value was "I take pictures with people who participated in an outdoor geology activity." This item reflects a typical behavior in our culture of being with people who have participated in an event, and the results show that pre-service teachers engage in this behavior. In addition, the second highest scoring item was talking about their experiences in outdoor geology with peers, which we interpreted as pre-service teachers sharing their experiences with their peers. In addition, the question about whether they talk about outdoor geology learning with their families was the third highest scoring item, which suggests that peers and family members communicate about outdoor geology learning. On the other hand, the three items with negative statements (I don't like most of my friends who come to the field trip, the instructors and administrators don't like me, and I wish I didn't attend the field trip because of my relationships with other people) had the lowest results, suggesting that the negative perceptions or images were not created because of the relationships with the people participating in the field trip.

Table 8. The average and standard deviation of pre-service teachers for social domain questions

Question number	Question	Mean (SD)
5	I don't like most of my friends on field trips.	1.90 (0.957)
9	Instructors and administrators who participate in field trips don't like me.	1.87 (0.873)
16	My relationship with my instructors and administrators affects my academic performance.	3.00 (1.200)
18	I talk about outdoor geology learning with my family at home.	3.75 (1.156)
22	I wish I hadn't gone on the field trip because of my relationships with other people.	1.81 (0.912)
25	I talk about my experiences in outdoor geology with my peers.	4.01 (0.883)
26	I endeavor to maintain relationships with people who participated in the expedition even after the expedition is over.	3.33 (1.010)
31	I know what to do with other students in an outdoor geology lesson.	3.75 (0.736)
33	I take a photo with the people who participated in the field geology study.	4.09 (1.011)

Table 9 summarizes the results of the *t*-test between primary and secondary schools. Eight of the nine questions were statistically significant. For the three items with negative statements (I don't like most of my friends who come on field trips, Instructors and administrators don't like me, I wish I didn't attend field trips because of my relationships with other people), elementary pre-service teachers had higher mean values than secondary geoscience pre-service teachers, and these results were statistically significant. In other words, the results of the three items can be interpreted as suggesting that elementary pre-service teachers may have more difficulty relating to people who participate in outdoor geology learning than secondary geoscience pre-service teachers.

Table 9. The result of the *t*-test in which the questionnaire on the social domain was classified based on elementary and secondary

Question number	Pre-service teachers			
	Elementary ($N = 38$) Mean (SD)	Secondary ($N = 31$) Mean (SD)	*t*	*P*
5	2.32 (0.873)	1.39 (0.803)	-4.554	0.000***
9	2.24 (0.852)	1.42 (0.672)	-4.455	0.000***
16	2.66 (0.994)	3.42 (1.311)	2.668	0.010*
18	3.89 (1.134)	3.58 (1.177)	-1.125	0.265
22	2.26 (0.860)	1.26 (0.631)	-5.422	0.000***
25	3.76 (0.998)	4.32 (0.599)	2.877	0.005**
26	2.95 (0.985)	3.81 (0.833)	3.857	0.000***
31	2.95 (0.985)	3.81 (0.833)	3.857	0.000***
33	3.82 (1.136)	4.42 (0.720)	2.682	0.009**

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

The results for all but three of the five questions showed that secondary geoscience pre-service teachers had higher mean values than elementary pre-service teachers, and these results were also statistically significant. In other words, secondary geoscience pre-service teachers perceived themselves to be relatively more comfortable or relaxed in relating to and interacting with people involved in outdoor geology learning,

peers, instructors, and administrators compared to elementary pre-service teachers.

In summary, it was determined that secondary geoscience pre-service teachers would have more interaction with the social aspects of outdoor geology learning than elementary pre-service teachers.

3.1.5. Pre-service teachers' perceptions of technology

The results of the pre-service teachers' perceptions of the fifth technical domain are *t*-test results of the distribution of scores for the technical areas by question and categorized by primary and secondary schools. The technical domain refers to the ability to handle technical aspects in a distance learning environment, such as virtual reality-based outdoor geology learning and virtual outdoor geology learning, which is a key shift from the traditional classroom environment and essential for enhancing learning in a virtual environment [24]. For example, the slow adoption of newer technologies such as VR, AR, etc. can lead to inadequate software dissemination and technical domain barriers for school-based teachers [41]. In this sense, the technology domain is approached as an element and area where new and emerging technologies can be addressed in a virtual learning environment.

