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EduChange Methodology

Jiří Pánek et al.

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EDU CHANGE

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ABOUT THE EDUCHANGE

“Making Knowledge Together – Addressing Climate Change through Innovative Place Based Education and Blended Learning” is the official name of the Erasmus+ Strategic Partnership project, that we (project team members) used to call simply EduChange. The project aimed to innovate our way of teaching about Climate Change in both local and global perspectives via the field course methodology. It brought together students and teachers from four European universities – University of Malta, Utrecht University (the Netherlands), Norwegian University of Science and Technology, Trondheim (Norway), and Palacky University Olomouc (Czechia) with an idea, that teaching and learning in the field is often rather traditional and teacher-led. Through EduChange, we wanted to transform field courses into innovative, creative learning environments in which teachers, students and pupils can create knowledge together. We believe that supporting innovation and creativity can be achieved via international partnerships and inter- and trans-disciplinary approaches.

Our consortium includes partners from various European countries with various geography-related backgrounds (environmental science, geography for teachers, urban geography, geoinformatics, island studies, biology, science teacher education, etc.) but with a common objective to innovate the way we teach about climate change. Our partnerships with local high-schools further strengthened the role of higher education regionally as well as channelled the knowledge from universities towards the public (i.e. with upper secondary school students). The place-based education adopted during the project assumed the creation of knowledge together – connecting scientific perspectives with local knowledge and daily experiences.

The overarching topic was Climate Change education with the focus on the issue of water in the environment. By coming from various geographical and socio-economic environments, our student as well as four university cities experience different issues related to Climate Change and water. Topics can reach from lack of fresh water on Malta via flash floods in Olomouc or extreme precipitation in Trondheim to water management/seawater rise in Utrecht. We strived for practical field courses that stimulate deeper learning.

In the project, we used a student-centred approach and a well-balanced mix of innovative teaching methods for field- and place-based education, such as blended learning or modern playful and multimedia methods. Our students experienced both roles – being students during the field courses and being teachers during their local activities with secondary school students in their home countries. We believe that this mix of roles and experience created the atmosphere where members of the project create knowledge together and experience innovative teaching methods from the teacher’s and the learner’s perspective.

All the teaching materials created during the project by both teachers and students are published online under open licence at the project webpage – www.educhange.net. Our teaching methods include short educational clips (educlips), online multimedia maps (StoryMaps), GeoGames, virtual reality tours, and many more. All of these methods are born of the digital era and are highly valuable supplements to traditional classroom lectures, lab work and group discussions.

The authors of the respective chapters of this book are members/former students of the EduChange team, and it has been my pleasure to work with them for the past three years. Therefore, I take this opportunity to thank all of them for their contributions to this book and all the hard work they gave to the EduChange project.

It is also my pleasant duty to gratefully acknowledge the support by the Erasmus+ project EduChange (no. 2017-1-CZ01-KA203-035519) funded by the European Union. Without this support, this book, nor the whole adventure, would never be alive.

Jiří Pánek

CONTENT

CHAPTER 1: THE KNOWLEDGE BASIS FOR TEACHING CLIMATE CHANGE AND WATER ISSUES VIA PLACE-BASED EDUCATION WITH GEOSPATIAL TECHNOLOGIES....7

CHAPTER 2: DESIGNING EDUCHANGE 19

CHAPTER 3: FIELD COURSES AND THE "EXTENDED CLASSROOM" AN OVERVIEW OF OUTDOOR ACTIVITIES IN THE EDUCHANGE PROGRAMME....25

CHAPTER 4: TECHNOLOGY AND GAMIFICATION DURING THE EDUCHANGE PROJECT 44

CHAPTER 5: TRANSFORMATIVE PEDAGOGIES - A USEFUL THEORETICAL FRAMEWORK FOR PROMOTING ESD....56

CHAPTER 6: ASSESSMENT AND ESD – WHICH WAY FORWARD? 63

CHAPTER 7: POSTERS AS A LEARNING METHOD TO PROMOTE EDUCATIONAL RESEARCH LITERACY A CASE STUDY OF STUDENTS WORKING WITH CLIMATE CHANGE ISSUES: CREATING POSTERS.... 72

CHAPTER 8: CLIMATE DATA SOURCES FROM A GEOSPATIAL PERSPECTIVE 82

CHAPTER 9: PHOTO STORIES – EFFECTIVENESS THROUGH COLLABORATIVE IMAGE CREATION....99

CHAPTER 10: HOW TO DESIGN AND CONDUCT FIELDWORK LESSONS WITH LOW-COST VR.... 109

CHAPTER 11: PLACE-BASED EDUCATION IN AN INTERNATIONAL ENVIRONMENT: REFLECTIONS ON PARTICIPATING IN THE 2019 EDUCHANGE PROJECT FROM A STUDENT PERSPECTIVE 118

CHAPTER 12: MAKING SENSE OF INTERNATIONAL EXPERIENCES – THE VALUE OF REFLECTION 128

CHAPTER 13: THE EFFECTIVENESS OF THE EDUCHANGE PROJECT IN DEVELOPING KNOWLEDGE, VALUES AND ATTITUDES ABOUT CLIMATE CHANGE 138

CHAPTER 1: THE KNOWLEDGE BASIS FOR TEACHING CLIMATE CHANGE AND WATER ISSUES VIA PLACE-BASED EDUCATION WITH GEOSPATIAL TECHNOLOGIES

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Abstract

Climate change adaptation is a telling example of a wicked problem (Favier, Van Gorp, Cyvin & Cyvin, 2021). Pre-service teachers face the challenge of teaching this wicked problem to their students. Place-based education offers teachers the possibility to let their students study the effects of climate change and possible adaptation measures in their local environment. Geospatial technologies, as survey apps, storymaps, excursion apps and virtual reality (VR) can be used to let students explore the effects of, and possibilities for, adaptation to climate change in their living environment and other places. However, in order to design high quality education, (future) teachers need to have an extensive knowledge basis. They need to have knowledge in the fields of Technology (T), Pedagogy (P), and Content (C), *and* knowledge at the interplay of these fields. The TPCK framework (Mishra & Koehler, 2006) describes the different types of knowledge that (pre-service) teachers need.

According to the literature, the knowledge can be transferred to (future) teachers in courses, but it is more effective to let (pre-service) teachers actively transform their content knowledge so that it becomes accessible for students; engage in designing, conducting and evaluating tasks; share their outcomes with fellow (future) teachers; and reflect on what was learned. These activities were the core of the EduChange course. This chapter describes the TPCK framework into more detail, and describes how the different activities of the EduChange program contribute to the development of the knowledge basis of (pre-service) teachers.

EduChange

In 2017, lecturers and teacher trainers from universities in Malta, Olomouc (Czech Republic), Trondheim (Norway) and Utrecht (Netherlands) joined forces in the form of an Erasmus+ partnership to improve climate change education. Together, they designed a course called 'EduChange' for students in geography education, science education and environmental education at the four universities. We wanted to equip the pre-service teachers with knowledge, skills and attitudes needed of design and conduct innovative lessons about climate change.

The need for innovative climate change education

The widespread attention for Climate Change Education is legitimized by the role of young people as future consumers, decision makers, policy makers, change agents (see for example Israel, 2012; Feja et al. 2019, Hoffman 2019, Kuthe et al. 2019). In order to avoid catastrophic climate change, it is necessary to considerably reduce carbon emissions. Radical changes are needed in the way we produce and consume energy, food and other products to make sure global temperatures do not rise more than 2°C. Also, changes are necessary in the way we travel and build our homes. This requires individual change towards sustainable behaviour, as well as systemic change. However, besides reducing global warming via mitigation, IPPC (2017) argues that adaptation is also needed to reduce the impact of climate change.

To contribute to sustainable change, people need to become fully aware of the enhanced greenhouse effect, and the causes, effects and solutions of climate change. Also, they need to feel the urgency of the issue, and feel the agency to contribute to mitigation and adaptation. However, climate change mitigation and adaptation is often seen as a wicked problem (Favier, Van Gorp, Cyvin & Cyvin, 2021): It is a complex issue which includes natural, technical, economical, societal, political and psychological dimensions. There are many stakeholders, with often conflicting interests. Also, there are multiple solutions, but they are not 'true' or 'false', but rather 'good' or 'bad' – depending on the perspective. This leads to controversies about what should be done. Not only should people understand the wickedness, they should also have the competences to contribute to solving the wicked problem. This requires, among others, a fundamental change of self-understanding of our role and our attitudes and practices towards the environment.

Several authors have called for innovation in teaching socio-scientific issues (Aikenhead 2011). Teaching and learning about climate change often focuses on the development of knowledge about the causes and mechanisms of climate change. Less attention is paid to the local effects and strategies for mitigation and adaptation. As a result, young people perceive climate change as something abstract and distant (Bosschaart, 2019). It is therefore important to focus on visible effects of climate change. In the EduChange project, we decided to focus on water issues, as they are very suitable to make climate change concrete. Heavy rains and droughts can be observed directly, and so can flood protection and water retainment measures. Also, water issues directly affect the daily lives of citizens.

