Expedition 2 Grad

The 2°C target in the Alps
– An Experience in Virtual Reality

UNI FR

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phGR

Z hdk

FNSNF

parc naziunal svizzer

UNESCO World Heritage
Swiss Alps Jungfrau-Aletsch
World Nature Forum

Figure 1 - Equipped with 3D glasses, the expedition participants embark on the «Expedition 2 Grad».

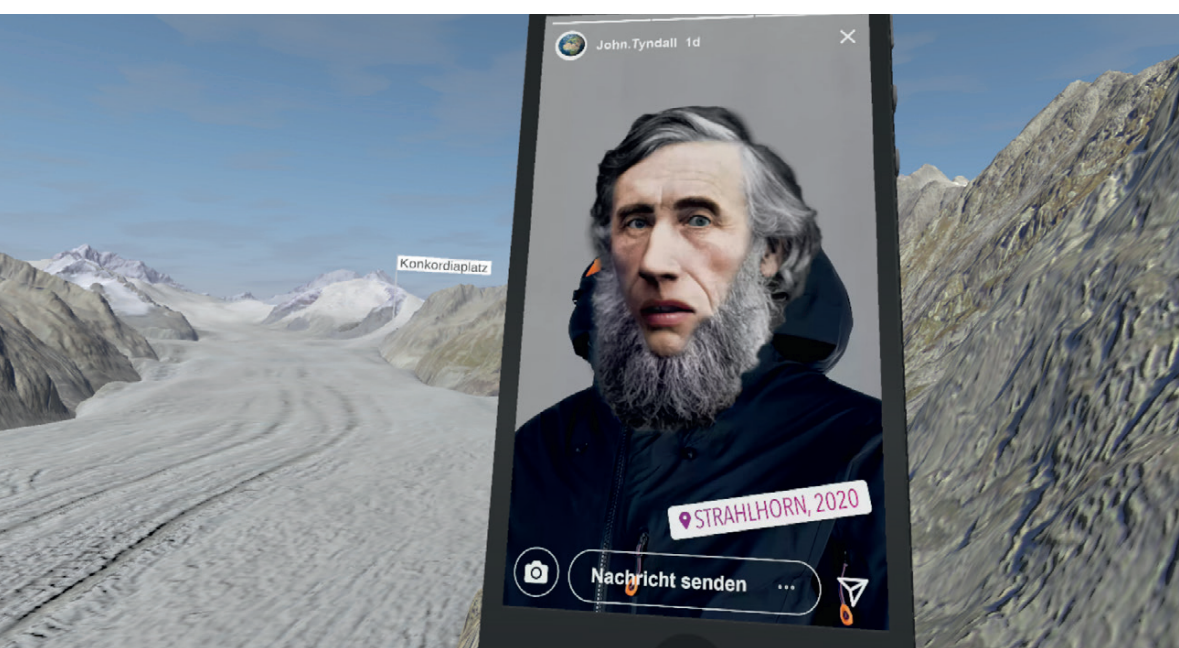**Figure 2** - In John Tyndall's room at the Hotel Belalp.

Figure 3 - John Tyndall shows you the view on the Aletsch glacier.

Expedition 2 Grad

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1 Introduction

As anthropogenic emissions of greenhouse gasses has changed the climate drastically and global temperatures have risen sharply (IPCC, 2014), climate change is one of the major challenges for society in this century. With the Paris Agreement of December 2015 most nations committed to limit the increase in global average temperature to well below 2°C (UNFCCC, 2015). To achieve this goal a drastic reduction of greenhouse gas emissions in all areas of our society is needed (Knutti and Rogelj, 2016).

As in many other regions in the world, warming in Switzerland is unequivocal. Surface air temperature has increased in all regions of Switzerland since the start of the instrumental record (CH2018, 2018). In Switzerland's alpine environment the consequences of global rising temperatures can be observed, e.g. by retreating glaciers, thawing permafrost and increasing danger from potential natural hazards (e.g. Etzelmüller, 2013; Huss et al., 2017; Haeberli et al., 2019). However, global warming cannot be stopped, although by global efforts the temperature increase can still be limited to not exceed +2°C until the year 2100 (Lenton et al., 2019). But what exactly do these +2°C mean? What are the consequences of this temperature increase for nature and landscape and what will change for us humans?

The objectives of the project «Expedition 2 Grad» focused on visualizing and experiencing a 2°C climate warming in the Alps by means of a VR-Experience in two partner museums.

The main objectives of the project were:

- to enable the target group to experience changes and impacts in the high mountain cryospheric landscape and to make climate change tangible using a VR-Experience.
- to create awareness about climate change based on visualized impacts of an average 2°C temperature increase on the mountain cryosphere in comparison to scenarios implying a higher increase.
- to interact with younger generations and sensitise them to the impacts of climate change.
- to link up with initiatives that show actions towards a decarbonised future world.
- to evaluate the effects of the media on the target audience with the aim to improve the general communication on climate change and assure long-term effectiveness of the project.

The «Expedition 2 Grad» is primarily intended for school classes of Secondary and Gymnasium level (12-17 years). The main module is the interactive VR-experience but it also includes an adapted supporting program with a moderated class discussion.

By means of Virtual Reality (VR) participants undertake the «Expedition 2 Grad»: In a virtual world around the Great Aletsch glacier the target audience interactively experiences the effects of increasing temperatures on the alpine environment. By this journey through space and time, emotions are triggered and the users experience the region of Aletsch through the eyes of their grandparents and of future generations.

The virtual-reality allows the public to experience a global warming of 2°C in a high mountain environment. The politically determined and abstract 2 degree target can

be clearly communicated in an impressive way. The result is meant to motivate reflection – on individual decisions but also efforts of the society, which in the end lead back to personal behaviour. Questions on what climate change exactly means and how we can cope with the challenges of climate change as society have been discussed and answered in a common discussion.

Year	2018									2019												2020			
Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mai
Project Month		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Milestones		1			2					3			4,5	6		7		4,5	6		7				8	
Conceptual Phase																										
Organizing meetings and Kick-off workshop		█																								
Conceptual framework, Defining content of the experience			█	█																						
Intensifying contacts with museums and schools				█	█																					
Setting up evaluation concept					█																					
Development phase																										
Compiling scientific content			█	█	█																					
Developing and testing Virtual Reality experience			█	█	█	█	█	█	█	█	█	█														
Developing material for Post-Processing						█	█	█	█																	
Setting up web platform (structure and content)								█	█	█																
Planning and constructing museum installation												█					█									
Realization phase																										
Implemeting, maintaining and running VR in museums													WNF	█	█		SNP	█	█							
Supporting school classes																										
Maintaining and updating web platform													█	█	█	█	█	█	█					█	█	
Foster interaction with target audiance (museums, schools social media)													█	█	█	█	█	█	█	█	█					
Evaluation Phase																										
Quantitative measures													█	█	█	█										
Pre-Post testing													█	█	█	█										
Evaluation report																							█	█		
Securing sustainability and perspectives											█	█											█	█		
Synthesis (publications)																									█	█

Nr.   Milestone
 1   Kick-off meeting
 2   start teacher/school infomation
 3   start media work
 4   start of exhibition in museum
 5   panel discussion: students and scientists
 6   science cafe
 7   closing event
 8   project conclusion

Figure 4 - Project timeline as published in the initial project plan.

2 Activities

The duration of the project covered two years. As outlined in the proposal project plan and the schedule (Figure 4), we planned the realisation of the project work in four phases. During the first year, the project team iteratively developed the concept, started with the development of the different steps, to be ready with the final exposition module only one year after project start. The realization phase with the planned expositions in the visitor centres of the Swiss National Park (SNP) in Zernez and the World Nature Forum (WNF) in Naters, and additional other unplanned possibilities for expositions was a great success for the project. The evaluation realised with school classes visiting the exposition at the National Park visitor centre in Zernez went parallel during the second year of the project.

2.1 Conceptual phase

2.1.1 Conceptual framework

In the beginning of the project, two meetings have been held with all involved project partners. The kick-off meeting (12.4.2018) was to launch the project and mainly dedicated to create the organizational framework. Thereby the objectives, responsibilities, budgets and schedule have been discussed and agreed on. At the second meeting (30.5.2018) the content was discussed. All partners were present and could bring in their ideas, expertise, expectations and motivation. This meeting was a key moment of the project, as all people with their different background agreed on the way forward and knew what their tasks and responsibilities in the project are. This meeting devoted to the content was the real starting point for the project. At this meeting we also decided that the visitor centre of the Swiss National Park will start with the exposition in April 2019 for four months.

2.1.2 Defining content of experience

The aim of our project was to raise awareness for and even generate a tendency to act upon the causes of climate change by means of a VR immersion in an environment in which the effects of rising global temperatures at higher elevations in the Alps are experienced. Recently, VR-environments have gained the interest of humanitarian organizations such as the UN, but also actors like the World Bank. A range of VR-experts have started to experiment with the modalities of this technology hoping to create what VR-documentary maker Chris Milk has called an "empathy machine" (Gregory, 2016). Because of its capacity to generate a strong illusion of place and an illusion of presence, an illusion of "being there", recent authors have indeed argued that a crucial affordance of VR-technology is its capacity to influence people's emotions and to generate empathy with for example refugees, roofless people, prisoners (Jones, 2017; Shin, 2018; Yoo and Drumwright, 2018). Similar technologies are now being used to raise awareness for environmental change, such as the VR-project by Jeremy Bailenson, whose aim is to raise awareness for the process of ocean acidification. These technological advances are promising, and heralded for being much more powerful in generating even long-lasting impact on behavior (Ahn et al., 2014). While unmistakably powerful in thrilling people, the uncritical use of VR-technology to generate emotions without really knowing why and what has

made scholars like Nash (2018) worried about the moral potential of VR. These critiques triggered a number of crucial questions for the content of our project. Does the illusion of presence really trigger the same effects as "the real experience"? And more importantly, to what extent is any democratic debate about an issue still possible if powerful emotions are being engineered by a particular group of people (Chouliaraki, 2013)? Which kind of emotions can/should be generated in our climate change communication? And isn't climate change communication already saturated by emotional messages?

