Using Virtual Reality to communicate glacier change and climate impacts

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Contents

Abstract

This report presents a pilot study exploring how Virtual Reality (VR) can support climate change education by helping young people better understand glacier change. As part of the LEVERAGE (*VOGARAFL*) project, a short VR experience was created to show glacier calving and the positive feedback mechanism that accelerates glacier retreat at Breiðamerkurjökull, Southeast Iceland.

The study examined how students responded to and interpreted this material using a mixed-methods approach. Three groups of University of Iceland students—studying tourism, glaciology, and environmental and natural resources—each took part in dedicated VR sessions, where they individually experienced the glacier simulation before participating in group discussions. Quantitative survey data (N = 15) and qualitative reflections were collected to evaluate engagement, comprehension, immersion, and the educational usefulness of the VR environment.

Students rated the VR system highly for usability, clarity, and technical performance. Most found the environment easy to navigate, and the glacier calving animation helped make the scientific process more understandable. However, immersion and emotional response varied, with fewer students reporting strong emotional engagement. Factual knowledge scores also differed across disciplines, with glaciology and environmental students performing better than tourism students.

Participants suggested improvements such as increased interactivity, greater freedom of movement, and more realistic visuals.

Overall, the findings indicate that VR can capture attention, stimulate curiosity, and support understanding of glacier processes, especially when combined with discussion and reflection. While the small sample size limits broader conclusions, the results offer useful guidance for developing future VR-based climate education tools and support the LEVERAGE project's goal of engaging young people in creative and collaborative climate learning.

1. Introduction

Effective climate change communication is essential for shaping how people understand, feel about, and respond to the changing environment. Over time, many different approaches—such as news coverage, social media campaigns, documentaries, and art-based projects—have been used to help audiences connect with the realities of a warming planet. Each approach conveys both facts and emotions, influencing how individuals interpret climate issues and their own role in addressing them. Understanding how people experience these messages is therefore important, especially for young audiences, who are frequently exposed to climate information and often strongly affected by its emotional impact.

In this context, the aim of this study is to develop educational materials that encourage creative peer-to-peer discussions and collaboration among young people about the impacts of global climate change. The study supports experiential learning through innovative media formats—particularly a Virtual Reality (VR) experience)—to make complex environmental processes more understandable and emotionally engaging.

This research represents the second phase of the LEVERAGE (*VOGARAFL*) project, which aims to support climate change education and communication through creative and participatory learning. The broader project – a cooperation between the University of Iceland´s Hornafjörður Research Centre and two NGOs; The Icelandic Youth Environmentalist Association (*Ungir Umhverfissinnar*) and Landvernd - Icelandic Environment Association (*Landvernd – umhverfissamtök Íslands)* - focuses on encouraging young people's emotional engagement and critical thinking by linking scientific knowledge with immersive communication approaches, including documentaries and VR experiences.

To reach these goals, the current study uses a reception study approach, examining how young people respond to and interpret new forms of climate communication. The materials are tested through paired focus groups and VR sessions, which explore how immersive technology can stimulate engagement, empathy, and understanding of climate change and its effects.

The following chapters outline the design and implementation of a pilot VR experience focused on glacier change, describe the methodology used to gather both quantitative and qualitative data, and present the results and reflections drawn from student participants' experiences.

2. Literature review

In recent years, VR has emerged as a powerful medium for communicating climate change by turning complex scientific concepts into direct, emotional, and immersive experiences. Traditional media often fail to overcome psychological distance, where climate change feels remote or abstract. VR reduces this gap through presence, immersion, and embodiment (Markowitz & Bailenson, 2021), allowing users to experience environmental change as if they were physically there. This embodied perspective can evoke stronger emotional and cognitive engagement than text or video alone.

Research shows that VR can enhance environmental literacy—helping users not only learn facts but also develop empathy and motivation to act. Fauville et al. (2020) found that VR contributes to all four dimensions of environmental literacy—knowledge, attitudes, competencies, and behavior—while Stepanova et al. (2019) showed how immersive design can evoke the *Overview Effect*, promoting feelings of awe and interconnectedness that support environmental awareness. Similarly, Markowitz and Bailenson (2021) argue that VR helps translate abstract climate science into personally meaningful experiences by making distant impacts tangible and emotionally salient.