Climate change education is often rather 'traditional': teachers provide knowledge, and schoolbooks present a fixed future (Pauw & Beneker, 2015). As a result, students may not feel that they can be agents of change. When teaching complex topics such as climate change, it is important to do this in a way that it engages students in dialogues, discussions and debates. An activist pedagogy can empower students to critically examine their beliefs, values, and knowledge with the goal of developing a reflective knowledge base, an appreciation for multiple perspectives, and a sense of critical consciousness and agency (Ukpokodu, 2009). Chapter 5 discusses how theories about transformative pedagogies can be used in Education for Sustainable Development.

Monroe et al. (2019) and Bosschaart (2019) argue that it is important to bring climate change close to students. Teachers should try to make climate change personally relevant for them. Climate change education should therefore focus on the effects of climate change in the living environment of students, and focus on effects that can already be noticed: fieldwork and place-based education can contribute to this.

Fieldwork encompasses "*any component of the curriculum that involves leaving the classroom and learning through first-hand experience*" (Boyle et al. 2007; p. 300). Fieldwork has many benefits for learning about issues in the local environment (France & Haigh 2018). It contributes to learning by connecting theory with the real geographical world outside, especially when cognitive processes are connected with affective processes (Oost et al., 2013). Furthermore, fieldwork can create opportunities to train professional and social skills of students (Dillon 2006; Dunphy & Spellman 2009; Nundy 2001; Scott, Fuller & Gaskin, 2006). Place-based education moves beyond making theory from the schoolbooks concrete in the surroundings of the schools. It uses the local community and environment as reference for teaching instead. Place-based education recognizes the importance of local knowledge and uses experiences of students for learning. It connects the school with the local community, and aims to create critical active citizens (Sobel, 2005; Gruenewald, 2003; Smith, 2002). Place-based education, according to Davies (2014, p. 65) offers promising opportunities for effective climate change education because it can "*use place as a medium; and connect that place to emotional and social meanings through messages about localized impacts of climate change*". Moreover, Place-based education can give students a sense of agency. By engaging in local action, they learn how to solve environmental and social issues (McInerney et al. 2011).

Innovative *geospatial technologies (GST)* such as storymaps, virtual reality, survey apps, excursion apps offer many possibilities for studying climate change and water issues in the classroom and in the field. Storymaps provide access to spatial data such as digital maps of the effects of climate change on global to local scales, and allow students to interact with these maps. Climate data collected in the Copernicus programme, by NOAA and by NASA offers many posibilities for use in secondary education. But in order to use this data, students should have basic understanding how this data is collected. Chapter 8 provides a general framework of information workflows from collection of geo-data to analysis and visual presentation, and Chapter 4 discusses how GST can be used in education.

With virtual reality, students can visit fieldwork sites without leaving the classroom. They can study 360-degree photos of places where the effects of climate change are visible or where adaptation measures are conducted. Survey apps can be used to collect data about climate and water in the field. The data is automatically combined and visualised in digital maps. Finally, students can use an excursion app to follow a route in the field. There are also more complex geospatial technologies, such as webGIS and desktop GIS that allow the user to manipulate, visualize and analyze climate data by applying tools.

The required teacher knowledge basis

Designing lessons about climate change adaptation via place-based education with geospatial technologies requires an extensive knowledge basis. Following Shulman's (1986) PCK framework, (future) teachers need *Pedagogical Knowledge (PK)*, which also includes knowledge about how to design and conduct lessons in general. Besides this, they need *Content Knowledge (CK)*, also called *Subject Matter Knowledge (SMK)* about climate change and water issues. However, as Shulman argued, teachers also need a specific kind of knowledge at the interplay of Pedagogy and Content. This knowledge is called *Pedagogical Content Knowledge (PCK, Figure 1).*
The PCK framework has been refined in the past few decades, but common ground between all definitions in the literature is that it includes knowledge about how to transform specific content so that it can be used in educational settings; knowledge about strategies for teaching this content; and knowledge about how students learn (Fernandez, 2014; Van Driel, Verloop, & De Vos, 1998). Magnusson et al. (1999) identified five components of PCK. For teaching climate change and water issues via placed-based education, these components are: ("orientation") awareness of one's own beliefs about the purposes and goals of teaching about climate change and water issues; ("curriculum") knowledge about the position of climate change and water issues in the curriculum; ("students' thinking") knowledge about students' preconceptions and attitudes towards local climate change and water issues; ("didactic strategies") knowledge about how to transform knowledge about local climate change and water issues so that it becomes accessible for students, how to design tasks, and how students learn when they work on these tasks; and ("assessment") knowledge about how to assess students' progression in knowledge about climate change and water issues. With these five components in mind, the EduChange program was designed.

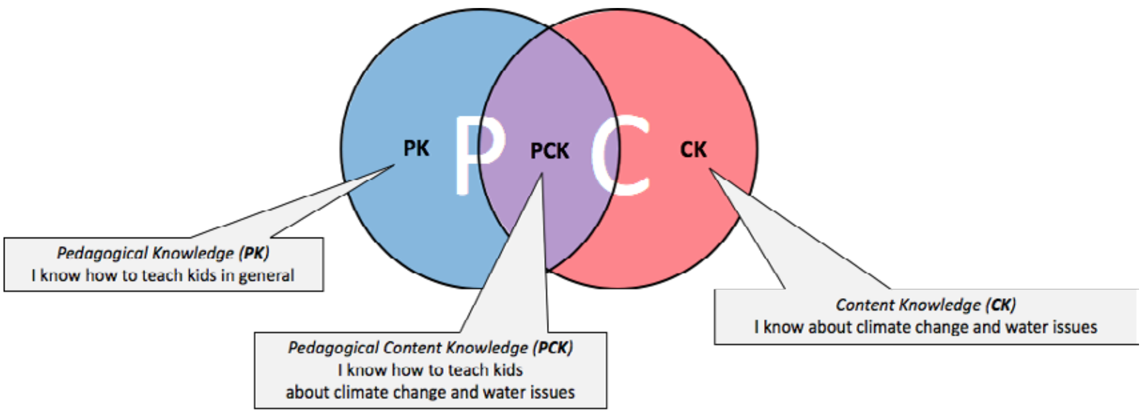

Figure 1: The PCK framework (cf. Shulman, 1986), specified for teaching climate change and water issues via place-based education

In order to integrate technologies in education, (future) teachers need even more knowledge. Mishra and Koehler (2006) added a third field in the framework (*Figure 2*): the field of Technology (T). Pure *Technological Knowledge (TK)* refers to knowledge about how to use domain general technologies, such as Word, Excel and PowerPoint. Geospatial technologies can be used for studying geographic and environmental issues such as climate change and water issues, and using this kind of technologies requires knowledge at the interplay of the fields of Technology and Content (Bryant & Favier, 2015; Favier & Van der Schee, 2012): *Technological Content Knowledge (TCK)*. This is because the user should connect formulating and answering geographic questions with applying the right functionalities of the applications. When technologies are used in education however, teachers should also connect it to the field of Pedagogy. In order to design and conduct education about climate change and water issues with geospatial technologies, teachers need to have a specific type of knowledge at the centre of the TPCK framework: *Technological Pedagogical Content Knowledge (TPCK)*.

TPCK can also be subdivided into five components, just like PCK. For integrating geospatial technologies in education, we distinguish the following components: ("orientation") awareness of one's own beliefs about the purposes and goals of integrating geospatial technologies in place-based education; ("curriculum") knowledge about the position of geospatial technologies in the curriculum; ("students' thinking") knowledge about students' preconceptions and attitudes towards the use of geospatial technologies; ("didactic strategies") knowledge about how to transform methods used to study e.g. climate change and water issues with geospatial technologies so they can be used in secondary education, how to design tasks with geospatial technologies, and how students learn when they work on these tasks with geospatial technologies; and ("assessment") knowledge about how to assess students' progression when they work with geospatial technologies.

In the EduChange project, geospatial technologies were purely seen as a means to support learning about local climate change and water issues. Learning to use geospatial technologies was not a goal. Furthermore, we used relatively simple geospatial technologies that do not require extensive training. Therefore, it was not necessary to pay attention to the position of geospatial technologies in the curriculum, the preconceptions and attitudes of students, and assessment of skills in using geospatial technologies.