Climate change as a slow and abstract process has always been difficult to be communicated to lay audiences, which is the argument by a range of scientists, states, activists, organizations and media (Moser, 2016). These actors have used and created a range of communication frames during the past decades to get "lay people" care about this topic including also political decision makers, who are important key players when necessary measures have to be taken. They have mainly introduced the issue of climate change by activating emotions such as fear and nostalgia but also hope, and through the use of icons such as polar bears and glaciers. The result is indeed that – just like any domain – the communication domain of climate change is currently filled with certain emotional repertoires. Today, people do understand climate change mainly through particular emotional registers and relate to climate change through iconic images. Moreover, studies have shown that the climate change communication field is saturated with apocalyptic messages (Swyngedouw, 2010) urging people to adapt their individual behavior (Kenis, 2016), neglecting the variety of forms of collective agency and the specific socially situated forms of blame that result from this (Rudiak-Gould, 2014). The project, therefore, tried to build on the strengths of already existing climate communication logics (the feelings of loss when confronted with the impact of climate change on highly valued pristine nature most particularly (see Höijer, 2010)) through making these logics even more thrilling by reducing the mental distance towards the issue in a VR-experience and creating a specific affective atmosphere (Anderson, 2009). However, in order to not fall back into the already existing logics of individual responsibility, the project constructed a detailed and nuanced agonistic perspective to document historical responsibilities and most importantly provided the tools to start imagining a range of hands-on individual and collective forms of agency to tackle climate change.

2.2 Development phase

2.2.1 Compiling scientific content

For the construction of the 3D visualizations we used data from swisstopo and scientific modelling. Three-dimensional terrain data (swissALTI3D) (swisstopo, 2018) covering the area that should be visible in the VR was extracted from the entire dataset. Past and future glacier surface elevation for the period of 1900-2100 was provided by a dataset from Jouvet et al. (2011). The glacier bed topography is based upon the modelling of Linsbauer et al. (2012). Further we used aerial photographs (SWISSIMAGE) (swisstopo, 2020) of the visualized area to map it as a surface texture onto the terrain model. Aerial photography of recent glacier fore fields have been used to map animated past and future glacier stages with a realistic surface texture.

The terrain model of swisstopo was modified for each animation time step (1880-2100) using glacier surface data modelled by Jouvet et al (2011) and glacier bed topography from Linsbauer et al. (2012). For this, we first had to resample the glacier surface elevation data to a resolution compatible with the swissALTI3D data. Secondly, we combined the modelled and resampled glacier bed topography with the high-resolution surface elevation data. For each timestep (1880-2100) this topography dataset was merged with the modelled glacier surface elevation data. Final-

ly, the resulting terrain data had to be converted from 32bit tif format to 8bit png format to make them compatible with the VR visualization software.

2.2.2 Developing and testing VR experience

The first steps for the design team consisted in acquiring the data for animating the glacier retreat as well as visualizing the environments. Photogrammetric methods were used for translating a real hillside and a hotel room into their respective digital twins. The resulting models had to be adapted for rendering in real-time game engines. They were then combined with height and imagery datasets from swisstopo (see chapter 2.2.1) into a realistic environment. A professional actor lent his voice to the main character of the story, John Tyndall. The audio was then synchronised with a digital representation.

The interactive part should make participants feel in control during various points of the experience. Yet, there was no time to conduct a tutorial or introduction, so a very simple, gaze-based interaction system was used. Iterative tests of the timing were conducted at various points of development in order to guarantee a natural flow. Careful planning was necessary to make sure that the images in the VR headset never dropped below 90 frames per second to avoid simulator sickness.

2.2.3 Set up website

The website www.expedition2grad.ch was an important pillar of the communication strategy and covered the online communication of the project. The platform was not only to summarize the most important background information on the project, but also served as an advertising channel and business card during the project development.

The website announces the VR experience through a 360° video and several images. They provide the visitor with an idea of what they have to expect. It also explains how the virtual world was designed with the help of scientific data. Since it was realized in close cooperation between design and science, it was important to make the people working for the project clearly visible.

2.2.4 Planning and preparing the pedagogical program for school classes

In the beginning of the project (proposal) it was planned that the PHGR would be responsible to design and prepare the pedagogical program as well as the evaluation. However, with ongoing project work it became obvious that PHGR will focus on the evaluation only. As the pedagogical knowledge was available at the National Park (SNP) and as they were in charge of guiding the school classes through the program, the SNP took over the task of preparing the pedagogical program.

Figure 5 – Time schedule for the workshop and the inclusion of the VR-experience.
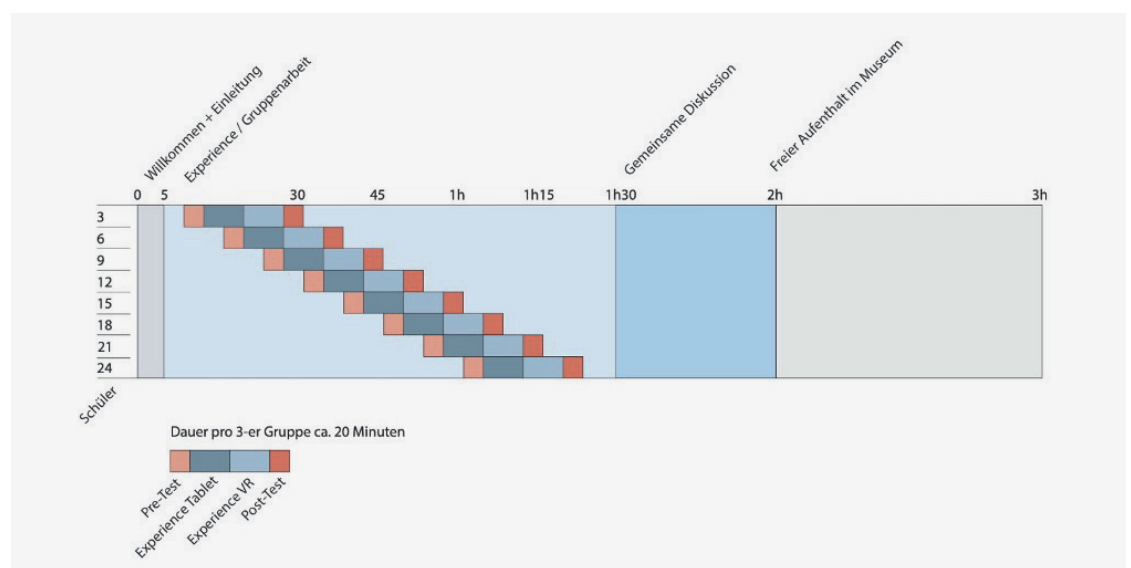
The three collaborators working for public relation and communication in the SNP designed the pedagogical program on their own, with several consultations with the project leaders and on the basis of the general project idea.

The major challenge was the timing. It was necessary to allow a class visiting the VR experience, which consisted in only three VR-modules. A single person was occupied by about 15 min at the station (short interrogation / intro & VR experience). Furthermore, the program should achieve the goals mentioned before (see chapter 1), i.e. creating awareness and assuring a certain long-term effectiveness of climate change and its mitigation, and also had to include the scientific survey (evaluation).

Accordingly, we designed a two-hour workshop, consisting in an introduction for the whole class, a workshop phase with several individual tasks (with different difficulty levels and subjects) that could be interrupted any time, as soon as there was a slot free at a VR-module (see Figure 5 for time schedule). A guided class discussion concluded the program, to sum up the whole experience.

The individual tasks were designed along three major subjects: (i) causes, (ii) consequences and (iii) mitigation of climate change, whereby a link to the Alps and especially to the SNP and the WNF was included where reasonable.

The team of the SNP created completely new material for the pedagogical program accompanying the VR experience, from the power point intro and outro to the workshop sheets to posters and furniture of the classroom. After a direct exchange, the entire material (digital & analogue) with extra explanation was handed over to the team of the WNF in Naters. Furthermore, each teacher having visited the workshop got a link to the webpage of the SNP, where all pedagogical material is offered as word- and PDF-files for download, in order to enable a certain spread, hoping that the subject of climate change would be treated in further school lessons.

2.3 Realization phase

2.3.1 Implementing running VR in museums and at exhibitions

The partners at SNP built the wooden exhibition modules, which had a clean and sturdy look. During the exhibitions, some challenges emerged considering the implementation of the still relatively new Virtual Reality technology. Both from a software and hardware standpoint, it became clear that the medium is made for personal use and not for heavy duty in exhibitions. Regular software updates made remote maintenance necessary and a total of six headsets broke over the course of all exhibitions. On the plus side, observations showed that no matter the age group, users understood how to put on the VR headset, start the experience and advance through the story.

Beside the two possibilities to showcase the «Expedition 2 Grad» at SNP and WNF, we have been contacted by many different organisation and events to be present with our VR-modules. By building additional exhibition-modules and flexible time planning, it was possible to realize the presence at different events and location. This was connected with the use of additional resources. A welcome addition was the use of one module in the "Museum für Gestaltung" Zürich for its special exhibition "Wissen in Bildern" with approximately 20'000 visitors. Most of the additional events however were one- or two-day exhibits. The material for the exposition had to be transported, set up and supervised during the entire time. Many different members form the project staff volunteered to be present, but also some students were engaged to help to cover transport, construction and supervision. A complete list of the schedule of showcasing the «Expedition 2 Grad» is listed in chapter 3.6.