However, the effectiveness of VR depends strongly on design. In a large field experiment, Quiroz et al. (2023) demonstrated that body movement within VR increases users' *self-efficacy* (confidence in their ability to understand science) but can also hinder learning if movements are not meaningful to the task. The study also found that message framing matters—linking ocean acidification directly to "climate change" reduced learning compared to more specific, neutral wording. This suggests that overly politicized or abstract frames may distract from core educational goals. Moreover, the study showed that learning and trust in information indirectly influenced pro-climate behavior through increased risk perception, indicating that cognitive understanding must be paired with emotional and perceptual engagement to influence behavior.

Other experimental studies reinforce these findings. Meijers et al. (2023) found that immersive VR wildfire experiences led to stronger emotions and spatial presence but only modest behavioral effects. Dhunnoo et al. (2023) showed that realistic flood simulations elicited empathy and fear while improving understanding of local climate risks. Participants in both studies expressed a desire for more interactivity and movement, highlighting that engagement depends on meaningful embodied participation. Likewise, Newman et al. (2022) demonstrated that graphical realism and sensory quality in virtual nature scenes improve feelings of calm, presence, and credibility—key to creating believable and emotionally engaging experiences.

From a psychological standpoint, VR is not just an educational tool but also a vehicle for perspective-taking and empathy. Studies show that embodying alternative viewpoints—such as being an animal or scientist—can shift moral and cognitive framing, deepening personal connection to environmental issues. Yet, as Fauville et al. (2020) and Quiroz et al. (2023) emphasize, behavioral change rarely follows automatically from emotional impact alone. Instead, lasting outcomes depend on integrating VR into reflective and social learning contexts—for example, classrooms, museums, or group discussions—that allow participants to process what they experience.

Research shows that VR is an engaging and useful tool for teaching about climate change. It helps people feel more aware, empathetic, and connected to the issue, but it works best when combined with reflection, interaction, and group discussion. This Glacier VR project attempts to align with this research direction. By combining scientific facts, realistic glacier calving simulations, and group discussions, it uses effective teaching methods to help students better understand, feel connected to, and personally relate to climate change and its direct implications.

3. Methodology

3.1 Study overview

This study examined University of Iceland students' responses to a short Virtual Reality (VR) demonstration illustrating the processes of glacier calving and climate change–induced glacier retreat. The study adopted a mixed-methods approach, combining quantitative survey data with qualitative insights from semi-structured discussions.

The purpose was to evaluate how students from different disciplinary backgrounds engaged with and understood climate change concepts presented through VR, and to assess how immersive technologies might enhance climate communication and education.

3.2 The VR experience demonstration

A short VR experience was developed to visualise key processes of glacier change. The demonstration featured a 3D animation showing the calving of a glacier and the subsequent positive feedback mechanism that accelerates glacier recession and promotes expansion of the pro-glacial lake at Jökulsárlón, Iceland (figure 1).

Figure 1: Screenshot of VR experience showing glacier calving process as a positive feedback mechanism

The narrated sequence lasted just over one minute and took place within a virtual representation of the Breiðamerkurjökull glacier front, created using drone photography processed via photogrammetric reconstruction. This provided a highly detailed model of the glacial landscape, while the 3D animation was synthetically generated using Computer Generated Imagery (CGI) software.

The experience was designed and rendered in Unreal Engine and viewed through a Meta Quest 3 VR headset connected to a PC. After viewing the animated sequence, participants were encouraged to remain in the environment for several minutes to explore and gain a sense of spatial immersion and scale.

3.3 Participants and setting

The study involved three groups of university students (total *N = 15*) from the following disciplines:

- Geography & Tourism
- Glaciology
- Environment and Natural Resources (ENR)

Each group participated in a dedicated worksession held in a controlled university setting. These sessions were designed to introduce students to the VR experience, facilitate data collection, and allow discussion of their responses. Participants viewed the experience individually but took part in shared reflections and discussions within their groups directly afterwards (figure 2).

Figure 2: University of Iceland students view the VR experience by means of a VR headset

Demographic details, disciplinary background, and education levels were captured in the quantitative survey and are presented in the results section.

3.4 Data collection

Two main data collection methods were employed: a quantitative survey and semi-structured discussion with the student groups.

Quantitative survey

An online questionnaire was administered immediately after each session using SurveyMonkey. The survey consisted of 14 questions, combining multiple-choice, Likert-scale, and open-ended formats. It assessed participant engagement, immersion, comfort, usability, understanding, and perceived realism of the VR experience.