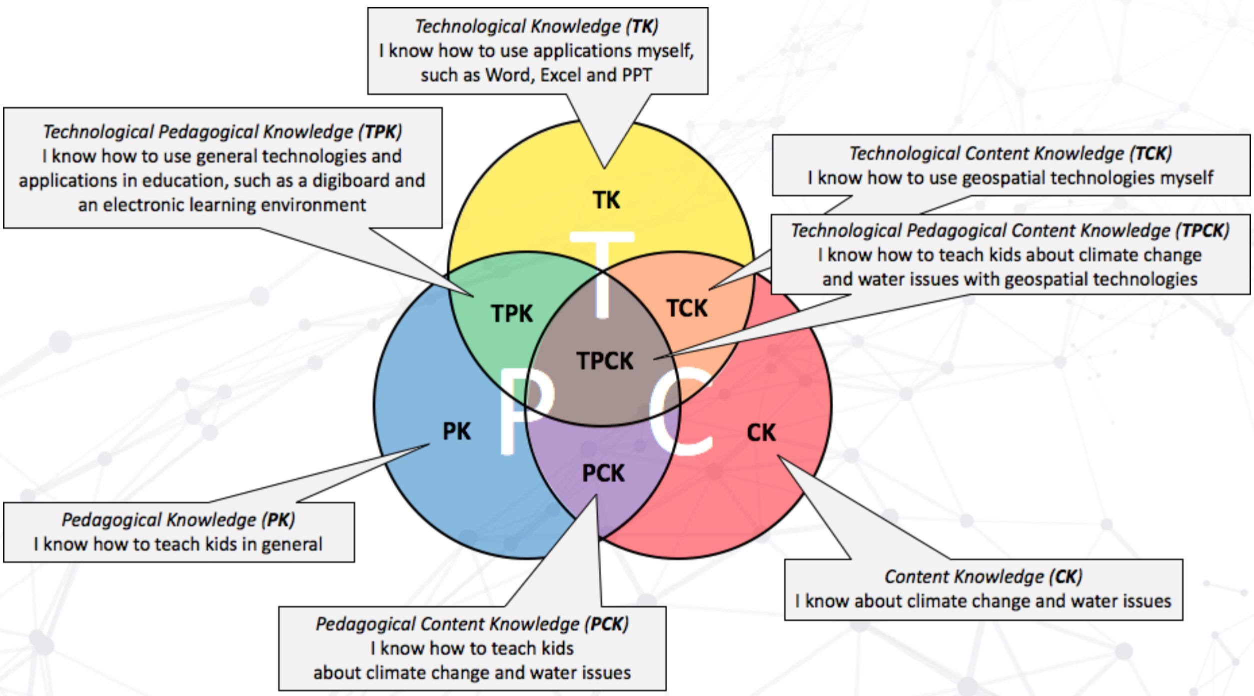

Figure 2: The TPCK framework (cf. Mishra & Koehler, 2006), specified for teaching about climate change and water issues via place-based education with geospatial technologies.

The design of the EduChange project and TPCK

This section describes the design of the EduChange course, and how it was intended to contribute to the development of knowledge in the different components of the TPCK framework.

Overall design and activities

The students participated in a training week in February. The program consisted of lectures, workshops, fieldwork and social activities. In the following months, the participants designed lessons in pairs or triads. The lessons were implemented in local primary and secondary schools. In the comeback week in May, the pre-service teachers met again to share their experiences and reflect on their lessons. During this week, the participants also followed advanced workshops and conducted fieldworks. There were three cohorts of participants: 2018, 2019 and 2020 (*Figure 3*). In between the three cohorts, the program of the course was adapted, mainly on the basis of observations made during the course and evaluations with participants. The activities of the final design of the training week and comeback week as conducted in 2020 are listed in *Figure 3A and 3B*, together with the knowledge that they were supposed to develop.

Figure 3: Overall design of the EduChange project

Cohort	*February*	*March*	*April*	*May*	*June*
1 (2018)	*Training week in Olomouc*	*Designing lessons in home countries*	*Testing lessons in home countries*	*Reflection week in Trondheim*	*Wrap up*
2 (2019)	*Training week in Malta*	*Designing lessons in home countries*	*Testing lessons in home countries*	*Reflection week in Trondheim*	*Wrap up*
3 (2020)	*Training week in Utrecht*	*Designing lessons in home countries*	*Testing lessons in home countries*	*Online reflection week (due to covid-19)*	*Wrap up*

Figure 3A: Activities of the final design for the training week of the EduChange project. E = Explicit, I = Implicit

		Components of the teacher knowledge basis					
Day	**Activity**	**CK**	**PCK 'orientation'**	**PCK 'Curriculum'**	**PCK 'Student understanding'**	**PCK ' Instruction strategies'**	**PCK 'Assessment'**
0	*Ice breaking event*	-	-	-	-	-	-
1	*Introduction (welcome, goals and logistics)*	-	-	-	-	-	-
	Workshop 'Fieldwork'	-	*I*	-	-	*E*	-
	Presentation 'Water system of the Netherlands'	*E*	-	-	-	-	-
	City tour "History and water system of Utrecht"	*E*	-	-	-	-	-
	Workshop "Environmental game"	-	*I*	-	-	*I*	-
2	*Presentation 'Youth perspectives on CC'*	-	-	-	*E*	-	-
	International lunch	-	-	-	-	-	-
	Poster presentations and discussion	*E*	-	-	-	-	-

3	*Workshop 'Educational Design'*	-	*I*	-	-	*E*	-
	Fieldwork at the river Rhine	*E*	-	-	-	*I*	-
4	*Workshops 'Photostories', 'Place-based education', 'Survey apps' and 'Virtual Reality'*	-	*I*	-	-	*E*	-
	Brainstorming and developing lessons	-	-	-	-	*I*	-
5	*Fieldwork in the peatlands district near Gouda*	*E*	-	-	-	*I*	-
	Brainstorming and developing lessons	-	-	-	-	*I*	-
	Prototype lesson presentations and discussion	-	-	-	-	*I*	-
	Reflection and evaluation	*I*	*I*	*I*	*I*	*I*	*I*
	Farewell dinner	-	-	-	-	-	-

Figure 3B: Activities of the final design for the comeback week of the EduChange project. E = Explicit, I = Implicit

		Components of the teacher knowledge basis					
Day	**Activity**	**CK**	**PCK 'orientation'**	**PCK 'Curriculum'**	**PCK 'Student understanding'**	**PCK 'Instruction strategies'**	**PCK 'Assessment'**
1	*Introduction (welcome, goals and logistics)*	-	-	-	-	-	-
	Presentation of lessons and experiences (part 1)	-	-	-	-	*I*	-
	Presentation 'educ. for sustainable dev.'	-	*I*	-	-	*E*	-
	Virtual fieldwork Tautra	*E*	-	-	-	*I*	-
	Online pub-quiz	-	-	-	-	-	-
2	*Presentation of lessons and experiences (part 2)*	-	-	-	-	*I*	-
	Virtual fieldwork Trondheim	*E*	-	-	-	*I*	-
3	*Workshop 'Assessment of CC education'*	-	-	-	-	-	*E*
	Expert feedback on lesson	-	-	-	-	*I*	-
	Adapting the lesson	-	-	-	-	*I*	-
4	*Presentation 'geospatial technologies and CC'*	*E*	-	-	-	-	-
	Virtual fieldwork Trondheim mountains	*E*	-	-	-	*I*	-
	Presentation 'Curriculum for the Anthropocene'	*E*	*I*	-	-	-	-
5	*Reflection and evaluation*	-	-	-	-	-	-

In this chapter we cannot discuss all activities of the EduChange project in detail. Below, we therefore highlight some important characteristics of the design of the course, and how they are based on insights from theory and practice.

Teaching (T)PCK in and interdisciplinary international classroom

Due to the complexity of the issue, teaching climate change, like other sustainability issues, requires an interdisciplinary approach (Tilbury, 2005), involving the natural, technical, economical, societal, political and psychological dimensions. We therefore recruited students from different Master programs: environmental education, geography education, science education, environmental sciences and geospatial technologies. The participants had a common interest in climate change and sustainability education, and all felt the urgency and desire to stimulate young people to contribute to sustainable change. Participants brought in different expertises: Their CK varied regarding climate change. All participants were acquainted with fieldwork methodologies that are used in their disciplines, which is also part of CK. About half of the participants had experience with at least one kind of geospatial technologies, which is TCK. Finally, about a quarter of the pre-service teachers had previous experience with secondary education, and therefore possessed some PK and PCK. During the training week, we let participants from different backgrounds work together in small groups, so they could share and combine their knowledge. Chapter 1 discusses how internalization contributed to students' learning, based on survey data. Then, Chapter 11 offers students accounts of the EduChange program, with a focus on internationalization and place-based education.

Wicked problems are always context dependent (Cantor et al. 2015; Jordan et al. 2014). This especially applies to climate change, as it can for example cause more precipitation in one place and less precipitation somewhere else. Furthermore, the characteristics of the water system and the social-cultural, economic and political systems also vary from place to place. The differences between the four countries are profound: Malta is a highly urbanised semi-arid island with porous rocks and no rivers; Czech Republic a landlocked country with many hills; Norway a sparsely populated Nordic country; and the Netherlands a densely populated delta. Adapting to climate change should be tailored to the local circumstances. Meanwhile, as people face different water issues in the four countries, they can have different perspectives on these issues.

Research by e.g. Sanders, Borko, and Lockard (1993) showed that a coherent basis of CK is a prerequisite for the development of PCK. An important assumption of the EduChange course was that the internationalisation component would allow students to experience how climate change and water issues vary between the four countries and this would add to their understanding of the whole issue. The development of this CK about spatial variability in climate change and water issues was stimulated via several activities, the two most important were: (1) a research and poster presentation task; and (2) fieldtrips.