2.3.2 Supporting school classes

Concerning the SNP, all school classes in the Engadine Valley, the Val Müstair and other communities nearby (such as Davos i.e.) were invited individually, as the contact to these schools is quite close. Facebook posts, the general SNP and «Expedition 2 Grad» websites and the numerous contributions in the media news attracted school classes from other areas in Switzerland (i.e. Zurich, Schaffhausen etc.).

Each school class had to subscribe via email, whereas max. 26 scholars could do the workshop at once, two classes per day (1 class in the morning, 1 class in the afternoon). As soon as a person in charge from the SNP team (total 4 collaborators) was found, a confirmation was given by mail, with individual agreements directly negotiated between the person in charge and the teacher.

For the exhibition time at WNF, the schools were informed about the «Expedition 2 Grad» in a very similar way as described by the SNP. First, schools in the World Heritage communities were contacted, since contact with the World Heritage schools is very close and they had priority. In addition, school classes from all over Switzerland were made aware about the «Expedition 2 Grad» by means of the UNESCO newsletter, the general WNF and «Expedition 2 Grad» websites and various media releases. Each school class had to register using a registration form (https://docs.google.com/forms/d/e/1FAIpQLSfkY-fNJ5NdlCj1cmpuk_REzZer-lCuh4dtGCg8cKII2sT_pw/viewform). After receiving the application form, the relevant class teacher was contacted by the person in charge at WNF to discuss further details, such as previous knowledge of the pupils, age, school level etc.

2.3.3 Maintaining website

During the project development, important milestones and side events were published in the news section, which allowed us to draw attention to the project. The news history also shows a unique view behind the scene, process from the development of the storyline to production of 3D assets to several exhibitions, media publications, related news in science and talks. During the exhibition phase, further information on the exhibitions, events and press release could be accessed and communicated.

2.3.4 Interaction with target audiences

The interaction with the core target audience mainly took place at SNP and WNF when school classes booked the program «Expedition 2 Grad». Staff from both organisations have accompanied the classes through the pedagogical program, which at the end led to a guided group discussion. The guidelines for this group discussion is available in the material of the pedagogical program.

When arriving, each class was welcomed in the exhibition, guided through the experience and the workshop by the same person from the SNP. At the end of the workshop discussion, each scholar had to write his "climate mitigation aim" onto a small letter. 2-8 weeks after the workshop ("intervention"), each teacher was contacted again with an envelope, containing the personal "climate mitigation aims" of the scholars. The teacher handed them back to the scholars and let them fill in the last evaluation form. This procedure was chosen in order to evaluate a certain long-term effect of the intervention or to reach a certain sustainability of the VR-experience. In order to treat each school class as individually as possible, a short talk with the teachers was usually done before they visited the exhibitions. Furthermore, the pedagogical material was designed to meet the large spectrum of ages, previous knowledge and school level.

Just like the SNP, each class was welcomed at the WNF auditorium. First, a short introduction on climate change was given. Afterwards the «Expedition 2 Grad» was held in the exhibition and a final discussion with the pupils followed. Afterwards each pupil could write his „climate mitigation aim" on a small piece of paper. Sin-

ce the focus of the visit should be mainly on the actions - „so what can I do?" The small papers were given to the teacher in a separate envelope with the request to hand out the slips of paper to the pupils again after one month, so that on the one hand the pupils could control themselves. On the other hand, to achieve a certain sustainability of the VR experience. Finally, a QR code was handed out, with which the teacher and the students could fill out an online questionnaire to let the teacher and the students judge the experience.

At the additional events (see chapter 3.6), the contact to the visitors was very intense. At most events the people did not belong to a specific target audience, but can be described as a public of laypersons. Especially people in the queue waiting to use the VR-module could easily be involved in discussion about climate change. After experiencing the «Expedition 2 Grad» many people were very impressed and full of emotion they wanted to share.

Scientist and project staff member were present at all different occasions when exhibition the VR-experience and ready to discuss with interested people and explain their point of view.

2.4 Evaluation phase

2.4.1 Variable operationalisation for measuring program impact and evaluation

To get some insights about what participating students think and perceive during the VR-experience and the accompanying pedagogical program, participants are asked to answer a short questionnaire before (pre-test), after (post-test) and ~four weeks later their participation (follow up-test). In collaboration with VR-developers and project management, the following topics are included in the questionnaire and are examined:

Perceived severity and perceived probability of consequences of climate change depending on program participation (pre, post and follow up):

Perceived severity and probability of negative consequences are meant to be both preconditions to motive building for environmental actions (see "Integriertes Handlunsmodell (IHM)"; Martens, 1999; Rost et al., 2001). For this examination it was of interest, how these constructs change due to program participation (see chapter 3.8). Therefore, the following questions are asked at each questionnaire (pre, post, follow up). The null-hypothesis that participating at «Expedition 2 Grad» has no impact on these constructs is tested by repeated measures ANOVA.

Six questions are asked to measure perceived probability of consequences of climate change. The questions combine three by climate change affected subjects ("me" as individual and "inhabitants of the Alps" as directly affected people and "humanity") with two variables affected by climate change ("rise of average global air temperature" and "glacier melting"). With these six questions a scale for perceived severity was calculated and used for program impact control (see chapter 3.8; higher values indicate according to the IHM (Martens, 1999) a higher probability of motive building)[1].

The scale show good reliability (cronbach's alpha for pre-test=0.855; for post-test=0.880, for follow up=0.782, reliability measures do not accelerate if items deleted).

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1   Item-example: «Für mich gilt, dass der Anstieg der globalen Durchschnittstemperaturen (Klimawandel) die Menschheit insgesamt ... «überhaupt nicht betreffen wird» (1) bis «sehr stark betreffen wird» (6).

There are two questions concerning perceived severity of consequences of climate change. First the participants are asked about their perception of possible negative consequences of rising global air temperatures and second, about negative consequences of melting glaciers[2].

At every test (pre, post, follow up) there were high correlations between the two questions (r ranging from r=0.595 to r=0.613) with higher means for perceived negative consequences on rising global temperatures than for glacier melting. For this report, the two questions were averaged and used as a scale.

Rating of visual elements during VR-experience (post-test):

For developers the perception and valuation of some graphical elements by participants during the VR-experience were of interest. Therefore, the "igroup presence questionnaire (IPQ, see for example Schubert, 2003)"[3] for VR-experience was adopted (aspects "feelings during VR" and "comparability of experience with real life experiences"). The participants are asked five questions.

A second aspect related to some implemented graphical features during the VR-experience was surveyed: The helpfulness of visual elements to understand the passing of time during VR-experience. Participants were asked about cloud movement, year dates, spoken language by John Tyndall, glacier movement and appearance of John Tyndall.

The two above mentioned measures were compared with developers expectations concerning what they were awaiting to be a good result.

Program recommendation (post-test):

Program satisfaction was measured by one question: if participants can recommend the «Expedition 2 Grad» to their family and friends. Results were compared with expectations by program developers.

Intention implementation due to program participation (follow up):

In retrospective, participants were asked two questions about their deliberate actions concerning reducing their own CO_2-emissions. First, they indicated if their visit at SNP and the connected participation at «Expedition 2 Grad» had influenced their everyday behaviour to deliberately reduce CO_2-emissions (general intentions). Second, they were asked, if they tried to implement their intentions made as part of the pedagogical program at SNP (specific intentions)[4].

2.4.2 Sample of evaluation

All 33 classes participating at the program at SNP have been asked to complete the questionnaires. However, test participation was voluntary and anonymous[5]. Hence, different numbers of participation result: pre-test n=340; post-test n= 354 and follow up test n=230. At pre-test 51.5% of participants are female and 47.4% male; 1.2% do not indicate their sex. Mean age of scholars is 14.28 years (ranging from 10 to 20, standard deviation=1.60). 5.3% of the questionnaires were filled by teachers and other pedagogical staff (their answers were included in the analyses).

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2   Possible answers range from: «negative consequences are very small» (1) to «negative consequences are very fatal» (6).

3   Questionnaire: http://www.igroup.org/pq/ipq/index.php

4   There were also open questions to define which exact intentions they implemented in everyday live and which not. This analysis's are not part of this report.

5   Within-subject assignment was done by an individual code set by the participants, e.g. «second Letter of last name» and others. Due to this procedure some mistakes occurred resulting in some data loss.

Not all classes/individuals participated at all three tests[6]. Instructional materials to secure implementation objectivity for the pedagogical staff were prepared. The participants could enter the questionnaire by QR-Code with their mobile devices. There is no evidence for a systematic bias to drop in or drop out by participants. Completion rates are very high: if started, more than 99% finish the survey and there is not much missing data (less than 2%).

The dataset allowed to perform comparisons between a) pre-and post-test with n=236 and b) pre- and follow up-tests with n=99[7].

2.4.3 Sustainability and perspectives
- Severe impacts of Covid-19 pandemic

In the beginning of the year 2020, various companies, exhibition spaces and event managers expressed their interest to show the whole exhibition or parts of it. However, all these planned events had to be put on hold or were cancelled because of the COVID-19 pandemic. Therefore, the promising future of a commercial use of «Expedition 2 Grad» is currently uncertain. However, we hope that the still existing interest will soon emerge again, as both VR technology as well as the topic of global warming and glacier retreat are still up to date.