The survey also included factual and conceptual questions related to glacier processes and climate change, allowing for evaluation of learning outcomes across disciplines.

Semi-structured discussion

Following the survey, participants engaged in a semi-structured group discussion designed to gather deeper qualitative insights. Discussion topics covered emotional engagement, realism, interaction, and educational potential. Students were also invited to share suggestions for improving the experience and to reflect on where such VR materials might be most effectively used (e.g., museums, exhibitions, or classrooms). All discussions were recorded through facilitator notes and later coded thematically to identify recurring themes and perceptions.

3.5 Data analysis

Quantitative Data

Survey responses were analysed descriptively to identify trends and patterns across participant groups. Data were summarised in percentages and visualised in figures to represent key variables such as engagement, comfort, perceived realism, ease of use, and knowledge comprehension.

Qualitative Data

Responses from the open-ended survey items and semi-structured discussions were subjected to thematic analysis, resulting in five overarching categories:

1. Engagement and Learning
2. Realism and Immersion
3. Design and Interaction
4. Context and Setting
5. Reflection and Broader Impact

These categories guided the structure of the qualitative results chapter in this report.

3.6 Ethical considerations

Participation in the study was voluntary. Students were informed about the purpose of the research and provided consent prior to participation. All responses were anonymised, and no identifiable personal information was recorded. The study adhered to the university’s ethical guidelines for research.

4 Results

4.1 Participant background

The study included 15 students from three fields related to environment and sustainability: six from tourism, six from glaciology, and three from environmental and natural resources (ENR). Most participants were male, and one chose not to report gender (table 1). The majority were between 20 and 25 years old, with a few aged 26–30 and over 31. Most were studying for or had completed a Bachelor's degree, and three held a Master's.

Table 1: Participant Background Information (N=15)

Items	Categories	Frequency
Gender	Female	6
	Male	8
	Do not want to answer	1
Age	20–25	11
	26–30	2
	> 31	2
Highest education completed	Graduated from high school	2
	1 year of Bachelor study	3
	2 years of Bachelor study	3
	3 years of Bachelor study	4
	Master's degree	3
Respondent Group	Tourism students	6
	Glaciology students	6
	ENR students	3

4.2 Survey results

Engagement and immersion in VR

Participants reported mixed experiences of engagement and immersion in the virtual environment (Figure 3). Just over half of the participants (8 out of 15) indicated neutrality when asked whether the experience left them feeling energized, while 3 agreed and 4 either agreed or strongly agreed. This suggests that only a small group found the experience truly invigorating. Immersion levels were also uneven. Six participants remained neutral about becoming so involved in the virtual environment that they lost awareness of their surroundings, five agreed, and one strongly agreed, while the remaining three disagreed or strongly disagreed.

Emotional engagement appeared somewhat stronger. Five participants reported neutrality toward the idea of feeling emotions they wanted to share when describing the experience, six agreed, and three strongly agreed. This indicates that the environment succeeded in prompting emotional reflection for some participants.

Concerns about social perception were also evident. Only two participants agreed and four strongly agreed that they were not worried about what others might think, while five disagreed and four remained neutral. This pattern suggests that social context influenced how comfortable participants felt during the activity.

The most positive responses related to movement realism. Ten participants agreed and two strongly agreed that moving inside the virtual environment felt realistic, while only three expressed neutrality or disagreement. These results highlight the technical success of the VR system in creating a convincing sense of spatial presence, even though emotional and social aspects of immersion were more varied.