Conducting academic research provides many opportunities for learning (Brew, 1988; Brew, 2012). In preparation of the training week, students in cohort 2 and 3 were given the task of doing a small (desk)research in which they had to study a particular regional climate change or water issue. Students in the second cohort could choose their own topic and region. However, in order to make the task more relevant, we instructed students in the third cohort to focus on an issue in their own country. Students wrote an abstract, gave and received peer feedback, and developed a research poster. In cohort 3, students chose topics such as: how climate change increases the risks of landslides in the Trondheim area, sand supplementation measures conducted on the Dutch coast, flash floods in the Czech Republic, and fresh water shortages in Malta. During the training week, participants presented their poster to their peers, and discussed the differences in effects of climate change and in adaptation policies. Chapter 7 further explores how the (desk) research and poster presentation task contributed to students' learning.

Fieldwork and place-based education

Fieldwork and place-based education can be valuable in climate change education. A quarter to a third of time during training and comeback week was spent on fieldworks. These fieldworks had a particular disciplinary signature, such as ecological zonation at tidal flats near Trondheim or flood protection measures along the Rhine near Utrecht. However, the fieldworks were always connected to the broader issue of climate change. During the fieldworks, the visiting students could learn from experiencing new places, while the receiving students could see their country through the eyes of strangers.

The fieldworks varied from teacher- and student-led excursions to field research and enquiry fieldwork (Oost et al., 2013). After the fieldtrips, we discussed the characteristics of a relevant, consistent, practicable and effective design for fieldwork with the students. Furthermore, a part of the students participated in a half-day workshop on place-based education.

All these activities aimed to develop knowledge in the component "didactic strategies" of PCK. See Chapter 2 for more information about how we designed outdoor activities, and how they contributed to the development of students' PCK.

Geospatial technologies

Geospatial technologies are a valuable tool to let students learn about climate change in different places, and to enhance fieldwork projects. During the training week, especially during the field trips, we let students use geospatial technologies such as storymaps and survey apps. For example, during the field trip to the River Rhine, students used their smartphone to access a several digital maps. A historic map was used to see how the landscape used to look like 20 years ago. This made it easier to recognise river management measures (such as floodplain excavation and digging of secondary channels) that were carried out here to reduce flood risks. In the fieldtrip to Gouda, students used a digital map on their smartphone that showed the depth of water on streets when there are heavy rains. Students had to go to dark blue areas in the map, and try to reason why water would accumulate there, for example because it was relatively low or no possibilities for infiltration. In the field trip to Trondheim, students used a survey app to collect data about signs of extreme weather induced landslides. Students had to take pictures, and describe what can be seen in the field. All data were automatically combined and visualised in a storymap. By integrating the geospatial technologies, we showed students how the technologies worked (TCK) and their benefits for use in fieldwork and place-based education (TPCK, component "orientation"). Also, students learned how technologies can be used in fieldwork tasks, and what problems may occur (TPCK, component "didactic strategies"). Chapter 4 further discusses the possibilities offered by Geospatial Technologies to support outdoor education.

Besides the use of geospatial technologies in fieldtrips, a part of the participants followed one of the two workshops on geospatial technologies in education. One workshop focused on virtual reality, the other on survey apps. The workshop about virtual reality consisted of a presentation about different models for in-class virtual fieldwork, and how virtual reality can be used in preparation or debriefing of real fieldwork. Also, we let students collect photos with a 360-degree camera. Next, we showed them how to develop a tour with the Google's free VR Tour Creator, and let them develop and view their own tours. In the workshop about survey apps, students first used a survey app designed by one of the workshop leaders to collect data in the field with their smartphone. The data was automatically combined and visualised in a storymap. Then the workshop leader showed how the survey app and storymap was developed. Next, the participants developed their own survey app and storymap and tested them with their peers. Chapter 10 further explores the possibilities of Virtual Reality for supporting geographic and environmental education.

In both workshops, we discussed the technical and didactic strengths, weaknesses, opportunities and threats with the students at the end, based on their experiences, supplemented with our own experiences. So, the idea of both workshops was that participants were first given information, then experienced educational technologies themselves and were shown how these technologies were developed, and finally conducted a (very short) full cycle of designing, testing and evaluating of a learning activity with these technologies. In such a way, the workshops aimed to develop not only the participants' TCK, but also provide a basis in TPCK, component "didactic strategies".

Connection to students' preconceptions

According to Kuthe at al. (2019), climate change education can only be effective when it is tuned in to its audience. Therefore, preservice teachers need to have insight into how students in primary and secondary education think about climate change, and how lessons can connect to these preconceptions (cf. Van Driel's et al. , 1998). For this reason, we included a presentation about the latest international research on how students think about climate change, and how to connect education to students' perceptions. Special attention was put on psychological mechanisms such as distancing and delay discounting, and how they can explain the discrepancy between opinions about the severity of the problem and willingness to act (see for example Bosschaart 2019).

Furthermore, we discussed ideas from the literature about how to deal with these biases, and how to make sure that young people feel the urgency and become agents of change. The presentation on perceptions aimed to develop knowledge into the components "students' thinking" and "didactic strategies" of PCK.

Training in educational design

Some participants had already some experience with teaching in general and educational design specifically, but most did not. During the first cohort, we observed that some students struggled with formulating clear learning objectives. Many of them used the official curriculum as a guideline. Others focused on practicalities over objectives and content. In order to tackle this problem and raise the output to a higher level, we included a half-day workshop in the training week. The workshop focused on formulating learning goals, transforming content to content for use in educational settings, and designing challenging tasks.

After the first cohort, we also decided to include interactive lectures on methods of teaching for sustainability that aim at reaching not only cognitive goals but also affective components, as these affective learning goals were often not addressed in the lessons that students developed. Climate change education needs to focus on values and attitudes rather than knowledge if it aims to be effective. A number of studies from around the world indicate that behavioral change does not come directly through the increase in the knowledge domain but mainly through factors that touch upon emotions, attitudes and values. In the EduChange program, we therefore included a workshop on "photostories", which is a promising approach for including values and attitudes in climate change education. See Chapter 9 for a more detailed description of how to let students create photostories.

Learning from theory and practice, reflection and sharing

An important part of the EduChange philosophy was that the participants would put the PCK they gained into practice. We therefore let them design lessons about climate change and water issues, and conduct them in a local school. The transformation of roles - from taking part as students to becoming teachers requires a transformation of CK and operationalisation of PCK. Hashweh (2005) and Magnusson et al., (1999) argue that PCK especially develops with experience. Reflection (Park and Oliver, 2008) and sharing experiences (Dogan, Pringle & Mesa, 2016) can significantly contribute to the development of PCK. For this reason, we let students evaluate their lessons, and present their findings during the comeback week. After the comeback week, the students adapted the materials, and the lessons were made available via http://educhange.net.

In the comeback week, we also included a presentation about the Anthropocene, and let students discuss their ideas on what they would like to achieve in climate change education, and why they want to achieve this. Doing so, we tried to make students more aware of their own beliefs about the purposes and goals of teaching about climate change education, which falls in the component "didactic strategies" of PCK.

Discussion and conclusions

In the EduChange project, we tried to stimulate students' knowledge, skills and motivation to design and conduct lessons about climate change and water issues via place-based education with geospatial technologies. A training week (including preparatory tasks), at the beginning of the program focused on the development of a Content Knowledge (CK) about spatial variations in the effects of climate change and possibilities for adaptation and ways to study these issues in the field. This was mainly done via desk research and poster presentations by students, and field trips. Exchange of knowledge between students from different disciplines and different countries played an important role. Besides content knowledge, we also introduced students to different geospatial technologies, and in such a way tried to develop their Technological Content Knowledge (TCK). But the larger part of the focus was on how to teach about this topic, using innovative pedagogical concepts such as place-based education and using geospatial technologies.

We tried to form a basis of Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPCK), via presentations, workshops, design activities, feedback and reflection. After the training week, students put their newly gained knowledge into practice and designed and conducted lessons for a local school. In the come-back week, we let students evaluate and exchange their experiences. We further tried to expand their PCK by providing students with information about assessment tasks can be designed in an climate change courses (Chapter 13). We also let students reflect on their orientation towards climate change education.

The following chapters provide more insight into the different activities of the EduChange program, and their theoretical basis. At the end of the book, Chapter 13 evaluates the effectiveness of the EduChange Project in increasing students' knowledge and attitudes towards climate change.

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CHAPTER 2: DESIGNING EDUCHANGE

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Introduction

The EduChange project set its ambitions high: it aims to improve climate change education by focusing on innovative and place-based methods for teaching climate change education. The impacts of climate change cannot be taught solely from textbooks. Place Based Education, field-work with collector apps and webapps, StoryMaps, VR and games have more potential to make climate change less abstract, to tackle misconceptions and to change attitudes of students in secondary education. (Pre-service) teachers thus need to have a toolbox full of innovative teaching approaches and an understanding of how to apply these tools. To achieve the latter, hearing about innovative teaching approaches is not enough, hands-on experience is required, preferably from different angles (as student and as teachers).