2.4.4 synthesis (publications)

There are many ideas and there is a lot of material to write some publications. However, since all members of the project team were heavily involved in developing, realising and executing the project objectives, the time to start writing a publication was lacking. It is foreseen to start this process with a bit more distance to the project during the coming months.

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[6] Especially the follow up test had to be conducted 4 weeks after participation in the regular classroom. Not all classes had done this. We assume that pragmatic reasons are causal for this.

[7] Due to different evaluation-participation of classes and some mistakes made in identification questions, there are different sample numbers for paired-sample t-tests and repeated measures ANOVA.

3 Main results

3.1 Storyline and user experience

«Expedition 2 Grad» combines a direct experience of the evolution of Aletsch glacier between 1850 until 2070 with insights in why this evolution took place and what could/can be done about it. The direct experience nurtures an emotional involvement with the theme, decreases mental distance and invites people to get involved with the issue. The gradual involvement of the user is interwoven with an agonistic perspective: what are the potential modes of agency to act upon these feelings of loss, threat, despair? This emotional and agonistic journey develops through three different settings:

- At the tablets, users are introduced to John Tyndall, a 19th century English physicist, mountaineer and a pioneer in climate science. He acts as a story-teller (see Figure 7) and explains the very basic concept of how humanity got to a point where it could influence the global climate. On the tablet, users answer questions about their personal views on personal consumption, social engagement and political decisions. Depending on their answers, they get a score corresponding to 2/3/4 degrees Celsius (see Figure 8). Tyndall also introduces three different modes of agency: individual behavioral change, the collective setting-up of environmentally just alternatives and the collective protest mobilization to put pressure on powerful decision makers.

- Subsequently they step on a platform and put on a VR headset. In the virtual environment, starting at the hotel Belalp, John Tyndall welcomes them again and explains that he used to spend a lot of time there, looking at the glacier – still reaching far down the valley. Watching the retreat of the glacier in the early 20th century (see Figure 9), Tyndall questions to what extent he and his peers would have been able – already in the 19th century – to reduce the impact of industrialization. Time advances and the experience takes the users on a journey through time watching the retreat of the glacier until the year 2070 when most of its mass will have disappeared. The large jumps in time are made tangible through references to the users' grandparents, parents and eventual childrens' ages and typical consumption behaviors. The reference to these generations also helps to situate these generations' responsibility in shaping the past and to trigger intergenerational discussions. Depending on their score (see above), the users see different scenarios and get a feeling about the delayed reaction time of large glaciers on atmospheric temperatures and about how much difference a small change in temperature causes in the sensitive alpine environment. Near the end of the experience, Tyndall reminds the user about the different modes of agency.

- After these two technology-aided experiences, users are invited to discuss the modes of individual and collective agency they have been introduced to by Tyndall.

3.2 Exposition module: Tablet & VR station

The modules consist of a wooden console with integrated mobile tablet and a high-end PC as well as a wooden fence for security and comfort in the VR experience (see Figure 6). The first three consoles and fences for the exhibition was built by the SNP, the additional three sets were constructed at ZHdK.
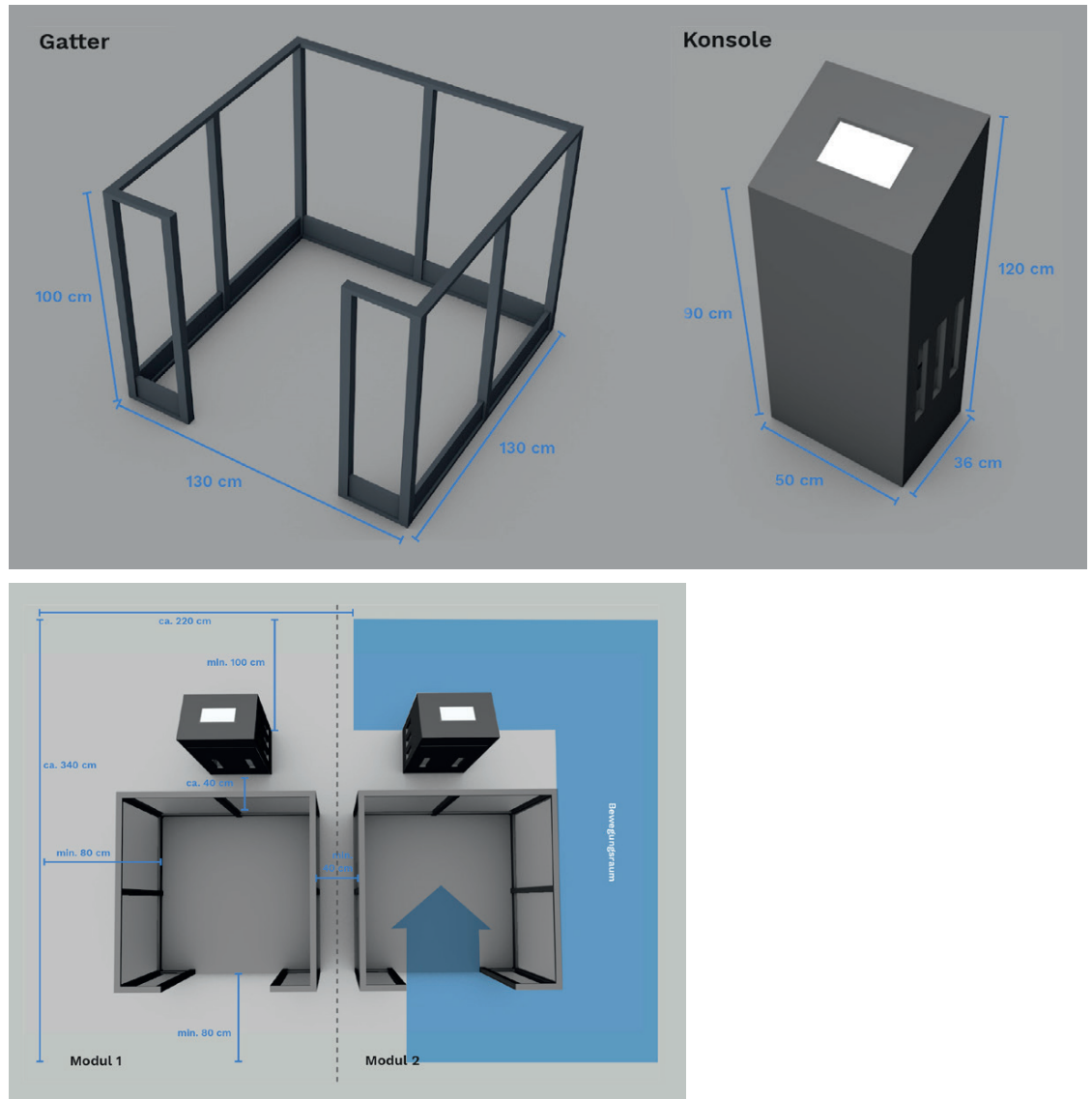
> **Measurable impact: Tablet & VR station**
>
> *Number of running modules: 6*
> *Hours of exposition: ~10'000*
> *Number of Users: ~30'000*

Figure 6 - Furniture used for the VR-Experience: consoles for the mobile tablet and to store electronic hardware and fence for security.

3.3 Tri-lingual version

The VR-experience that could be developed with the Agora project funding was exclusively in German. Thanks to the huge interest mainly triggered by the media reports, many requests for further appearances have been arriving. However, with a German version, the outreach of the project is restricted to German speaking people only. To be able to also address non-German speakers, and more importantly, to satisfy the second place of exposition at the WNF, different language settings were

needed. Therefore, a request for a supplementary grant was handed in towards Agora and got accepted. This made it possible to produce a French version to address also school classes and the general public from the French part of Switzerland and an English version to attract international guests.

During a few weeks' time the text was translated into French and English, the texts with the same professional speaker as in the German version were recorded, the language versions in VR and tablet (adjusting sound design, set up lip-sync and animations) implemented and the pedagogical material adapted. With a trilingual version of our VR-module it was possible to multiply the outreach of the communication efforts.

> **Measurable impacts: Tri-lingual version**
>
> *German speaking version*
> *French speaking version*
> *English speaking version*

3.4 Website

In addition to the VR exhibition, the website serves as an important communication tool that not only collects and communicated the project content but also documents the project beyond the exhibitions and the project duration.

3.5 Exposition at SNP and WNF

On the 2nd of April 2019, a press event took place at SNP to launch the «Expedition 2 Grad». Various newspaper reporters as well as members of two TV stations were present. After a short introduction, the reporters could observe a school class using the VR Experience as well as participating in the accompanying didactic program. Interviews were given by the whole project team and school children. This event resulted in a broadcast in the evening program of "Tagesschau", which led to broad exposure and further interest in the project.

The exhibition was presented at the National Park Centre in Zernez from 1st of April to end of August 2019. During this period, a total of 33 school classes with altogether 597 scholars visited the workshop, 17 classes from the National Park region (Engadine Valley, Val Müstair, Davos) and 16 from further away. The number of entries into the National Park Centre was significantly higher than in the previous years, whereby the VR-exhibition was one of the major attractions during this period. Some school classes even visited the Centre only for visiting the workshop (school classes usually visit the National Park Centre only if they are from the region of the SNP or if they have a school camp nearby, but not just to visit an exhibition.)

> **Measurable impacts: Exposition at SNP**
>
> *Duration of exposition: April 2019 - August 2019*
> *Number of classes participated: 33*
> *Number of students passing the pedagogical program: 597*
> *Number of regular museum visitors (potentially experiencing the VR): ~8000*

On 13th of September 2019, a press event was held at WNF to announce the start of the exhibition of «Expedition 2 Grad». A school class testing the exhibition was there and local media (newspaper and a TV station) were present to report.