Table 10 shows the mean values for the technical domain questions. The item with the highest mean value was the one that asked if outdoor geology learning could be used in a virtual world, and the pre-service teachers agreed that it could. In addition, the question about the need for technical skills to participate in outdoor geology learning had the second highest mean value, and the question about whether virtual outdoor geology learning could be another alternative for future social education had the third highest mean value. However, when asked if they were comfortable using new technology to engage in virtual outdoor geology learning, pre-service teachers gave answers ranging from 1 to not at all. Based on these responses, pre-service teachers tended to agree that virtual outdoor geology learning is an alternative and feasible option for future social education, and they also agreed on the need for technological skills for this purpose, but it can be interpreted that pre-service teachers are not currently familiar with handling new technologies.

Table 10. The mean and standard deviation of pre-service teachers for mechanical area questions

Question number	Question	Mean (SD)
30	I believe that I need mechanical skills to participate in outdoor geology learning.	3.78 (0.855)
38	I look forward to utilizing outdoor geology learning in the virtual world.	4.04 (0.865)
39	We believe that virtual outdoor geology learning will be another alternative for future social education.	3.75 (0.812)
40	I am used to dealing with new technologies by participating in virtual field trips.	1.41 (0.524)

Table 11 summarizes the results of the *t*-test between primary and secondary. Unlike the other domains, the only domain that was not statistically significant was the descriptive domain, which means that the interpretation of the mean values per item is the same for elementary and secondary geoscience pre-service teachers.

Table 11. *T*-test results of classifying questionnaires in technical areas based on elementary and secondary

Question number	Pre-service teachers			
	Elementary (*N* = 38) Mean (SD)	Secondary (*N* = 31) Mean (SD)	t	P
30	3.84 (0.855)	3.71 (0.864)	-0.637	0.526
38	4.16 (0.789)	3.90 (0.944)	-1.221	0.226
39	3.84 (0.789)	3.65 (0.839)	-1.002	0.320
40	1.32 (0.471)	1.52 (0.570)	1.568	0.122

3.2. Results of the in-person interview

3.2.1. Importance and value of virtual outdoor geology learning

The importance and value of virtual outdoor geology learning is comprised of two questions: one about which components of virtual outdoor geology learning are most important to you, and the other about the benefits and necessity of virtual outdoor geology learning.

Of the components of virtual outdoor geology learning (cognitive, psychological, geographic, social, and technical), there are two main categories, organized in order of frequency, that were mentioned as most important. Cognitive was the most common, followed by technical. Of the 12 participants, seven pre-service teachers emphasized the importance of the cognitive domain, geological knowledge, four pre-service teachers emphasized the importance of the technical domain, and one pre-service teacher emphasized the importance of the social domain. The pre-service teachers who emphasized the importance of the cognitive domain emphasized the importance of geological knowledge because the purpose is to learn geology, even if it is done in virtual reality. The pre-service teachers who emphasized the importance of technology said that accessibility is the most important aspect of the program because it is based on virtual reality. Finally, one commenter emphasized the importance of the social domain by saying that since it is virtual outdoor geology learning, participants may not be controlled, may be assertive, and may have difficulties in group activities and interacting with others, so the social domain is the most important because it is based on Vygotsky's social constructivism.

When categorized by elementary and secondary pre-service teachers, all three elementary pre-service teachers emphasized the importance of geological knowledge, four secondary geoscience pre-service teachers emphasized the importance of cognitive domains, another four emphasized the importance of technical domains, and the last one emphasized the importance of social domains. The results confirmed that elementary pre-service teachers emphasized geological knowledge and cognitive domains as the most important factors, while secondary geoscience pre-service teachers perceived cognitive and technical domains as the most important factors.

The second is the benefits and need for virtual outdoor geology learning. To quantify the benefits and need for virtual outdoor geology learning, during the interviews, the authors asked participants to express the need for virtual outdoor geology learning on a Likert scale of 1 to 5. As a result, 10 out of 12 students rated the need for virtual outdoor geology learning as 5 out of 5, and two students rated it as 4. When asked about the reasons for the scores, the responses were organized in order of frequency, and based on their past outdoor geology learning experiences, they shared the difficulties they experienced during the actual field trip, such as difficulties due to the effects of the weather and loss of concentration due to individual physical fitness problems during outdoor geology learning. They said that the virtual reality-based field trip would be helpful in overcoming these challenges. Another reason was that, given the increasing educational demand for non-contact learning environments, virtual field trips are one of the best ways to engage both students and teachers in the field, while making learning more interesting. When this question was broken down by elementary and secondary pre-service teachers, elementary pre-service teachers valued the content as engaging and interesting for students in the elementary setting. and engaging learning content for students in elementary schools. Secondary geoscience pre-service teachers, on the other hand, tended to look at virtual outdoor geology as a way to implement outdoor geology learning based on their own past experiences with outdoor geology learning.