A toolbox and competence in using the tools are however not the only ingredients required for designing climate change education. Designing education is complex. One might get carried away by particular details in a design: a stunning new tool, a clear notion of the layout of the product, or a new approach to teaching. However, educational design requires the ability to incorporate all factors into the design and align choices. Moreover it asks for a reflexive approach, a willingness to not only design and teach the activity but to also evaluate and reflect so it can be improved.

This chapter discusses EduChange from the perspective of educational design. It both describes the project as it went through three consecutive cycles of design, teach, reflect, and explains how it trained participants in educational design. As such, this chapter provides context with subsequent chapters of the book. The chapter starts by briefly explaining the EduChange philosophy, then discusses models on educational design and subsequently explains how educational design was incorporated in the project.

EduChange

EduChange aims to improve climate change education by using innovative and place-based teaching methods. Previous research has indicated that climate change education is oftentimes rather traditional, focusses mainly on causes and hardly counters the psychological distancing experienced by some many teenagers (Bosschaart 2019). Meanwhile, other authors call upon educators to prepare young people for their future place in society as citizens, consumers, policy makers, and even change agents (see for example Israel, 2012; Feja et al. 2019, Hoffman 2019, Kuthe et al. 2019).

EduChange responded to such calls for innovative climate change education and set the objective of: "*With a mix of place-based education, innovative & creative teaching strategies we aim to bring climate change and its effects close to the students, demonstrating it on particular issues in their places and will show them that climate change is no longer a distant vague concept but is something that impacts their lives here and now and in the future*" (EduChange 2017). The methods applied in EduChange to 'attack' psychological distancing used insights from outdoor education and fieldwork, placed-based education, and education for sustainable development and combined these with the application of new technologies (StoryMap, VR, GIS). International fieldwork in an international group would assist the participants in conceiving of climate change as a global phenomenon which affects places differently. The international and interdisciplinary nature of the programme furthermore provided participants with the experience of meeting different perspectives and broadening their horizon.

One essential element of the EduChange philosophy has not yet been mentioned: the element of transfer. From the onset of the project, we assumed that improving climate change education should not stop with instructing pre-service teachers about innovative methods. Experiencing the teaching methods as participants was an instrumental next step. But learning to apply the methods through actually teaching a secondary school class and reflecting on that experience was the final step. Participants in the EduChange project thus switched roles: from students to teachers – first in a small play-test event during the Fieldweek and then afterwards with real students in a real classroom. Although the majority of the participants were pre-service teachers, not all of them were enrolled in progammes for teacher training or the broader field of environmental education and communication. The EduChange project was therefore not geared to solely presenting a toolkit for climate change education. It aimed to promote both the knowledge of and competence and confidence in teaching about climate change of all participant. Chapter 1 of this book deals with this dimension of the EduChange project: how it helped its participants in developing their TPCK.

Educational Design

Designing education requires knowledge, confidence and skill and foremost the ability to oversee the big picture when designing teaching activities or materials. Over the years educational researchers have developed models that visualize the relations between the different components or factors that need to be taken into consideration when designing a teaching activity – regardless of whether this refers to a whole curriculum, a single lesson or a brief classroom activity. The models thus present important factors for the design and which will need to be aligned if one hopes to create effective education. Norwegian researchers Bjørndal and Lieberg proposed their didactical relational model in 1978, a model that was later updated by Hiim and Hippe (1998) (Skagen et al 2008). Their model, in the shape of a diamond, includes the following factors: learning goals, content, learning process, learning conditions, settings, and assessment. The didactical analytical model of Van Gelder was first developed in 1971. The original model is based on five analytical questions. Teachers in preparation of a teaching activity firstly need to know what their learning objectives are, and secondly they need to be aware of the 'starting position' of their students, what their students already know, feel, think about the subject matter. Subsequently teachers will reflect on the learning situation itself: content, media, learning activities, methods and teaching activities. Lastly teachers need to reflect on ways to evaluate the outcome. Slightly different, but incorporating many of the factors described in the previous two models is the Curriculum Spiderweb: a spiderweb that includes ten different components: aims & objectives, content, learning activities, teacher role, materials and resources, grouping, location, time and assessment. In the core of the web are the rationale and vision of the curriculum (SLO 2019).

The commonality between the models is the objective to perceive educational design in its complexity and interrelatedness. It warns teachers to not focus too much on one of the components as the lesson or activity needs to be aligned to the audience, their preconceptions, the envisaged use, its place in the overall curriculum etc.. These models are used in instruction of pre-service teachers, serve as reminders for experienced teachers and can be used as evaluation tools to establish the quality of a design afterwards.

Desiging EduChange

The EduChange consortium consists of four universities from different corners of Europe: Olomouc, Malta, Trondheim and Utrecht. The team was not only international, it was also interdisciplinary both in current position and disciplinary background. It's members work in teacher training programmes and disciplinary programmes (environmental sciences and geography) both at Bachelor and Master levels. An essential characteristic of the EduChange team was the reflective approach to the programme as an educational design. The team critically monitored the programme as a whole and the individual activities it consisted of. The team thus designed, taught, evaluated & improved the programme during the project's runtime.

The detailed schedule of the programme presented in chapter 1 (in the context of the TPCK framework) is thus the result of three years of teaching, evaluating and adjusting.

The programme ran for three consecutive academic years and welcomed three cohorts of participants: 2017-2018; 2018-2019 and 2019-2020. The framework of the programme was decided on at the onset of the project and was not changed during the runtime. The programme ran in the Spring semester and consisted of two international meetings where participants from four universities would gather in one location. The first international meeting was called Fieldweek, the second international meeting was named ScienceJam. The Fieldweek had to prepare the students for designing their own innovative lessons about climate change, the ScienceJam offered time for reflection, evaluation as well as dissemination. In between both international meetings, students had to plan, design and teach their climate change lessons in a secondary school in the area where they live. Students worked in pairs of groups of three in the design process. The covid-19 pandemic of 2020, however, did have its impact on the last episode of the project as international travel was banned and universities and schools closed.

The international meetings partly consisted of workshops, lectures, poster presentations and other classroom activities designed to discuss content (climate change, local water issues related to climate change), get insight in the starting position (young people's perception of climate change and environmental issues), familiarize with particular media and technologies (VR, GIS data on climate change, photo story, Storymap), and with teaching activities and methods (methods for ESD, curriculum for Antropocene, place-based education), and get deeper insight into what assessment actually means in the context of climate change education. As place-based education and fieldwork were an essential part of the EduChange philosophy about half of the time during the international meetings was spend outdoors. This allowed students to experience different formats of fieldwork (see chapter 3 on outdoor education), get an understanding of what is required for fieldwork to be an effective educational activity, as well as built their content knowledge on local water issues related to climate change. In chapter 1, figure 4A & 4B Favier explains in detail how the components of the EduChange programme thus contribute to development of competence and confidence of pre-service teachers as designers of lessons or activities.

Multiple sources provided the input for the critical evaluation of the programme. Participants completed an online questionnaire at the end of the international meetings. On the last day of each Fieldweek and ScienceJam a group conversation took place as well were participants were invited to provide feedback and suggestions. Additional information on the student experience was gained in wrap up meetings in the national teams, such as focus group meeting organized for the students from Utrecht University in July of 2018 and 2019.

The input of the students was complimented by observations from the professors – observations both of activities and of students' performance during those activities. Additional observations from the professors on the process of educational design by the participants (both play testing and actual design) and on the resulting teaching activities were of particular importance in the light of developing competences needed for educational design.

Each fall the team would meet and discuss the adjustments to the programme. Conversation during these meetings were open and critical. The revisions that were executed were on the one hand related to the location and setting of the Fieldweek, as the Fieldweek was organized in 2018 in Olomouc, 2019 in Malta and 2020 in Utrecht. The programme needed to be adjusted to both local opportunities for fieldwork and issues of transportation, and to the venue where all indoor activities would take place. Other revisions of the programme, both Fieldweek and ScienceJam were the result of outcomes of the student evaluations and observations by the professors.

The most important revisions of the programme after the first year were firstly including more activating forms of teaching (interactive lectures, poster presentation) as students noticed that plenary lectures did not sit very well with the philosophy of the project. Secondly, these revisions related to reflection: creating more time and room for reflection on the EduChange experience first in the ScienceJam of year 2 and subsequently also in Fieldweek of year 3 (see chapter 12 international experience). The most extensive changes to the programme related to educational design and will be explained below.

Learning Educational design in EduChange

As explained before, the participants thus learned about methods for climate change education and educational design in different ways: through instruction and hands-on in workshops, by experiencing activities such as fieldtrips and VR sessions as students, by designing and conducting lessons / educational activities themselves and by reflecting on their experiences. The workshops that familiarized students with particular media or methods were appreciated by the students.