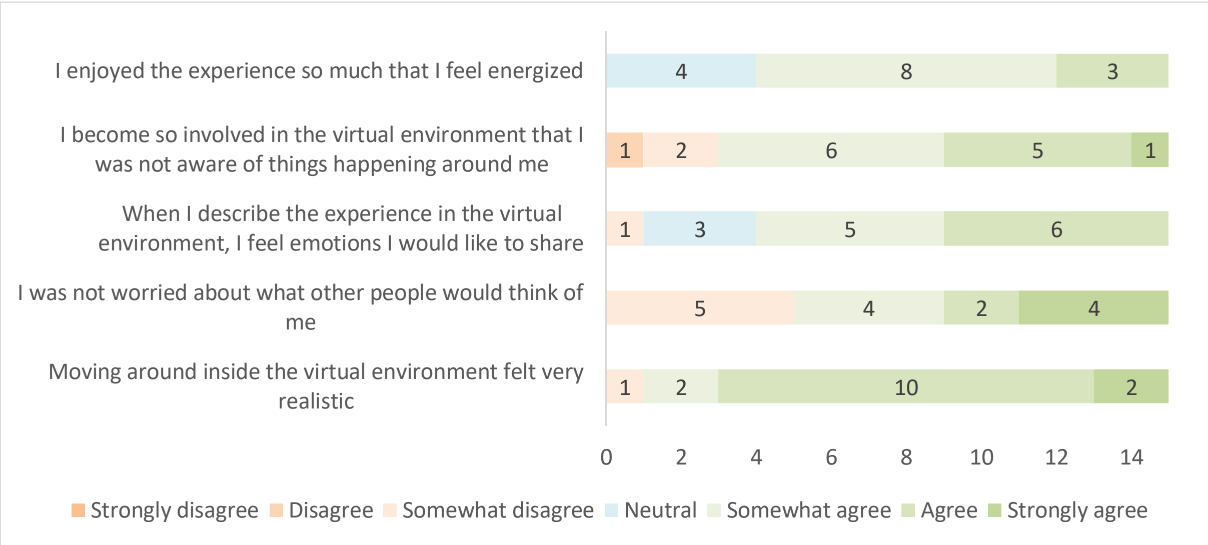

Figure 3: Participant responses to statements about their levels of engagement and immersion during the virtual reality experience (N = 15).

Comfort and nervousness

Participants expressed mixed feelings of comfort and nervousness in the virtual environment (Figure 4). When asked about approaching the edge of the ice cliff, 6 participants agreed and 2 participants strongly agreed that they felt comfortable knowing there was no real danger, while 3 participants remained neutral. However, a notable minority expressed discomfort, with 3 participants somewhat disagreeing and 1 participant strongly disagreeing.

Vertigo was most of the participant not an issue: 6 participants strongly disagreed and 3 participants disagreed with the statement that they felt vertigo when standing on the cliff edge. Only 2 participants somewhat disagreed, while small numbers agreed (1 participant), somewhat agreed (2 participants), or neither agreed nor disagreed (1 participant). This indicates that while a few participants experienced mild vertigo, most did not perceive it as a problem.

Nervousness related to headset use was also minimal. More than half (8 participants) strongly disagreed and 3 participants disagreed that they felt nervous using the VR headset. Only small numbers reported some nervousness, with 1 participant somewhat disagreeing, 2 participants neutral, and 1 participant strongly agreeing.

A similar pattern emerged when considering overall nervousness in the virtual environment. 6 participants strongly disagreed and 3 participants disagreed that they felt nervous, while 2 participants somewhat disagreed and 4 participants remained neutral. No participants expressed strong agreement.

These results suggest that while a few individuals experienced mild discomfort, the majority felt safe and at ease in the VR environment, even in scenarios designed to test psychological responses such as standing at the edge of an ice cliff.

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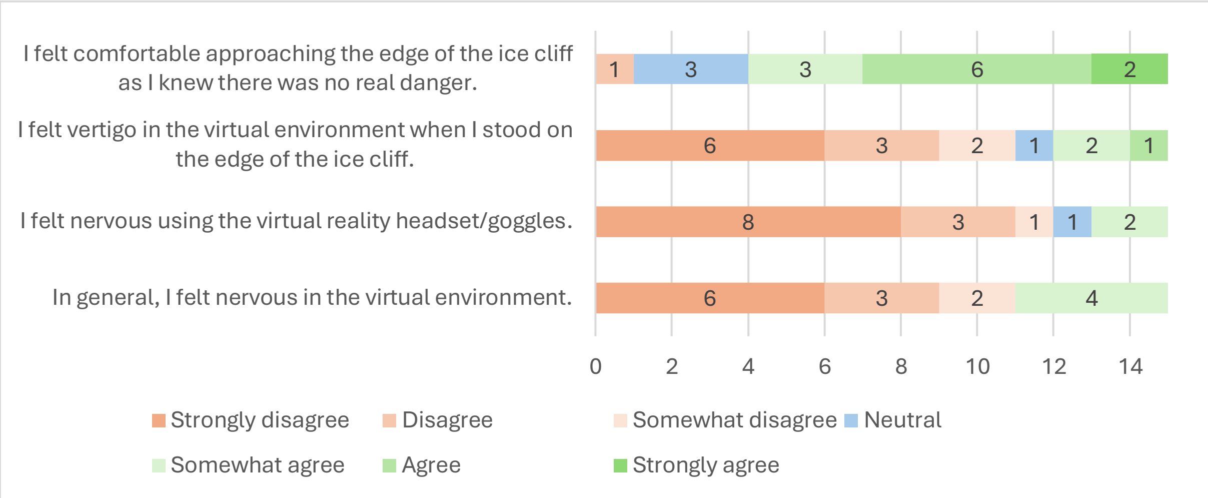

Figure 4: Participant responses to statements about their comfort and nervousness during the virtual reality experience (N = 15).