Figure 7 – John Tyndall, acting as storyteller and guide.

Figure 8 – Choosing the climate scenario according to the personal climate score.

Figure 9 – Views on Aletsch glacier in VR from the four different standpoints: (left to right) Belalp, Bettmerhorn, Strahlhorn and Konkordiahütte.

The exhibition is present at WNF since 10th September 2019. From September 2019 to February a total of 22 school classes with 440 pupils attended the workshop, 17 classes from the World Heritage communities (Naters, Lötschental, Reichenbach i.K.) and 5 from more distant regions. The number of admissions to the WNF was significantly higher than in previous years, with the VR exhibition being one of the main attractions during this period. The exhibition can still be admired at WNF until the end of 2020. Whereby new school classes have already registered again.

As part of the open day at WNF (Welterbetag) on 22th September, representatives from UniFR and ZHdK were also present to discuss with the public. In the morning and afternoon, a talk was given about causes and consequenses of climate change, the scientific and artistic background of «Expedition 2 Grad».

On 6th November the Pädagogische Hochschule Wallis (PHVS) invited to the WNF where the "Mittwoch.Forum" (a forum for exchange and pedagogical discussion of PHVS-employees and teachers) was held to discuss concepts of sustainable education in museums. The «Expedition 2 Grad» was used as an example and explained by scientific project staff of UniFr.

2.4.2019-31.8.2019	**SNP Visitor centre Nationalpark,** Zernez (see Figure 11) *http://www.expedition2grad.ch/?p=342* visitors: 8000
10.9.2019-31.12.2020	**WNF Visitor centre World Nature Forum,** Naters & Jungfrau-Aletsch (see Figure 10) *https://www.jungfraualetsch.ch/de/2grad/* visitors: 15'000
30.8.2019-1.9.2019	**Scientifica,** Zürcher Wissenschaftstage (see Figure 14) *https://www.scientifica.ch/ausstellung/natur-technik/* *Gletscher-als-Fieberthermometer-des-Klimawandels/* users: 350 (many uncounted visitors)
3.9.19	**Digitaltag Schweiz,** HB Zürich (see Figure 13) *https://www.digitaltag.swiss/* users: 100 (many uncounted visitors)
6.9.-7.9.19	**Jugend Kultur Festival,** JKF Basel (see Figure 12) *https://www.jkf.ch/de/infos#infos-jkf-2019* users: 150 (many uncounted visitors)
20.9.2019-16.2.2020	**Museum für Gestaltung Zürich,** Sonderausstellung «Wissen in Bildern» https://museum-gestaltung.ch/en/ausstellung/ wissen-in-bildern-informationsdesign-heute/ visitors: 10'000
23.10.19	**ETH-Klimarunde** https://c2sm.ethz.ch/events/eth-klimarunde-2019.html users: 50 (many uncounted visitors)
27.11.19	**BAFU-Kadertagung** zum Thema «Digitalisierung» (see Figure. 15) users: 20
28.11.19	**Tag der Forschung, ZHdK** https://www.zhdk.ch/forschung/tag-der-forschung users: 30

Figure 10 – Opening at the visitor center of World Nature Forum, Naters. (13.9.2019)

Figure 11 – Opening at the visior center of the Swiss National Parc, Zernez. (2.4.2019)

Figure 12 – Jugendkulturfestival (7.9.2019) Basel.

Figure 13
– Digialtag (3.9.2019) in the main hall at Hauptbahnhof Zürich.

Figure 14
– Scientifica (1.9.2019) In the Lichthof of the main building at University of Zürich.

Figure 15
BAFU-Kadertagung (27.11.2019) at Deltapark in Thun.

3.6 Places and occasions to showcase the «Expedition 2 Grad»

Beside showcasing at SNP and WNF the two project-partner, the «Expedition 2 Grad» was also showcased at different other locations and occasions (see Table 1). This was possible, because the number of running stations has been increased from three to six.

Scientifica, Digitaltag, and Jugend Kultur Festival were three large public events where the «Expedition 2 Grad» was present as at a market stand with two stations. The VR-experience was an outstanding attraction and the people have been queuing to experience themselves the retreat of Aletsch glacier in VR. To explain it to all visitors (also those not wearing the glasses) and to multiply the number of visitors, the «Expedition 2 Grad» one VR-glass was connected to a screen. There everybody could follow (in 2D) the user experience. All the stations have been running during the entire time (without bigger problems). During these events it was easy for the scientists and project staff to get in contact with the public and to start a dialogue.

One module was present in the "Museum für Gestaltung" Zürich for its special exhibition "Wissen in Bildern". The exhibition presented information design in printed and moving images and made immaterial knowledge playfully experienceable through interactive installations. The museum was very happy with the total number of 14'500 visitors as well as with feedback from press and school classes.

The presence at Scientifica was responsible for the invitation to present the «Expedition 2 Grad» at the ETH-Klimarunde and the BAFU-Kadertagung. The audience at the ETH-Klimarunde consisted of scientists, politicians, journalists and students that discussed and presented insights about different topics related to climate change. The «Expedition 2 Grad» was a nice attraction completing the thematic posters and related table discussions. In addition, the project staff easily could enter into dialogue with the public. The dialogue how VR can be used to engage people for climate change was the main point for the invitation to the BAFU-Kadertagung. The BAFU management was at a two-day retreat under the topic "Digitalisation" and reviewing different digital media. The «Expedition 2 Grad» was one of the about eight projects that were presented.

The «Expedition 2 Grad» was also invited by EDA and MeteoSwiss to be present at the COP 25 in December 2019 in Santiago de Chile. Due to the realization of the Tri-Lingual version, the VR-experience was planned to be showcased in the Swiss pavilion in the green zone of the COP. Everything was planned and the VR-experience could have been supported and maintained by local people (related to Universities), but unfortunately the COP 25 in Chile was cancelled. https://unfccc.int/cop25

The Verkehrshaus Luzern has approached the project team, about the data used to build the 3D-virtual world and retreat of Aletsch glacier. In the new planetarium show "mission earth" there is a scene where the retreat of Aletsch glacier under global warming is shown. This scene is based on the results from «Expedition 2 Grad».

https://www.verkehrshaus.ch/besuchen/planetarium/shows/detail/shows/show/mission-erde.html

Due to the COVID-pandemic several events had to reorganize their program. Some events were postponed by one year. The presentation of the «Expedition 2 Grad» for the following events is therefore still in preparation:

- Cumulus Design Conference in Rome 2020. Due to Covid-19, the conference has been postponed to June 2021; https://cumulusroma2020.org/
- Bergfahrt Festival Bergün 2020, www.bergfahrtfestival.ch; postponed to 4. – 6. Juni 2021

3.7 Pedagogical program for school classes

The team of the SNP in Zernez designed an accompanying pedagogical program for school classes. During a 2-hours workshop, simultaneously to the VR-experience, pupils had the opportunity to discover a broader overview on the causes, effects and dependencies of climate change – in Switzerland and elsewhere. Therefore, individual tasks were designed along the three major subjects: causes, consequences and mitigation of climate change. For each subject, worksheets were prepared meeting different knowledge or school levels. An additional thematic input was given by the decoration of the classroom with different statements of climate change critics and a poster depicting possible ways of action. With this wide range of tasks and themes, it was intended to treat the pupils as individually as possible. A key point was the final discussion guided by experts from the SNP-team. It aimed to show the participants different ways of action and to motivate them to take responsibility for an own contribution in solving the climate problem. It was, however, very important that the pupils should not leave with a guilty conscience, but should get aware that an individual can inspire others by own actions, that one can find alternative solutions with like-minded people and that collectively organized, one can influence politicians and decision-makers.

The collaborators from the WNF were allowed to adopt the educational material developed by the SNP and adapt it to their region. As mentioned above, the individual tasks were designed along three main themes: Causes, consequences and mitigation of climate change, with a link to the Alps and in particular to the region to the UNESCO World Heritage Swiss Alps Jungfrau-Aletsch where appropriate. The questions about the causes were adopted. The questions about the consequences were revised and adapted to the general exhibition in the WNF. The focus here was mainly on the permafrost at the Eggishorn or the problem of the Moosfluh. The mitigation of climate change was also adopted by the SNP.

3.8 Evaluation

Results are described with a particular focus on specific variables (see chapter 2.4.1).

**Perceived severity and probability of consequences
of climate change depending on program participation:**
A repeated measures ANOVA revealed significant differences on perceived probability of undesired consequences due to program participation (within subject factor: test-time (pre-test; post-test, follow up); Greenhouse-Geisser $F(1.804, 149.753)=4.891$, $p<0.05$[8]). Post hoc analyses show, that the increase of means from pre- to post-test is significant ($F(1,83)=6.027$, $p<0.01$, eta2=0.089).

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8   The values are Greenhouse-Geisser corrected because sphericity cannot be assumed.