In summary, we emphasized the importance of the cognitive domain, geological knowledge, as the most important component of virtual outdoor geology learning. Pre-service teachers were also positive about virtual outdoor geology learning because it can help overcome some of the challenges of going on an actual outdoor

geology field trip, such as the effects of weather, physical conditions, and individual fitness challenges when traveling to many field sites, and because it is a new and engaging way to teach students in a virtual learning environment. The pre-service teachers had positive perceptions.

3.2.2. Virtual outdoor geology learning experience

When asked about their experiences with virtual outdoor geology learning, all 12 pre-service teachers interviewed had no experience with virtual reality-based outdoor geology learning or field trips. However, one of the students interviewed had participated in a virtual reality-based science festival at her current university. Using the Metaverse platform, pre-service teachers organized a science festival that had previously been held in person in a virtual environment. We found that there was a positive perception of the virtual science festival as a new way to organize science festivals in a similar format to face-to-face. However, elementary and secondary pre-service teachers had no experience with virtual outdoor geology learning.

3.2.3. Strategies and training for virtual outdoor geology learning

This categorization is about learning strategies and pedagogical perspectives as part of a pedagogical approach to investigate perceptions of virtual outdoor geology learning [33]. The first set of questions asks pre-service teachers what skills they need to engage in virtual outdoor geology learning and why. This question was asked from the perspective of a pre-service teacher who had no experience with virtual outdoor geology learning as a pre-service teacher, but rather from the perspective of a pre-service teacher who needs experience with virtual outdoor geology learning. When asked about the skills needed to engage in virtual outdoor geology learning, the most frequent response from pre-service teachers was the ability to be comfortable with new technology. The reason for this is that since they are participating in virtual outdoor geology learning, they have to participate in outdoor expeditions not in a face-to-face environment, but through non-face-to-face, VR, AR, and other devices and equipment that are unfamiliar to them, so the pre-service teachers emphasized the importance of their ability to handle the devices and technical aspects of the expedition. The next most frequent response is the importance of being able to interact. For example, because it is a virtual field trip, it is expected that there will be a great deal of autonomy between the instructor and the student or between the student and the instructor, so it is important to be able to interact with the instructor or with others, such as in group activities, rather than doing something alone. This emphasized the importance of being able to interact with others, such as in group activities.

This question is designed to get a second teacher's perspective on the most important considerations for implementing virtual outdoor geology learning. 'What skills do you need to create a virtual outdoor geology lesson? From this question, we investigated pre-service teachers' perceptions of what they need as teachers to create and engage students in virtual outdoor geology learning. The results showed that all participants emphasized the importance of the technical aspects of implementing virtual reality.

Creating a virtual outdoor geology course is not something that pre-service teachers are familiar with and have never done before, so it is even more challenging to create one yourself. In light of this, exploring the skills needed to implement virtual outdoor geology learning, and most importantly, the skills required to implement it, may be a good place to start. In terms of the skills needed to create virtual outdoor geology lessons, all 12 pre-service teachers indicated that they needed to be able to use technical programs to implement virtual reality and be able to handle technical aspects. The reason for this is that if you think about conducting a field geological survey in virtual reality, you need to consider how you can organize it and teach it to your students. In this regard, pre-service teachers said that the most important skill in practice is the technical ability

to create virtual reality.

The third question was asked from the perspective of a pre-service teacher: “What training do you think is needed at the pre-service teacher training level to create virtual outdoor geology lessons? If such a training was offered, would you be interested in participating?” All 12 pre-service teachers responded that they would like to be trained in a program that allows them to implement virtual reality. In the same vein as the second question, respondents emphasized the importance of technology and the need for appropriate training at the pre-service teacher training stage to implement it.