Evaluation of environment, performance, and graphics

Participants gave consistently positive ratings of the VR system across environment, performance, and graphics (Figure 5). The virtual environment itself was most often rated an 8 (5 respondents) or 7 (4 respondents), with additional ratings of 9 (3 respondents) and 10 (2 respondents). Only a single participant rated the environment as low as 6.

System performance was rated even higher. A large part of respondents gave it a 9 (6 repondents), while a further four respondents rated it 8 and another four respondents rated it 7. Only one participant rated performance as 6, and none gave the maximum score of 10.

Graphics were also evaluated positively, though with slightly more variation. Nearly half of participants (7) rated the graphics as 8, and a further 4 respondents gave a score of 7. While a small number awarded top marks of 9 (1 respondent) or 10 (1 respondents), two respondents gave a lower score of 6.

Taken together, these results show that participants viewed the VR system as functioning reliably and producing a convincing environment, with the strongest evaluations directed toward performance and environment quality. Graphics were also well received, but with greater variation and occasional lower scores, suggesting some room for visual improvement.

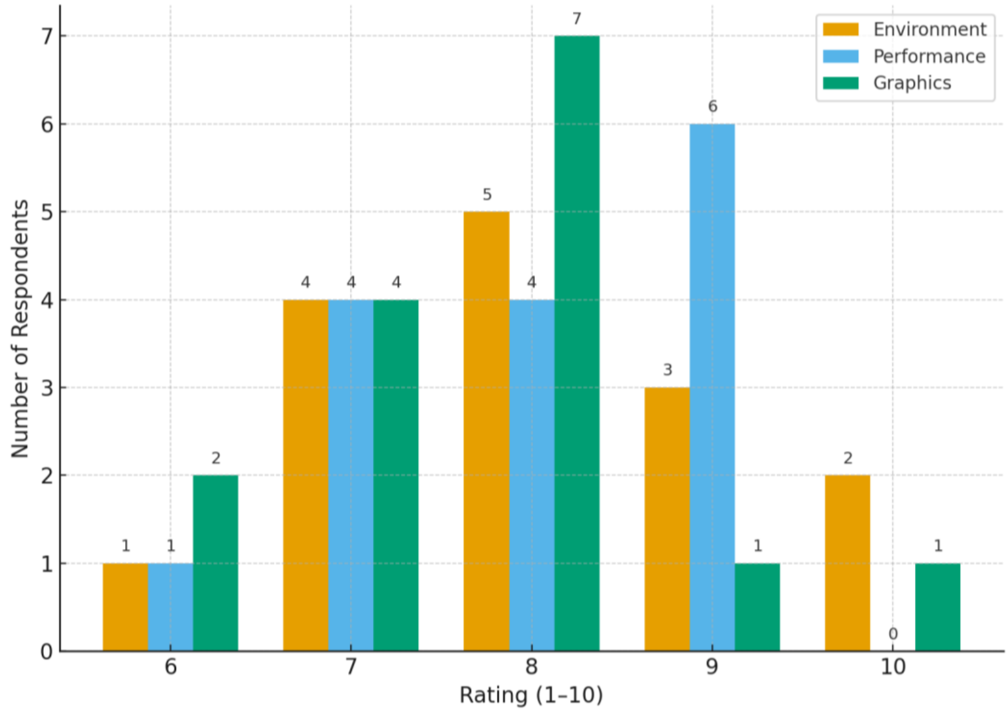

Figure 5: Respondents evaluation of the VR environment, performance, and graphics (N=15)

Ease of learning

Participants generally found the VR environment straightforward to learn (Figure 4). Nearly half of the respondents (7) described it as “very easy,” while one-third (5) rated it as “easy.” A smaller group (3) considered it “somewhat easy.” Notably, no participants described the environment as difficult to learn. This indicates that the system was largely intuitive, requiring minimal effort for users to become comfortable navigating the experience.