Figure 16 – Means of perceived probability of undesired consequences of climate change scale at different test-times. Values can range from 1=lowest perceived probability to 6=highest perceived probability. Note: Y-axis is cut at values 4 and 5.6. Error bars indicate 95% confidence intervals. Significant differences of means are tagged.
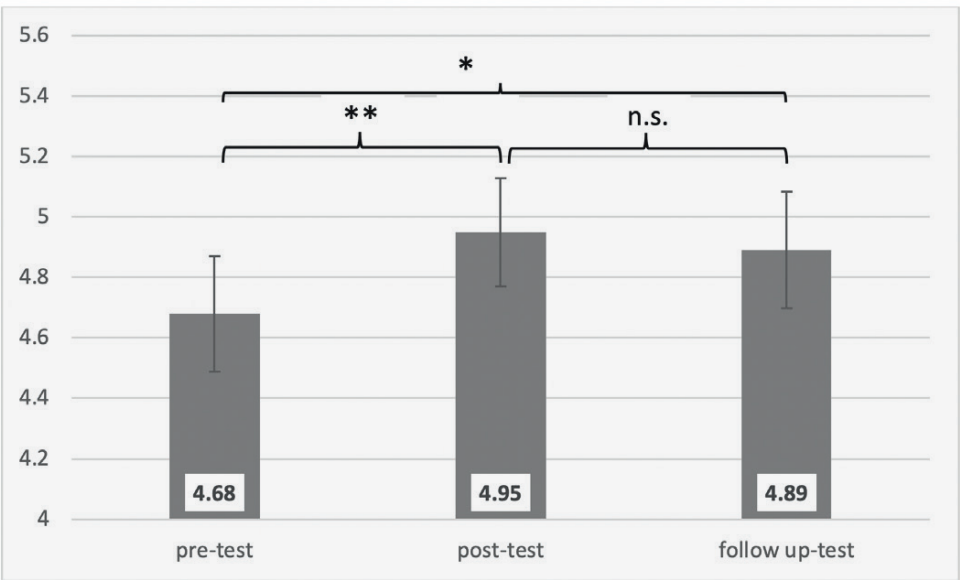

Figure 17 – Means of perceived severity of climate change scale at different test-times. Values can range from 1=lowest perceived impact to 6=highest perceived impact. Note: Y-axis is cut at values 4 and 5.6. Error bars indicate 95% confidence intervals. Significant differences of means are tagged.
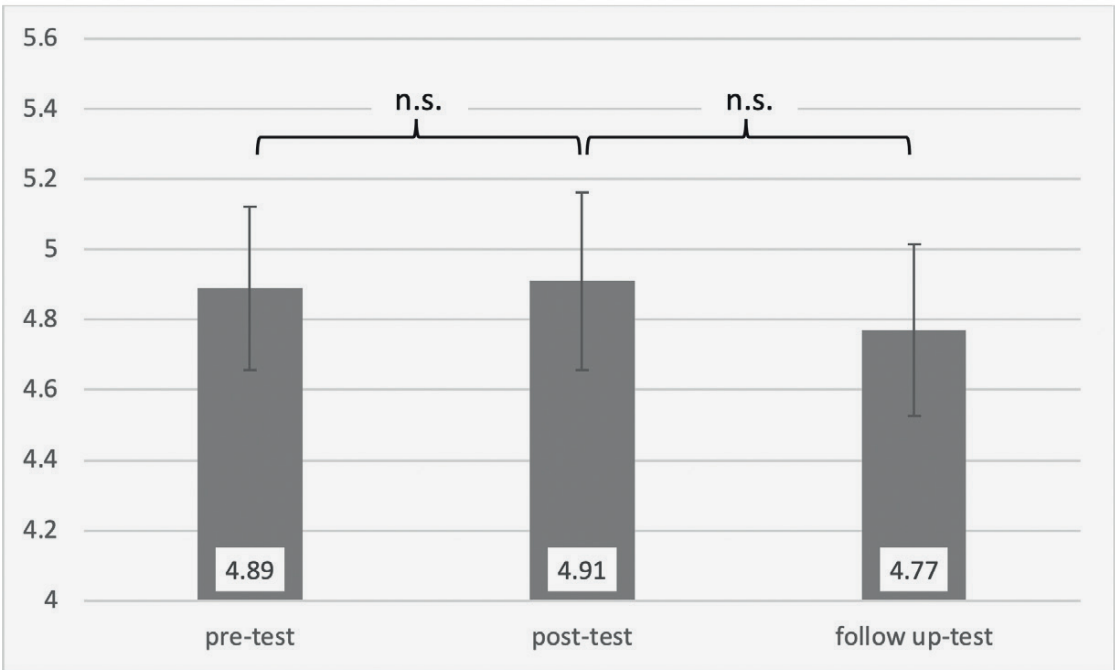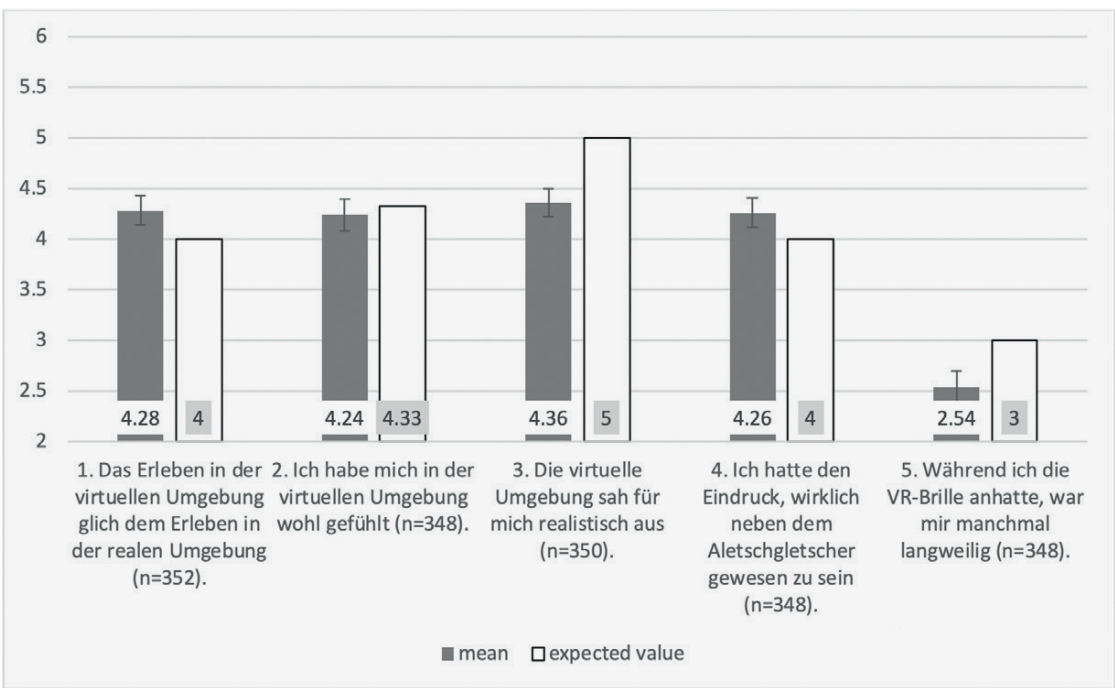

Figure 18 – Mean ratings of VR-experience (post-test). Grey bars represent actual empirical means by participants. White bars indicate developer's expectations for good values (n=3). Note: Y-axis is cut at value 2. Error bars indicate 95% confidence intervals.

Contrary, there is no significant difference between post-test and follow up test values ($F_{(1, 83)}=0.597$, p=n.s.). Thus, values does not decrease four weeks after program participation (see Figure 16). Accordingly, there is statistical evidence that the educational program «Expedition 2 Grad» had a significant impact on participant's perception of perceived consequences of climate change and in consequence, there is a higher probability of motive building (to act in climate friendly manner). The null hypothesis, that there is no influence of program participation on perception of the probability of negative consequences thus could be rejected.

For perceived severity of consequences there are no significant changes in values (Greenhouse-Geisser $F_{(1.653, 128.937)}=0.804$, p=n.s., see Figure 17)[9]. The non-significant result could mainly be due to perception on severity of climate change, where very high means are found on pre-, post- and follow up-test.

As a conclusion it can be said that participants hold favourable views for motive building (act in a climate friendly manner), even before program participation. Participation on the pedagogical program combined with the VR-experience seems suitable to affect their perception concerning some negative consequences connected to climate change, but not their perception of severity. The results thus indicate that due to program participation motivation is impacted in a way that motive building (to act in a climate friendly manner) is more likely.

**Rating of visual elements
during VR-experience (post-test):**

Ratings of VR-experience and helpfulness are only measured once, shortly after participation. As a benchmark, three developers of the project express their expectations on what good rating values would be. For comparison with empirical values expert ratings were averaged. Big differences could indicate optimization potential.

For the VR-experience the participants are less bored than expectations (see Figure 18). In addition, the appearance of the VR-setting was rated less realistic than expected. Other measures were quite close to expectations. To meet developers' expectations, there seems especially potential for a more realistic appearance of the VR-setting.

Questions 1, 3 and 4 are highly correlated (r ranging from 0.482 to 0.656). However, questions 2 and 5 are not correlated at all (r=0.035 among each other; boringness correlates slightly negative and good feeling slightly positive with VR experience), indicating that "boringness" and "good feeling" are independent emotions during the projects VR parts.

Figure 19 shows participants ratings of the helpfulness of specific graphical elements. Rated as the most helpful to support understanding passing of time was the glacier movement, followed by the spoken language of Tyndall and the display of the actual year. Perceived as less helpful were the elements of Tyndall's appearance and cloud movements. The difference to expectations was especially salient for Tyndall's appearance, it seems that this salient feature does not support understanding of time passing as hoped by developers. The same applies for the spoken language by Tyndall, but in less salient way. The opposite was true for glacier movements and written years. By developer's expectations and participants perceptions, cloud movement was rated least helpful.

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9   There are 79 datasets with data from all three test-times. If calculated by repeated measures t-test (comparison of two test-times), there is a significant difference for pre- post-test comparison (p<0.05) with higher n, indicating a short-term program participation effect. However, the effect is very small (d=0.15) and there is no long-term difference, even with higher n.