The fourth question was, “What teaching strategies would you utilize when implementing virtual outdoor geology learning? What teaching strategies would you need as an in-service teacher to implement virtual outdoor geology learning? Explain why.” While in all previous questions, pre-service teachers were able to express their ideas freely, more than half of the pre-service teachers had difficulty answering this question about teaching strategies. Some pre-service teachers were unable to provide additional answers because they were unsure. However, here are two examples, one from a secondary geoscience pre-service teacher and one from an elementary pre-service teacher, who struggled with teaching strategies. Secondary pre-service teachers agreed that the most important teaching strategies for virtual outdoor geology learning were repeated observations and finding regularities. Since the teaching method called virtual outdoor geology learning and the new environment may not be familiar to both teachers and students, it is important to be able to make repeated observations and derive some regularity from them in order to continue learning in new environments and conditions. One of the advantages of virtual outdoor geology learning is that you can observe a lot of things without the constraints of physical space, and in this regard, it was suggested that repeatedly observing a lot of things in a virtual space with fewer physical constraints and deriving regularities could be a good teaching strategy. On the other hand, pre-service elementary teachers said that they needed to think more about how to keep students engaged, focused, and not distracted when teaching in virtual reality, rather than teaching strategies. Considering that both teachers and students have little experience with classes held in virtual reality, it was thought that there would be many difficulties in holding classes on-site with elementary school students if the students were not in control, so there was an opinion that they would establish a teaching strategy considering how to control the students even though it was held in virtual reality. In addition, although the course is conducted in virtual reality, it is clear that more attention is paid to how the course can be taught in a given learning environment than to actual geological knowledge, such as student management and safety.

The fifth question is how virtual outdoor geology learning might ultimately benefit or impact students. How do you think virtual outdoor geology learning will impact students’ learning? The author’s expectation was that the question would have a vaguely positive effect on prospective teachers and the students who participated in it. In response, secondary geoscience pre-service teachers most often said that the learning effects of virtual outdoor geology learning would be positive for students in terms of being able to observe things that are difficult to observe in real field trips, being able to check their learning repeatedly, being able to participate in learning in a virtual space, and being able to learn efficiently. In addition, respondents commented on the applicability of virtual outdoor geology learning to other areas of the earth sciences, such as astronomy, oceans, atmosphere, and so on, noting that they expect students to benefit from the application of educational programs that can be utilized in a virtual environment. In another example, one of the secondary geoscience pre-service teachers said that her future students would benefit from virtual reality lessons. For example, in the past, astronomy was experienced indirectly with stellariums, but more recently, astronomy has become a direct experience with the Universe Sandbox, field teachers’ personal blogs, Space Engine, Theasys 360, and other programs that directly apply to astronomy, as well as indirectly, such as the use of simulations created by field

teachers at schools, and educational programs that can be used in other non-face-to-face environments. In terms of student engagement in virtual outdoor geology learning, pre-service teachers reported that they expected positive impacts in terms of student interest, fun, and motivation to learn, and positive learning outcomes for students in terms of experiencing something new and technological in virtual reality. To summarize, we expected that virtual outdoor geology learning would have positive learning effects in terms of observing or repeating observations that are difficult to experience in real field trips, learning efficiency, dealing with technical aspects in a new learning environment, and attitudes, interest, and motivation toward learning.

4. Conclusion and recommendations

The purpose of this study is to explore the perceptions of elementary and secondary geoscience pre-service teachers about unfamiliar experiential spaces as a condition for enabling outdoor geology learning and a component of outdoor learning. Moreover, in the current era of emphasizing non-face-to-face learning environments, overcoming the limitations of the unfamiliar experience space proposed by Orion [21] and defining an unfamiliar experience space that meets the emerging situation of virtual outdoor geology learning and investigating their perceptions of it may be meaningful as a basis for educating pre-service teachers in the future. To this end, we categorized the unfamiliar experience spaces presented by outdoor geology learning into five categories and explored their meanings through a survey, and further approached the value and importance of virtual outdoor geology learning, experience, strategies for virtual outdoor geology learning, and educational aspects through additional recent interviews.

The cognitive domain of the study explored the importance of geological knowledge as perceived by pre-service teachers. In the psychological domain, we explored the factors that may be familiar or uncomfortable in outdoor geology learning based on pre-service teachers' experiences. In the geography section, it was difficult to interpret that they had a lot of geographical information about the outdoor geology field trip locations, but they showed geographical information and familiarity with the locations they had experienced. In the social domain, they showed the possibility of interacting with people participating in outdoor geology, instructors, fellow students, administrators, and family members, and finally, in the technical domain, they showed that virtual reality-based outdoor geology could be an alternative teaching method in the future, and that they were not realistically prepared for it. Furthermore, the semi-structured interviews revealed that pre-service teachers had no experience with virtual outdoor geology learning to date. Although they did not have any experience with virtual outdoor geology learning to date, they were positive about the need for and value of virtual outdoor geology learning and interested in teaching and learning strategies for implementing virtual outdoor geology learning in the future. Based on these findings, the following conclusions were reached.