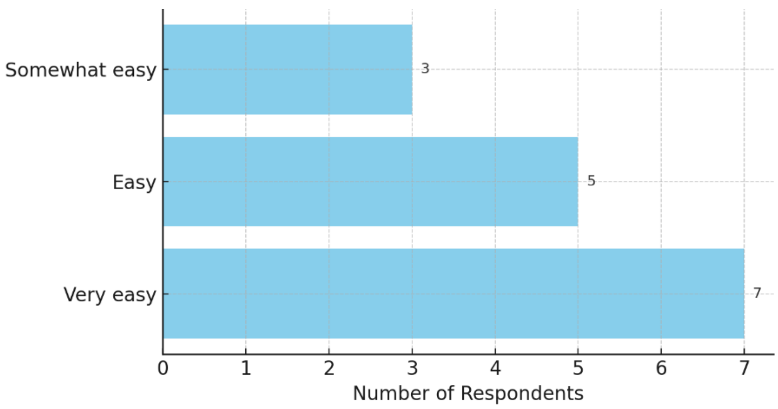

Figure 6: Respondents easy of learning of VR environment (N=15)

Understanding and cognitive content

Participants expressed a range of views regarding their experience with the VR environment (Figure 7). Overall, most respondents tended to agree that the educational content was accessible, although some expressed more neutral or uncertain opinions. The majority agreed or strongly agreed that the information about glacier processes was easy to understand, and over half expressed similar agreement regarding the clarity of the climate change impacts. Only a small number disagreed, indicating broad but not unanimous comprehension of the material.

In contrast, responses to the statement that the VR experience was overwhelming showed clear disagreement. Most participants disagreed or somewhat disagreed that the experience prevented them from understanding the message, suggesting that the level of immersion was appropriate and manageable.

Opinions were more divided regarding whether the VR experience provided new insights. While several participants agreed or strongly agreed that it did, others expressed more uncertainty or disagreement. This spread of responses suggests that, while the VR environment was largely successful in communicating information clearly, participants differed in how deeply the experience influenced their understanding and personal reflection.

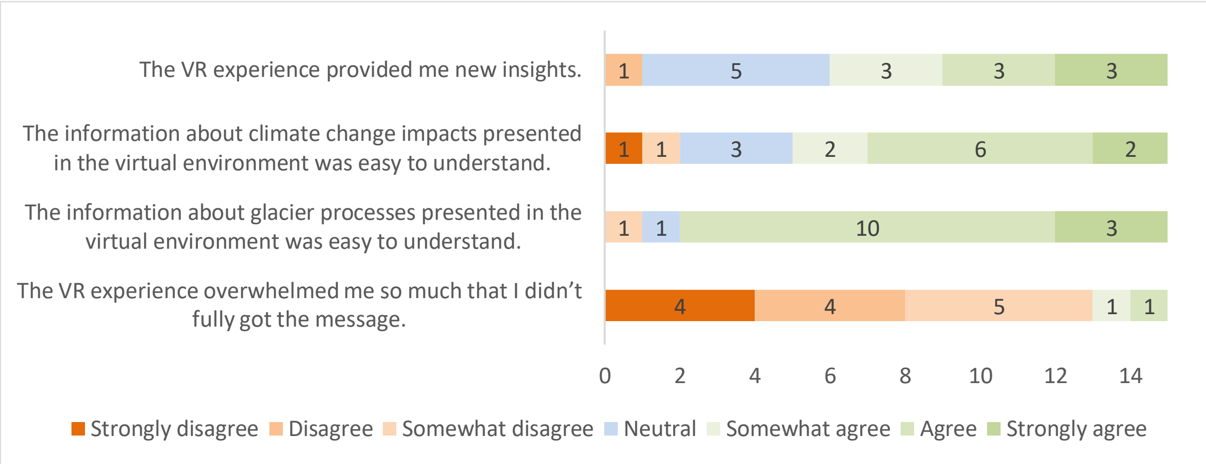

Figure 7: Participants' level of agreement with statements about their VR experience (N=15).

Knowledge of glacier processes

To get insight into the understandability of the knowledge provided through VR experience, this study included three factual knowledge question (multiple choice) with regard to the influence on climate change on different glacier processes what were represented with the VR as well as communication in the audio of the VR.