Figure 19 – Mean "helpfulness of visual elements" during VR experience to understand passing of time (post-test). Grey bars represent actual empirical means by participants. White bars indicate developer's expectations for good values (n=3). Note: Y-axis is cut at value 2. Error bars indicate 95% confidence intervals.
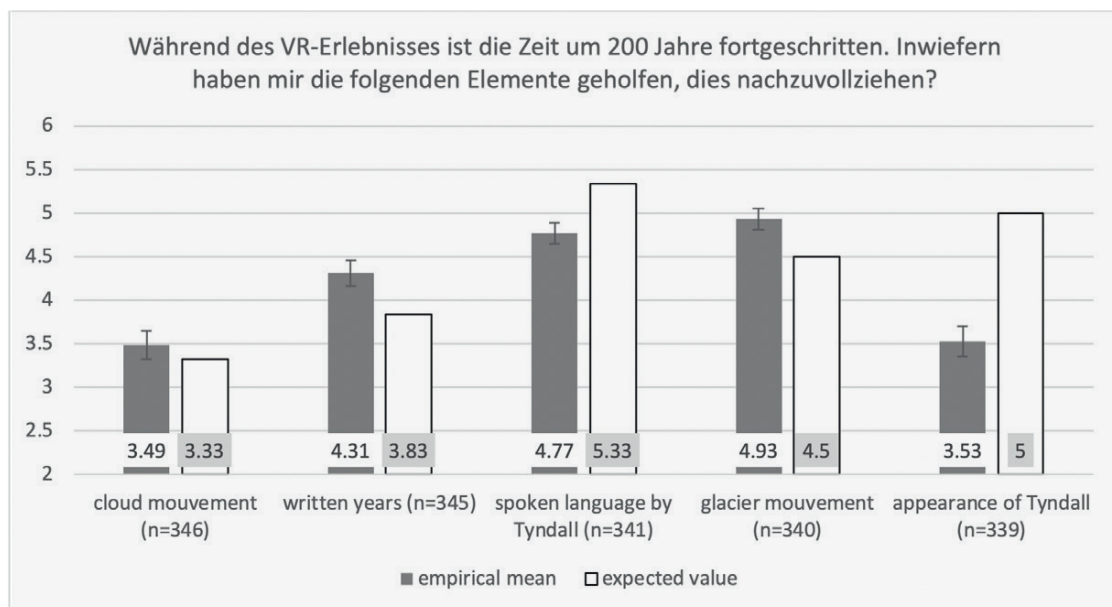

Figure 20 – Recommendation to others. Numbers indicate persons per category (n=341, no answer=13).
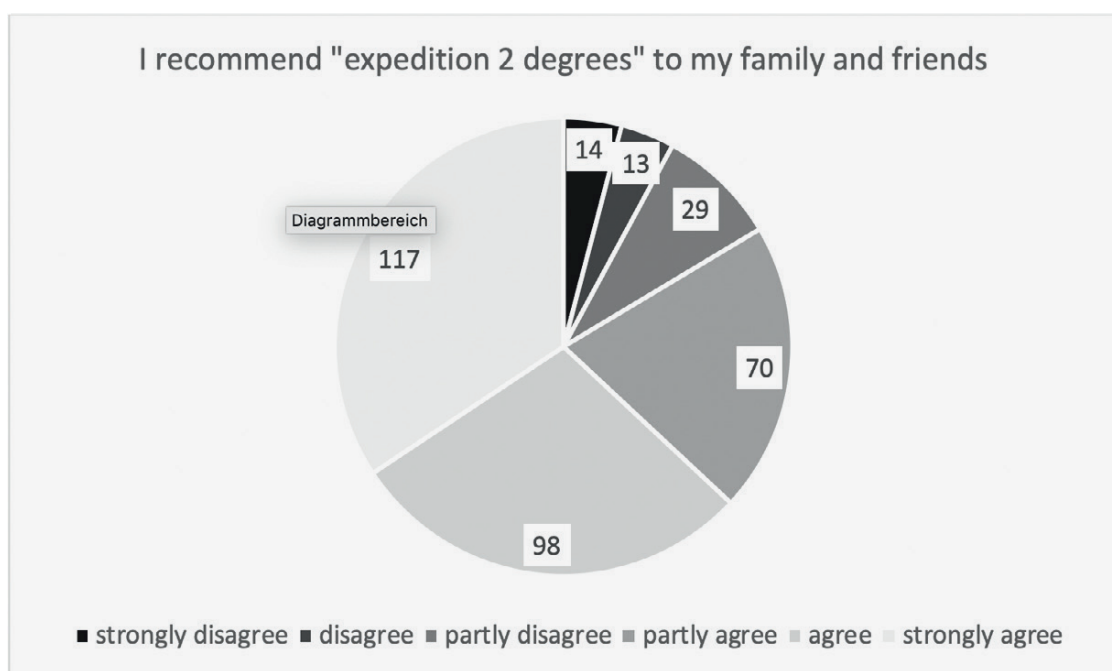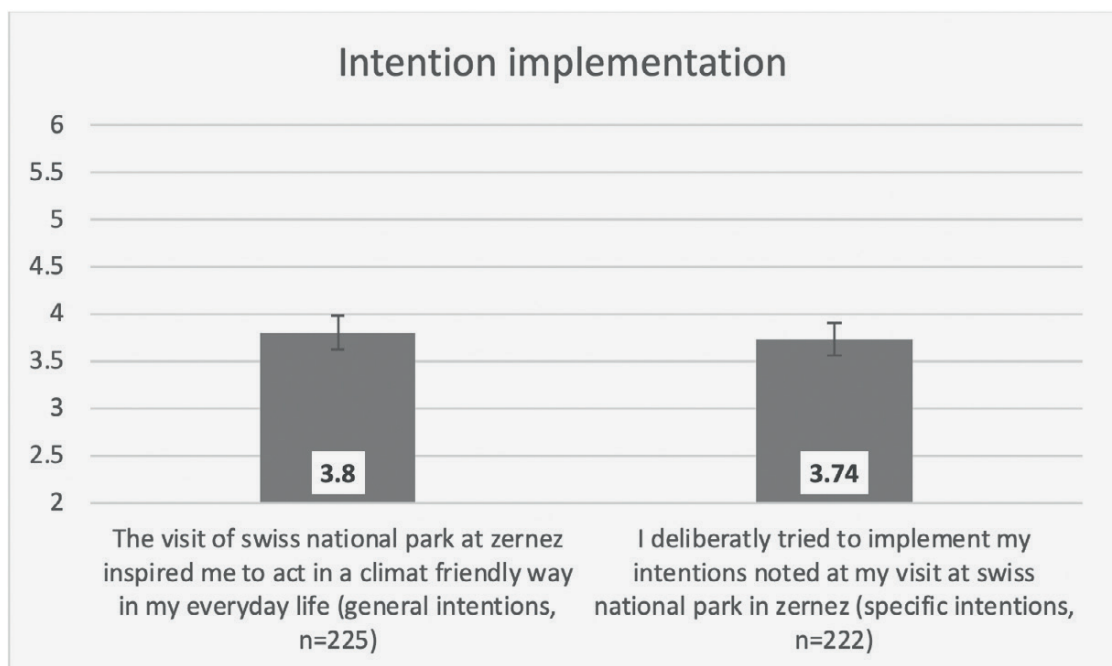

Figure 21 –Means for intention implementation at follow up-test (4 weeks after program participation). Values range form 1=strongly disagree to 6=strongly agree. Note: Y-axis is cutted at value 2. Error bars indicate 95% confidence intervals.

Program recommendation (post-test)

The results show, that the program achieve high recommendation ratings, 63% of participants strongly agree or agree with the proposition, only 8% disagree or strongly disagree.

This meets with one developer's expectation (empirical mean=4.69; expectation=4.75; participants with high agreement empirical=63%, expectation=60%). A second answering developer expresses very high expectations to recommendation: this person wants a maximum recommendation of 6 (strongly agree with 100%). To reach that, there is more work to do.

**Implementation of intentions due
to program participation (follow up)**

Results concerning retrospective judgments on implementation of intentions are displayed in Figure 21 (specific intentions on the right, general intentions to act in a climate friendly manner on the left).

Implementation of general and specific intentions do not differ (t(121)=1.011, p=n.s.) and are highly correlated (r=0.633). Results show, that for both questions ~a third of participants agree or strongly agree with propositions (32.6% resp. 27.8%), e.g. tried to implement intentions because of the program participation. About half of the participants only partly agree or disagree (49.1% resp. 53.9%). Only a minority was not affected by the visit concerning their behaviour (disagree or strongly disagree; 16.4% resp. 15.3%).

Results show that both general and specific intentions are correlated with measures of perceived probability of undesired consequences of climate change at post and follow up test (r ranging from 0.231 to 0.431), but not at pre-test and with perceived severity. This means that there is some evidence, that especially participants with increasing values in perceived probability of consequences after program participation are more likely to implement climate friendly actions.

As a conclusion, it seems that most participants were influenced in their everyday behaviour due to their participation in «Expedition 2 Grad».

> *Measurable impact: Evaluation*
>
> *Scholars attending at pedagogical program participating at the evaluation: at least 354*
>
> *Significant increase in some motivational factors due to program participation (p<0.05, medium effect size).*
>
> *Two thirds of participants recommend or highly recommend participation at expedition 2 degrees to family and friends.*

4 Deviations from project plan

In the initial project proposal, we planned with four months exhibition time (two months at SNP and WNF each) with three stations. Soon after starting the exhibition at SNP, it was obvious that the attention and demand are much higher and the «Expedition 2 Grad» has the potential to be showcased longer and also at different places and occasions. First, we extended the exhibition times in the partner museum. SNP hosted the «Expedition 2 Grad» during four months and the hosting time at WNF is foreseen to be 16 months. To be able to showcase the «Expedition 2 Grad» independent from the three stations running in the museums, three more stations could be acquired.