The first unfamiliar experience space of outdoor geology learning considered only the cognitive, psychological, and geographical domains of field trips. On the other hand, with the high demand and interest in non-face-to-face learning environments, it is necessary to define a new unfamiliar experience space for virtual outdoor geology learning. Reflecting this, this study redefines the unfamiliar experience space as a total of five elements: cognitive, psychological, geographical, social, and technological.

The results of the second survey showed statistically significant results for elementary pre-service teachers and secondary geoscience pre-service teachers in all four domains except the technical domain. This may ultimately be due to differences in resources for outdoor geology learning among secondary pre-service teachers compared to primary pre-service teachers. In other words, we hypothesized that secondary geoscience pre-service teachers would have a quality difference in terms of information and resources related to outdoor

geoscience learning, such as more information and opportunities to engage in lessons, than elementary pre-service teachers.

The third elementary pre-service teacher and secondary geoscience pre-service teacher had no experience with virtual outdoor geology learning, but the perceptions of the unfamiliar experience space revealed that they had positive perceptions of the need for and value of virtual outdoor geology learning and the potential for future alternative instruction. It was emphasized that there should be another training at the pre-service teacher training stage to improve the technical skills of pre-service teachers in order to take into account the need and demand for training to utilize virtual outdoor geology learning for educational purposes in schools in the future. In other words, the need for appropriate training at the pre-service teacher training stage to implement or teach virtual outdoor geology learning was raised.

From the three conclusions of this study, we recommend the following.

Firstly, this study is of academic significance as it proposes a new and unfamiliar experience space for outdoor geology learning in the context of the current emphasis on distance learning environments. In other words, based on the existing unfamiliar experience space proposed by Orion [21], many studies related to outdoor geology learning have been conducted in Korea, and we propose a follow-up study on outdoor geology learning and virtual outdoor geology learning that can be conducted in a non-face-to-face environment based on the newly defined unfamiliar experience space.

Secondly, this study is based on a new learning condition, virtual outdoor geology learning, which is an emerging subject matter in a contactless learning environment, so there are limitations in generalizing to learning in a contactless learning environment. In addition, there are limitations in terms of the participants of the study, which cannot be claimed to be representative of all elementary and secondary pre-service teachers. However, we are approaching virtual outdoor geology learning as one of the new curricula that can be applied in a non-face-to-face learning environment. It approaches an unfamiliar experiential space by exploring the basic conditions needed to enable it. This study's exploration of pre-service elementary and secondary geoscience teachers' perceptions of unfamiliar experience spaces suggests the need for new educational programs to investigate the training and skills needed at this stage of pre-service teacher preparation so that they can be used pedagogically in the future.

5. Summary

The purpose of this study was to investigate the perceptions of Novelty Space among elementary and secondary geoscience pre-service teachers. To this end, 38 elementary pre-service teachers from University A and 31 secondary pre-service geoscience teachers from University B participated in the survey. We also conducted face-to-face interviews with three elementary pre-service teachers and nine secondary geoscience pre-service teachers who agreed to participate in additional interviews, for a total of 12 participants. In addition to prior knowledge (cognition), prior outdoor learning experience (psychology), and familiarity with the outdoor study area (geography), we added social and technical factors to the unfamiliarity with the space. When categorized by primary vs. secondary and grade level, there were statistically significant differences in the cognitive, psychological, geographic, and social domains for elements of the unfamiliar experience space. The statistical difference may be due to the fact that secondary geoscience pre-service teachers have more experience or capital related to outdoor learning than elementary pre-service teachers than their elementary counterparts. In the semi-structured interviews, both elementary and secondary pre-service teachers emphasized the value or need for virtual outdoor geology learning, particularly in the area of technology. This study is of academic

significance in that it not only suggests the need to redefine the unfamiliar experience space for implementing outdoor geology learning for pre-service elementary and secondary geoscience teachers in light of the current educational context but also specifies the elements of the unfamiliar experience space.

Disclosure statement

The author declares no conflict of interest.

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