To prepare students for designing an educational activity in an actual school, a 'play-testing-event' was part of the Fieldweek. Students had to design a lesson in mixed international teams of four to six students. They were free to decide what age group or topic they would focus on. A full afternoon and evening and a few hours in the morning were reserved for preparation of the lesson. Students were invited to apply the media or activities they experienced in the workshops.
In the first cohort, the curriculum spiderweb was provided as a reminder of the need for alignment between all components of the lesson, but no further instruction on educational design was provided.

On the day of the play-testing event all groups explained the aim and context of their lesson and play tested a part of it. There were a lot of outdoor experiences included, some quizzes and kahoots and one simulation game. A number of the activities contained an element of competition and this let to fanatic garbage collecting and quizzing. One of the reflections of the day by the professors related to the pro's and con's of including a competition element in your classes. One important observation was that students hardly used the curriculum spiderweb to guide their design process. As a result, designs not always clear on objectives, but they were on target audience and how activity could be part of curriculum.

After Fieldweek students returned home and had two months to design a lesson for secondary school students on water issues related to climate change. A huge variety of activities was the result. A range of topics was covered, from sustainability in general, to flood risks. A similar variety in teaching approaches was evidenced (see Compendium 2018 at the project webpage). Two important observations were made that called for adjustments to the programme. Firstly, some groups struggled to define clear learning objectives. Secondly, few groups had, during the design process, given much thought on how to assess the learning outcomes of their lesson.

From the perspective of educational design, it thus became apparent that students may need more training, especially on defining learning objectives and creating constructive alignment in their lesson plans. Although many of them were or had been enrolled in teacher training, most of them were still novices when it comes to designing educational activities. A workshop on educational design was thus added. These additions provided the students with a framework to help them think about their design. The focus in this interactive workshop was on the spider web and included exercises with formulating and structuring learning objectives. Moreover, the components of the programme were more explicitly connected to educational design decisions. Debriefing of fieldtrips discussed not merely the experiences as participants, but also design decisions.

The focus on educational design was further enlarged on request of the students of the second cohort. On the first day of ScienceJam, students asked for more time to be allocated to evaluation of the lesson. After the interactive lecture on assessments, students were first invited to reflect on their design using the insights they gained form the lecture. To discuss potential improvements, expert panels were created where students could ask questions, get feedback on these changes they wanted to make.

The observations of the design process for cohort 2 and 3 did not lead to further changes to the programme of Fieldweek and ScienceJam. External factors did prove to hinder students in their design process. There was time pressure, which resulted from participating in EduChange next to other obligations (classes, internships etc.). It was not always easy to find a school willing to participate or participate in spring semester. The global pandemic furthermore made matters complicated.

EduChange legacy

This book partly serves as a testimonial to the EduChange programme. An international, interdisciplinary cooperation, uniting students and teachers around the cause of improving climate change education. The chapters in this book describe the EduChange experience and demonstrate how EduChange aspired to build the TPCK of pre-service teachers and to prepare them for designing innovative and effective climate change education. Several methods of teaching climate change are discussed along the way. The book also offers insights into the programme as a process of educational design – going through three subsequent cycles of designing, teaching, evaluating and adjusting the programme.

Although the project has now ended, its legacy continues, foremost in the memories and experiences gained by its participants. Participants that have graduated and moved on to their first jobs as teachers or professionals in the field of environmental sciences and geography. Graduates that carrying with them the drive, confidence and tools to contribute to tackling climate change.

Central to the EduChange project was the switching of roles: students participating became teachers who designed, taught and evaluated educational activities for secondary schools. This approach increased the outreach and visibility of the project - touching more lives than solely those of the participating students and professors. Several secondary schools, teachers and students thus became involved.

The amount of teaching activities designed, taught, and evaluated by the participants are the project's most tangible legacy. Three years of EduChange resulted in a variety of teaching activities developed by the participants for school classes of different age groups. The teaching activities focus on water issues related to climate change specifically and broader topics related to understanding climate change and climate change mitigation and adaptation. The activities incorporate several elements from the EduChange philosophy and thus represent innovative ways of teaching about climate change. Participants for example developed boardgames, designed fieldtrips in vicinity of the school, or created StoryMaps. All materials can be accessed in the compendium which is available online (www.educhange.net). The compendium is set up with previously described educational design models in mind. It thus provides users with all the necessary information to select materials to use in their own school classes: learning objects, target group, assessment, required materials, etc. All EduChange participants and staff hope that the innovative teaching activities will find their way to classrooms all over Europe.

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CHAPTER 3: FIELD COURSES AND THE "EXTENDED CLASSROOM" AN OVERVIEW OF OUTDOOR ACTIVITIES IN THE EDUCHANGE PROGRAMME

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Abstract

"Fieldwork can be defined as any component of the curriculum that involves leaving the classroom and learning through first-hand experience" (Boyle et al. 2007, 300). It thus involves all kinds of outdoor schooling activities carried out outside the classroom and managed by a school/teacher. It includes a variety of "extended classroom activities", such as traditional field trips as well as visits to Museums, Science centres and NGO's, but is always part of school activities, with organized teaching, not a leisure visit in the afternoon or during a weekend.

Several authors in science and geography education have shed light on the educational benefits of fieldwork and outdoor learning, and the potential for deep learning (Scott et al. 2006a; Oost et al. 2011; Marvell et al. 2013). From a review of 150 research projects on outdoor learning, Dillon et al. (2006) conclude that *"We found substantial evidence to indicate that fieldwork, properly conceived, adequately planned, well taught and effectively followed up, offers learners opportunities to develop their knowledge and skills in ways that add value to their everyday experiences in the classroom."*

An important lesson to be learned from the study by Dillon et al. (2006) is not only about the effect of fieldwork, but also about the need to successfully implement it. Several authors have discussed criteria for the successful design and implementation of fieldwork. In this chapter we use the framework elaborated by Kari Beate Remmen and Merethe Frøyland who have published several papers over the last few years on how to design and implement "extended classroom activities".

In this chapter we will describe and analyse all the outdoor learning activities carried out during the first 2.5 years of the EduChange project, including visits to several outdoor arenas and science centres in the Czech Republic, Malta, the Netherlands and Norway. The activities will be analysed based on Remmen and Frøyland's (2014) recommendations for effective fieldwork. In addition we will focus on one particular case study; a cross-subject excursion to a small island in Norway, Tautra, where students investigated the flora and fauna present in a small tract of tidal land to see how they have adapted to the tidal environment. We analyse in depth how this excursion proceeded and how the students responded to the activity. We compare this to Remmen & Frøyland's (2017) extended tool for designing outdoor (science) activities.

Introduction

A sunny day along a shoreline, a group of students and teachers are scattered over the tidal land of a small bay of Tautra. Small groups of students and teachers are on the beach, walking around with no clear direction, calling out to one another, and then moving on again. All slightly bending forward and looking down. They pick up shells, turn over rocks, point things out to each other and collect samples.

Some are far out in the residing water's edge, some stick closer to the meadow, and a few daredevils go for a swim. A passerby might perceive this to be a chaotic, unstructured moment of teaching, but afterwards the participants stated how much they had enjoyed the activity and how they had seen more than they had anticipated at the start of the activity. They were absorbed by the task and the hour appointed to it simply flew by. At the start of the activity it may have occurred to students that they were given rather a lot of time to explore the gradient of plant and animal life in the tidal land and to see how organisms adapted to the salty and wet-dry conditions, yet the amount of time available forced the students to keep exploring and asking questions, and many were able to look beyond a quick superficial gaze.

This field activity was one of the many teaching activities in the EduChange programme that took place outdoors and it embodied part of the EduChange philosophy; that of improving climate change education by using place-based education and fieldwork to make the topic relevant and concrete for students. In the application the objectives of EduChange were phrased as: "*With a mix of place-based education, innovative & creative teaching strategies we aim to bring climate change and its effects close to the students, demonstrating it on particular issues in their places and will show them that Climate change is no longer a distant vague concept but is something that impacts their lives here and now and in the future*". The main approach taken in the project to improve climate change education was innovative place-based education, which was comprised of a mixture of place-based and field-based education, new technologies (GIS, VR) and international exchange. In this chapter we will focus on the outdoor dimension of this EduChange philosophy. To assist climate change educators in their challenging task we will delve deeper into the design principles for effective fieldwork and outdoor education, and demonstrate how these principles were applied in the many field activities included in the programme.