Responses to the factual questions showed some differences in understanding between topics and participant groups (Table 2). Six participants correctly identified both factors that cause proglacial lake expansion, while the remaining nine participants gave partial, incorrect, or no answers. Understanding of the underlying process was higher, with nine participants answering correctly. Knowledge about the depth of Jökulsárlón was the strongest, with thirteen participants giving the correct answer.

Group comparisons revealed distinct patterns. ENR students answered all three questions correctly, glaciology students performed well overall but struggled with the more complex factor question, and tourism students displayed greater uncertainty, particularly regarding conceptual processes.

Table 2: The number of correct answers of the participants per student group on 3 factual questions (N=15).

Question	Tourism students (N=6)	Glaciology students (N=6)	ENR students (N=3)
Which factors contribute to the expansion of the proglacial lake?	0	3	3
The expansion of the proglacial is an example of what kind of mechanism?	1	5	3
How deep is the proglacial lake at Jökulsárlón?	4	6	3

Perceptions of climate change causes

Participants overwhelmingly attributed climate change to human activity (Figure 8). Nine indicated it is caused mainly by human activities, three believed it is entirely human-driven, and only one attributed it mainly to natural processes. These results demonstrate a strong consensus on anthropogenic climate change among the sample.

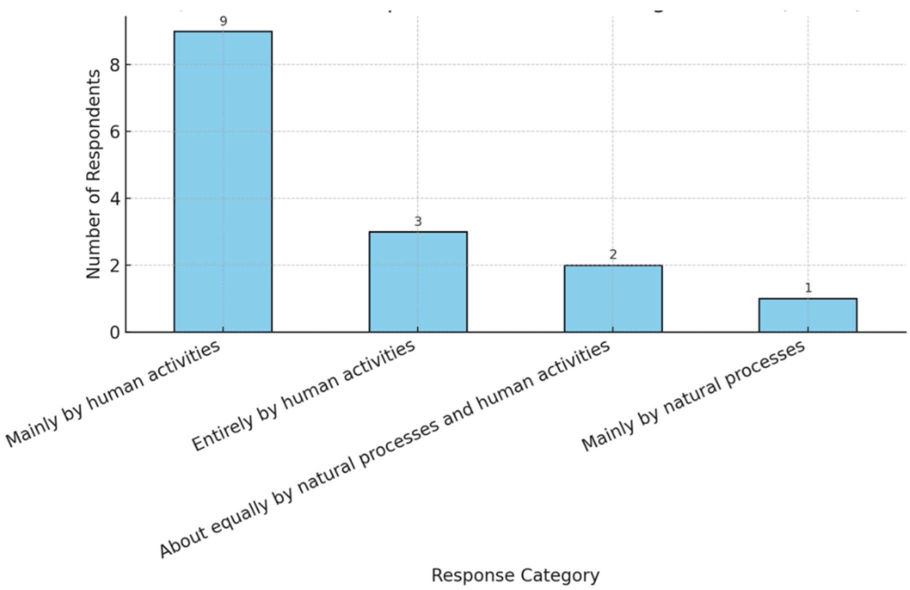

Figure 8: Perception of climate change causes (N=15).

Group comparisons in subjective experience

Cross-tabulation of participants' subjective VR experiences—such as immersion, comfort, and usability—showed no significant differences between the student groups. Most variation appeared in the factual knowledge results, where ENR and glaciology students displayed a stronger conceptual understanding than tourism students.

4.3 Discussion results

Following the three VR experience sessions conducted with student groups from different disciplinary backgrounds (further detailed in the Methodology chapter), participants were asked to complete a qualitative survey and subsequently took part in a semi-structured group discussion. The purpose of this discussion was to gather deeper qualitative insights into their perceptions of the VR experience and its effectiveness as an educational tool for illustrating climate change impacts on glaciers. Thematic analysis of the discussion responses revealed several aspects that captured the participants' reflections

Engagement and learning experience

Participants felt that, overall, the VR experience was an effective and engaging way to reach an audience and communicate complex information in a new format. Compared to traditional learning tools such as textbooks, the immersive qualities of VR were seen as offering a more stimulating and memorable way to absorb new knowledge. Several participants noted that the sense of presence created by the virtual environment encouraged them to pay closer attention and reflect more deeply on the topic of climate change and glacial transformation.