Due to the strong interest, it was possible to showcase the project product at many more places and occasions than initially planned and foreseen. This strong demand was highly gratifying, but on the other hand also demanding. For every occasion, the logistics and resources had to be planned. This was very challenging for the project staff. However, every place was also an opportunity to enter into dialogue with the public.

Already during the first year, in the development phase, we agreed that the pedagogical content will not be prepared by the PHGR. Instead the SNP took over this task, as they could allocated the necessary resources and could tailor it exactly to the needs of the workshops with the classes they had to supervise. This was taken into account with a small budget shift: 5000 CHF allocated for preparing the pedagogical program during the first year, was shifted from PHGR to SNP.

5 Commercial impacts

The high attendance of «Expedition 2 Grad» led to many requests to showcase the VR-experience. Whenever possible from the budget, the expenses for transport, logistics, renting, maintaining and supporting have been billed. With some of the money, the additional three stations have been acquired. The WNF asked to keep the VR-modules in its museum longer than the duration of the Agora project. Therefore, we agreed on a small rent, which covered the maintenance costs for the prolongation of the exhibition and the deficit having arisen at the beginning of 2020 when a student was engaged for 10% to manage questions about renting and possible future exposition places of the «Expedition 2 Grad». However, due to the COVID-pandemic, the demand has collapsed and the future of the «Expedition 2 Grad» is still open.

6 Output data

6.1 Media relations

The media event, taking place on the 2nd of April 2019 at the Swiss National Park to launch the «Expedition 2 Grad», generated a brought and diverse media echo in many newspapers, on websites, at radio and TV stations. In the output data the most important and elaborated media contributions are listed. However, not every news contribution on all the different webpages could be recorded. The same is true for the opening event and the open day (Welterbetag) taking place in September 2019, to launch the VR-experience in the World Nature Forum in Naters. Some articles are listed, but not every website where the «Expedition 2 Grad» was mentioned.

Measurable impacts: Media relations

Number of contribution in radio and television: 7-10
Number of contribution in print and online media: 40-50

6.2 Pedagogical program

Both partner museum prepared pedagogical material for the accompanying workshops for the classes visiting the VR-experience. The documentation of all the material resulting at the Swiss national Park, the first exhibition location of the «Expedition 2 Grad» can be accessed under the following link:
https://drive.switch.ch/index.php/s/giI7JlPQ1CqdAQ4

Measurable impacts: Pedagogical program

Number of documents produced for operating the pedagogical program: 35
Number of different students exercise sheets: 9

6.3 Data for evaluation

For evaluation, data was gathered before, direct after program participation and with a delay of four weeks (see chapter 2.4). The online-questionnaires were accessible via QR-codes (which are no longer valid). An image of these questionnaires can be downloaded under the following link:
https://drive.switch.ch/index.php/s/AGXOx59R2jqkJyc

To match individual data for evaluation, some personal data (e.g. age, teachers name) was collected and cannot be made public available, as it cannot completely be anonymised. Upon request, the data can be made available.

7 Contributions of the project partners

7.1 University of Fribourg (UniFR)

The project main applicant was Prof. Dr. Martin Hoelzle from the Department of Geoscience at the University of Fribourg. The project management and project lead was in the hands of Dr. Andreas Linsbauer, employed at the Department of Geoscience at the University of Fribourg. He was also responsible for the elaboration of major parts of the proposal and the coordinating the different project partner's contributions. The staff employed at the University of Fribourg was responsible to compile the scientific data (Dr. Martin Scherler) and to develop and construct the storyline (Dr. Bruno Meeus).

7.2 Zurich University of the Arts (ZHdK)

The project Co-applicant was the Subject Area Knowledge Visualization, Zurich University of the Arts (ZHdK) under the lead of Prof. Niklaus Heeb. At ZHdK all the works for building the virtual reality, the soft- and hardware components necessary for the VR-experience and the website have been set up. The main staff at ZHdK was Jonas Christen developing the overall scenery, Reto Spörri creating important parts of the necessary software and Noemi Chow helping to establish a realistic environment within the VR-experience.

7.3 Pädagogische Hochschule Graubünden (PHGR)

Dr Felix Keller enabled the contact to the «Abteilung Forschung, Entwicklung und Dienstleistungen» at Pädagogische Hochschule Graubünden (PHGR). Dr. Andreas Imhof from the PHGR was responsible for all steps of the evaluation.

7.4 Stiftung Schweizerischer Nationalpark (SNP)

Andrea Millhäusler and Hans Lozza from the Schweizerischen Nationalpark (SNP) were responsible for the exhibition of the «Expedition 2 Grad» at their visitor centre. Hans Lozza organised the opening event. Together with two colleagues Anna Mathis and Stefan Triebs, Andrea Millhäusler was responsible to develop and set up the supporting pedagogical program of the «Expedition 2 Grad» and she was responsible for the class workshops. Flavio Cahenzli built the first version of the furniture and was responsible for maintenance.

7.5 World Nature Forum (WNF) UNESCO World Heritage Swiss Alps Jungfrau

Janique Gattlen and Alessandra Lochmatter were responsible for the exhibition of the «Expedition 2 Grad» at their visitor center. Hans Christian Leiggener and Barbara Mäder organized the venue and the press information. Alessandra Lochmatter and Janosh Hugi adopted the pedagogical material to the needs of the WNF.

7.6 University of Zürich (UZH)

In 2018, Dr. Andreas Linsbauer started a new job at the Department of Geography at the University of Zurich. Thereby, he needed no employment on SNF money to work for the project, but he could work under the new position at the University of Zurich for the project. The University of Zurich is therefore also allocated as partner institution.

7.7 Contribution by SNSF collaborators

The following staff has been employed on SNSF project money. The Contribution made by these people is explained in the following.

7.7.1 Jonas Christen (ZHdK)

Responsible for coordinating the design team's effort with the scientific counterparts. Developing an overall look as well as modelling parts of the environment and animating the tablet info-movie. Working on technical and interaction concept in close collaboration with the rest of the team from ZHdK.

7.7.2 Reto Spöerri (ZHdK)

Development of the software and integration of all content of the project. Definition of technical and structural requirements for the content production and hardware environment. Release and maintenance of the software.

7.7.3 Noemi Chow (ZHdK)

Development of all graphic parts inkluding designing and animating John Tyndall in different time period, designing visual part of the clima quizz, designing all print products; poster, flyer. Development of several 3D assets. Working on overall conept within the design team of ZHdK.

7.7.4 Martin Scherler (UniFR)

His work mainly consisted of extracting, homogenizing and merging terrain model data from different sources for each of the animated years from 1880 to 2100. Further, aerial photographs of glacier forefields were collected representing different stages of glacier retreat. These images were later used to map areas were the glacier retreated between the animation timesteps.

7.7.5 Bruno Meeus (UniFR)

Bruno Meeus was responsible for the construction of the storyline. This construction followed a number of steps:

- Compiling a review of the relevant scientific literature on (1) pitfalls and promises in general climate change communication, (2) critical literature on specifically glacier melt communication across the world, (3) critical literature on

the use of virtual reality for communicating humanitarian and environmental causes with a specific focus on the relation between emotion and agency, (4) critical literature on forms of agency in agency-oriented communication, with a specific focus on modes of agency beyond individual behaviour change. The review was presented to the team-members in the form of a position paper and extensively discussed.

- Exploration of specific resources in the Aletsch region that would be useful as a basis for the construction of a storyline. Therefore the history of tourism in the region was explored, eventually leading to the discovery of the figure of John Tyndall who could form a node between different storyline dimensions: (1) the birth of 19th century upper-class Alpine tourism and specifically the construction of the hotel Belalp which currently has a dedicated Tyndall room, (2) birth of glacier science and atmospheric science and the role of Tyndall in relating these two disciplines, (3) Tyndall as a 19th century British public figure, closely connected to the industrial elites of 19th century Britain and hence directly linked to the main causes of the start of atmospheric pollution on an industrial scale

- Sketching of a general storyline framework connecting the historical evolution of industrial mass production and mass consumption in Europe and related mass burning of coal, gas and oil with the historical evolution of global temperature, an evolution mirrored by the gradual retreat of the Aletsch glacier, and finally offering insights in the different modes of individual and collective agency to tackle this evolution

- Writing of a detailed script for the VR and the iPad communication including instructions for imagery.

8 Conclusion

The overall project can be summarised as very successful. The inter- and trans-disciplinary working environment was extremely motivating for all participating collaborators and the final VR-experience is of outstanding quality resulting in an overwhelming media echo. The main project goals were all achieved by enabling the target group, represented by scholars, to experience changes and impacts of a high mountain cryospheric landscape. The scholars, but also the general public visiting the expositions, were strongly attracted by the VR-experience, which led to the creation of an increased awareness of climate change. The ability to sensitize the younger generation to the impacts of climate change and its relation to the increased CO_2 emissions and the necessity to perform strong actions towards a decarbonised future world can be seen as a great success of the project. The final scientific pedagogical evaluation has supported our research questions at the beginning of the project. The significant impact on the perception of the consequences of climate change and as a resulting outcome the increased motivation of the participants to act more climate friendly was particularly successful. The follow up test with the scholars several weeks after having visited the VR-experience showed that the motivation to act climate friendly did not decrease and therefore seems to have a very sustainable effect. In addition, the exhibition achieved high recommendation ratings, which is confirmed by the evaluation study, where 63% of the participants strongly recommended the VR-experience and only 8% disagreed. In addition, the fact that boringness and good feeling are independent emotions during the VR-experience seems to be interesting.

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