The extended classroom in EduChange

Fieldwork, outdoor learning and place-based education are part and parcel of the EduChange philosophy. The programme therefore included many instances of learning which would take place outside the confinement of the classroom or lecture hall (see table 12). These activities can be described as outdoor learning or fieldwork – although these concepts are at times used as synonyms, we recognize that they originate from different educational traditions and would not be viewed as interchangeable by all scholars. The definition of fieldwork which we will adhere to in this chapter sees fieldwork as: all learning activities organized by a teacher (or educational institution) which take place outside school buildings. Boyle et al. (2007; 300) add that fieldwork involves learning through first-hand experience. Fieldwork can range from brief field excursions in the vicinity of the school, requiring limited travel and limited time, to residential courses which often include more extended travels, and from guided "Cooks tours[1]" to project work in the field (Fuller et al. 2006). The concept "outdoor learning" has been defined in several ways. One rather broad definition used by Rennie (2014, p 120) in the context of science education includes every learning activity outside the school context. This definition encompasses learning through all forms of media, such as television, movies and the internet, and includes learning at home as well as during leisure activities. An alternative, narrower, conceptualisation by Dillon et al. (2006) limits its outdoor education to: fieldwork and outdoor educational visits. This defines outdoor learning as more or less synonymous with classic fieldwork. These field visits can take place close to school - even in the school gardens - or further away and can encompass urban areas, parks, rural areas and even wilderness areas (Rickinson et al. 2004). In this chapter we opt for a definition that sees outdoor learning involve learning activities outside school through field visits and visits to museums, science centres and NGOs which are organized by teachers and schools/higher education institutions. This is close to what Jordet (2009) describes as outdoor schooling: "*Outdoor schooling is a way of working with the schooling content where parts of a school's everyday life move out into the local community. Outdoor schooling implies regular and targeted activities outside the classroom.*" (translated from Norwegian by the authors).

[1] look-and-see tours referring to excursions where the teachers explains and students solely get on and off the bus and look to the left and to the right

Fieldwork and outdoor education thus share one important defining characteristic – they take teaching outside the classroom through organized educational activities in the field, in the surroundings of the school and in science centers. These visits can be to locations near the school and may even carry the signature of place-based education. Place-based education aims to ground education in the local community, not only by creating local field activities, but also by recognizing the importance of lived experiences and local knowledge for students' learning. However, this latter local focus, which includes the desire to forge connections with the local community and create critical active citizens (Sobel, 2005; Gruenewald, 2003; Smith, 2002) is not always present in fieldwork or outdoor learning. An important aspect of the EduChange experience for students was international fieldwork. Both during the Field Week and the ScienceJam one institute hosted the whole group, and staff and students thus either visited outdoor locations in a country unknown to them or guided international participants around their own local area (see also chapter 12 for international experience).

As teaching methods, fieldwork, place-based education and outdoor learning show promise for teaching about climate change and related water issues, especially as means of overcoming the many forms of psychological distancing evidenced in attitudes towards climate change. However, several authors have already stressed that while taking students outdoors can create memorable moments and can be perceived by students to be more fun than learning in the classroom, outdoor teaching activities are not inherently effective in climate change education. In this chapter we will demonstrate how we strived for effective field activities – meaning activities which would lead to deep learning[2] and present participating students with inspiration for their own future practices as teachers in environmental, science or geography education.

Thus this chapter offers a critical look at the different outdoor learning and fieldwork activities organized during 5 of the 6 international meetings. It includes data from 3 subsequent cohorts. The third cohort, however, saw their ScienceJam meeting transformed into a virtual / online meeting, due to the covid-19 pandemic and the resulting bans on traveling and meeting. This third cohort did virtual fieldwork activities instead, but these will be excluded from this chapter.

Field course methodology in the EduChange programme

Several authors have written about the many benefits of fieldwork and outdoor education. In geography education, fieldwork is considered a core teaching practice and an essential part of geography education (Kent et al 1997, Fuller et al. 2006, Scott et al. 2006a, Dummer et al. 2008, Dunphy and Spellman 2009, Hvorka and Wolf 2009, Oost et al. 2011, Marvell et al 2013, France and Haigh 2018, Van Gorp et al. 2019). Likewise, in biology education fieldwork is what evokes an interest in students to study biology or ecology (Barker et al. 2010). As a result, geography, biology and environmental educators lament the threat fieldwork is under – because of the high costs (monetary and time investment) and the potential risks (in the form of health issues, damage to equipment, and liability issues) (Barker et al. 2002, Magntorn & Helldén 2006, Boyle et al. 2007, Dunphy and Spellman 2009, Herrick 2010, Norðdahl and Jóhannesson 2014, Glass 2015,). Dillon et. al (2006, p. 54) – after reviewing 150 papers on "Research on Outdoor Learning" in the fields of science, geography and environmental issues from 1993-2004 in the UK, concluded that "*learners in all ages can benefit from effective outdoor learning*". However, at the same time they ask educational policy makers to "*recognize that despite positive research evidence and the long tradition of outdoor learning in this country, there is growing evidence that opportunities for outdoor learning are in decline and under threat*". While several countries are increasingly restrictive in regard to taking school children outdoors – due to such issues as safety, the new Norwegian curriculum (starting autumn 2020) for compulsory education has increased its focus on the use of outdoor schooling. As a result, some universities are running dedicated courses on "Outdoor Education".

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[2] Deep learning is that which fosters a seeking of meaning/intention to understand, as well as relating evidence to conclusions, motivated by interest and an ability to collaborate and discuss (Maguire et al., 2001)", cited from Scott et al. (2006a). This in contrast to surface learning/instrumental learning (memorizing with lack of understanding) or strategic learning (studying more achievement oriented) , cf. Maguire et al. (2001).

The many benefits of taking students into the field are mentioned by several scholars (Kent et al 1997, Fuller et al. 2006, Scott et al. 2006a, Dummer et al. 2008, Dunphy and Spellman 2009, Hope 2009, Hvorka and Wolf 2009, Herrick 2010, Stokes et al. 2011, Glass 2015, France and Haigh 2018, Van Gorp et al. 2019). Fieldwork is, first and foremost, fun; it offers students hands-on experience and active engagement with the real world, and often results in memorable moments. Fieldwork can contribute to cognitive, affective, and even psycho-motor learning objectives (Wilson et al. 2017), especially as it immerses students in the real world. Students can gain a better understanding of theory by observing it in practice, and they can see how processes may occur differently in different places due to the context. Fieldwork also confronts students with reality; they will come to understand that seeing issues firsthand is different from just reading about those issues. Furthermore, many authors mention the skills which can be gained through fieldwork; research skills, professional and technical skills related to future professions and soft skills. Additional benefits of fieldwork are increased motivation, opportunities for community building (between students and between student and teachers), and increased self-efficacy and personal development in students.

Fieldwork is considered a signature pedagogy in geographical education and in areas of biological education, and it is also perceived to be a tool for effective education in sustainability and climate change education. There are lively academic debates on the requirements for fieldwork to reap this potential. France and Haigh (2018) offer an overview of 40 years of publications on fieldwork in Journal of Geography in Higher Education and they highlight the different perspectives and subsequent pedagogies on fieldwork over that 40 years – varying from teacher-centered tours to team projects and reflective trips. Other authors have similarly discerned typologies of fieldwork, focusing on approach, type of activity and the role of the teacher (see for example Kent et al. 1997. Fuller et al. 2006, or Oost et al. 2011).

Notwithstanding the recognition that fieldwork has many benefits, scholars such as Fuller et al. (2006), Dummer et al. (2008) and Oost et al. (2011) point out that a visit to the field will not automatically lead to deep learning. If not properly embedded, aligned and executed, fieldwork will not stimulate students to look beyond a superficial tourist gaze (Simm and Marvell 2013).
If teachers want their students to gain a deeper understanding, they will need to think about how they structure, organize and embed field activities in their lessons and in the broader curriculum as a whole (Fuller et al. 2006, Oost et al. 2011). Moreover, they also need to think about how they assess fieldwork (Dummer et al. 2008).

The aim of the EduChange project was to improve climate change education – with a strong focus on overcoming the distancing effect. Fieldwork and outdoor education offer a number of particular benefits in this regard. Local fieldwork has the potential to counter psychological effects which can occur in relation to climate change, as in cases where people perceive climate change to be a distant phenomenon, both in time and place. Moreover, fieldwork can stimulate engagement with climate issues. However, the extent to which these objectives can be reached depends on the effective design of the fieldwork. Thus the following section focuses on design principles for effective fieldwork and outdoor education.

Typology and principles for effective education through fieldwork and outdoor teaching activities

Fieldwork comes in many different shapes and sizes. Categories of fieldwork activities originate from different pedagogical approaches. Herrick (2010) presents a typology of fieldwork in which the two axes represent the type of activity (from observation to participation), and the level of autonomy of the students (from dependent to autonomous). Similarly, Oost et al. (2011) have mapped different types of fieldwork on two axes. This presents variations in the roles of the students and in the roles of the teachers (see figure 3). Traditionally, many field courses and field trips in disciplines such as biology, geography and geology were teacher-led excursions; termed as "Cooks-tours" or "look and get on the bus" tours (Kent et al. 1997; France & Haigh 2018).

These tours are teacher-centered because teachers define the parameters (where and when to get off the bus, what to observe) and reduce the role of students to passive observers. However, scholars such as Herrick (2010), Oost et al. (2011) and Remmen & Frøyland (2017) cast doubts on the effectiveness of such traditional excursions as those learning experiences which may foremost result in surface learning because of the passive role of the students, and a focus on procedural information.

Over the last decades new pedagogies for fieldwork and outdoor education have been developed and through the form of the tasks, the teamwork required and an increased degree of autonomy, they are intended to involve students more actively in the field (see figure 3).