Realism, visuals, and interactivity

Those who had previously visited glaciers in real life commented that, while the VR simulation did not fully replicate the physical or emotional impact of standing within an actual glacial landscape, it was nonetheless the "second best" option when compared to other forms of media such as films or photographs. Participants particularly appreciated the animation depicting the calving of the glacier, describing it as a striking and informative moment. However, some felt that this feature could be better integrated into the wider virtual environment, ideally with the processes and scale presented in a more realistic and immersive way.

At the same time, participants expressed that the level of user interaction was limited. They suggested that the experience could be improved if users were able to move around freely or engage directly with elements of the environment. Such interactivity, they felt, would not only make the simulation more engaging but also enhance its educational value by allowing exploration and discovery.

Context and educational setting

Participants also discussed how the setting in which the VR experience is presented might influence how effectively users engage with and retain new information. It was noted that certain contexts—such as museums, science centres, or educational exhibitions—may encourage users to approach the experience with greater curiosity and openness to learning. These venues were therefore seen as particularly suitable for presenting the VR experience in an educational context. By contrast, more casual or entertainment-oriented environments might reduce users' focus on the learning objectives, underscoring the importance of thoughtful placement and framing of such immersive experiences.

5. Discussion

5.1 Enhancing the VR experience

Participants viewed the VR system positively, rating its usability and performance between 7 and 9 out of 10. Most found it easy to use, though about half felt only moderately immersed, suggesting that stronger interactivity and sensory detail could improve engagement. Students particularly valued the glacier calving animation but wanted it more fully integrated into the environment, with options to explore, manipulate objects, or access additional information such as climate data or time-lapse changes. Enhancing graphical quality and realism could also make the experience more immersive, especially for users accustomed to high-quality digital media. Addressing social concerns—such as self-consciousness about using the headset—through individualized setups or preparatory guidance may further improve comfort and emotional involvement. Incorporating interactive features that encourage active problem-solving, decision-making, or role-playing can also make the learning experience more meaningful, supporting deeper engagement and confidence (Dhunnoo et al., 2023; Quiroz et al., 2023).

5.2 Emotional and learning impact

While participants reported moderate emotional engagement, the experience was not always transformative. VR successfully captured attention and made glacier processes clearer but did not consistently prompt deeper reflection or learning. This suggests that VR alone may not guarantee emotional or cognitive change. Integrating VR into broader educational frameworks that include discussion, reflection, and connections to real-world experiences could enhance its impact (Fauville et al., 2020; Quiroz et al., 2023). Adding narrative elements, role-playing, or decision-based tasks may also help participants think critically, retain information better, and link scientific understanding to personal and emotional engagement—an essential step toward motivating climate action.

5.3 Educational and communication implications

The findings highlight VR's strong potential as a communication tool for climate change education among young adults. Participants generally understood the human causes of climate change and found glacier-related content clear and accessible. However, disciplinary differences influenced how they interpreted the material: glaciology and environmental students showed higher factual understanding, while tourism students expressed more uncertainty. This suggests that VR experiences may resonate differently depending on learners' backgrounds. Adapting content to match each group's prior knowledge and learning needs could make VR more effective. To maximize impact, VR should be embedded in structured settings—such as classrooms, museums, or workshops—where facilitation supports reflection and dialogue (Fauville et al., 2020). In this way, VR can move beyond passive visualization to become a dynamic and social learning tool that deepens understanding and engagement with climate change.

6. Conclusion

This study forms part of the LEVERAGE (*VOGARAFL*) project, which aims to develop educational materials that inspire creative peer-to-peer discussions and collaboration among young people on the impacts of global climate change. Through the use of VR, the project seeks to support experiential learning by making complex environmental processes more understandable and emotionally engaging. The findings of this pilot phase indicate that VR can effectively capture attention, stimulate curiosity, and provide a shared platform for learning and reflection about glacier change and its wider climate implications.

Participants rated the VR system highly for usability, performance, and clarity, and most found it easy to learn and navigate. The glacier calving animation helped make abstract scientific processes tangible, while the immersive setting encouraged engagement and conversation. However, varying levels of emotional involvement and immersion suggest that future iterations could benefit from greater interactivity, realism, and opportunities for user exploration and reflection to deepen understanding and engagement.

A key limitation of this study is the relatively small number of participants (N = 15), which restricts the generalizability of the results. Nevertheless, the pilot achieved its core aim of testing how immersive technologies can enhance climate communication and education. The insights gained provide a valuable foundation for further development of the VOGARAFL project, supporting its broader goal of empowering young people to engage critically, collaboratively, and creatively with the challenges of climate change.

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