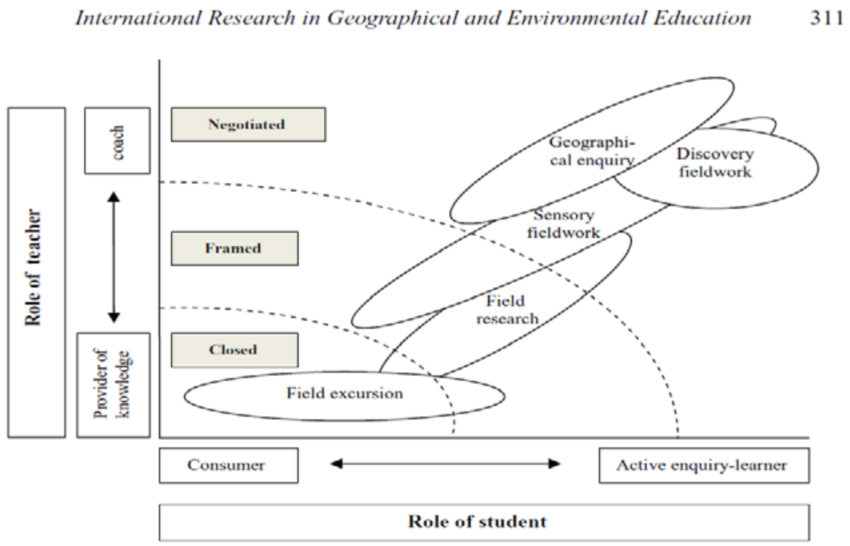

Figure 3: Typology of fieldwork based on the mutual roles of the teachers and students. Source Oost et al. (2011; 311)

The degree to which fieldwork is more teacher - student-centered not only depends on the type of activities and tasks students carry out in the field, it is also determined by how the fieldwork is introduced and debriefed (Oost et al 2011) and by the mode of interaction used by the teacher before, after and in the field. Scott et al. (2006b) introduce a 2x2 model (table 1) on the effectiveness of oral interaction in the classroom based on the direction and openness of the interaction. The model was not intended to instruct teachers on which position in the model they ought to take when talking. The main point for teachers is to be aware of their position when teaching students, to recognize the possible tension between authoritative and dialogic approaches, and to be able to reflect on which positions are appropriate to the task at hand.

Thus, teachers can vary their positions and use different modes of oral interaction. Giving instructions about where to go on a field trip is a typical example of noninteractive and authoritative communication, which can be very effective when a teacher wants students to see a particular landscape feature or investigate a specific neighborhood. Summing up using students' findings and arguments after they have had some time in the field to work on an assignment is an example of a noninteractive but dialogic communication. The model also reminds teachers that they should be explicit in their expectations – What are they looking for in their interaction with students in the field?: an exact answer (interacting, but authoritative) or the exploration of a question from different points of view (dialogic interaction). This latter type of communication can lead students to a higher level of knowledge.

Table 1: Four classes of Communicative Approach. Rewritten from Scott et al. (2006b). Authoritative is here defined as: "In authoritative discourse the teacher's purpose is to focus the students' full attention on just one meaning. It is in this sense that we have chosen to use the word "authoritative" (whilst acknowledging the underlying dialogic nature of the interaction). Additionally, we have chosen the word "dialogic" to contrast with an authoritative communicative approach" (Scott et al., 2006b, p. 610).

	Interactive	**Noninteractive**
Dialogic	Interactive / Dialogic	Noninteractive / Dialogic
Authoritative	Interactive / Authoritative	Noninteractive / Authoritative

Oost et al. (2011) further explain that to be effective fieldwork must be embedded in the course and in the curriculum. Taking students on a one-off trip may create a memorable moment but it will not necessarily lead to deep learning. Embedding fieldwork and outdoor learning activities in the curriculum means students acquire the necessary skills to do fieldwork over a number of years, their progress is monitored and their confidence levels grow over time. Embedding field activity in the course implies not only a proper introduction to the activity and a debriefing afterwards, but also a deliberate design, as Remmen & Frøyland (2017) emphasize: the choice to take students out of the classroom needs to be "on purpose" as the topic cannot be taught to the same effect in the classroom. In a similar vein, teachers must reflect on the learning objectives they want students to accomplish with the field activities and align the activities with the cognitive, affective and psycho-motor learning objectives they want to achieve. When the aim of the trip is to drill sampling methods this should be a very different design to one where the teacher's aim is for the students to become engaged in environmental issues, for example.

In their didactical tool for the Extended Classroom, Remmen & Frøyland (2017) developed six steps to guide teachers in their design of outdoor educational activities (Table 2). Their intention was to stimulate teachers to develop outdoor science teaching that fosters deep learning in students (Remmen & Frøyland, 2017, p. 227). These design guidelines reflect principles of enquiry-based learning, for example when arguing that the need to start with a theme can be investigated from several perspectives: thematically, dialogically, didactical and psychologically and can be used to focus on real world problems similar to those studied by scientists.

Table 2: Design principles for outdoor education Six design steps for the "Expanded classroom", designed by Remmen & Frøyland, (2017, p. 225-226), translated by the authors.

1. Choose theme
   a. Could the theme be enquired into from several perspectives?
2. Choose an assignment that the students have to solve
   a. Four criteria for high-quality assignments
      i. Need to come from a contracting authority (real or fictive)
      ii. Similar to problems that scientists handle
      iii. Require that students need to use science knowledge and skills
      iv. Let the students have opportunities to make choices and argue for them
3. Formulate goals for the understanding that helps the students solve their assignment
   a. Formulate goals in four dimensions; Knowledge, method, purpose, and form
   b. Distinguish between understanding at a minimum of two levels: In-depth (master and apprentice) and surface (novice and naïve)
4. What is possible for students in the alternative area that is not possible in the classroom
5. Choose activities that help the students in demonstration and in building understanding
   a. Three phases: Prework, outdoor and post-work
   b. Stimulate in-depth learning activities, "thinking moves", among the students
6. Formative assessment that helps the students solve their mission
   a. Use assignments to examine how the students relate to goals for understanding

Evaluating Field activities in 3 cohorts of EduChange

The EduChange philosophy led to a varied programme, with both classic indoor teaching (even some lecturing), interactive workshops in small groups, student presentations, game-based activities and a range of outdoor activities (see table 12). These outdoor activities extended well into a third of the teaching time in the programme (a schematic overview of the programme can be found in chapter 1). An overview of all outdoor & field activities in both Field Week (instruction week) and ScienceJam (reflection week) in all three cohorts is presented in Table 3 below.

Table 3 demonstrates that the outdoor activities often served multiple purposes, such as community building, getting acquainted with the host city and being introduced to local water issues. Particularly at the beginning of the week, this triple familiarization was important. On the first day community building (both among the students and between students and teachers) was stimulated during the landscape fieldwork by allocating students to mixed (meaning international) groups.

In the EduChange project our aim was: "*to transform field courses into innovative, creative learning environments in which teachers, students and pupils create knowledge together.*" This represents a desire to move away from teacher-led, look-see tours towards other pedagogical approaches – those on the upper righthand side of Figure 3, where the students are active enquirers and the teacher acts as coach. However, the degree to which the field trips were student-centered varied. The main field trips relating to water issues in Field week were all preceded by an introductory lecture on a particular topic by either a guest speaker or by one of the lecturers involved in the programme.

In the field the lecturers would refer back to this introduction to connect the theory to the real world.

Table 3: Aim and format of the different outdoor activities during Field Weeks 2018-2020, and ScienceJam 2018 & 2019.

	Activity	Aim	Format
Field week	Landscape fieldwork (cohort 1-3)	Community building Familiarizing with host city Discovering variety of modes of local fieldwork	Self-guided by students
	City walk (cohort 3)	Familiarizing with host city and water in the city	Teacher led, interactive.
	River walk 1 (rural) (cohort 1)	Understanding local water issues and local adaptations / measures	Teacher centred introduction & excursion
	River walk 2 (rural) (cohort 2)	Understanding local water issues and local adaptations / measures Affective / psycho-motor (hike & view)	Teacher-centred introduction lecture, teacher guided walk
	River walk 3 (urban) (cohort 3)	Understanding local water issues and local adaptations / measures, understanding wickedness of problems	Teacher led fieldwork using mysteries and assignments
	Water educ. centre (cohort 2)	Recognizing different pedagogies and formats for education in water education centre	Teacher centred introduction and non-guided visit
	Science museum (cohort 1-2)	Recognizing different pedagogies and formats for education in science museums	Non-guided visit
	Place check (cohort 1-3)	Familiarizing with place check as method in place-based education	Teacher led, Interactive workshop
	Field day 1 (cohort 1)	Understanding local adaptation measures Affective / psycho-motor (hike & view)	Teacher- centred tour and bus tour Non-guided hike
	Field day 2 (cohort 2)	Understanding water issues in marine environments Creating awareness of pollution Affective: value of small-scale nature conservation project	Teacher led, introduction & guided excursion
	Field day 3 (cohort 3)	Understanding local water issues and local adaptations / measures, understanding wickedness of problems Skill: Drilling & creating a profile of soil in peat lands	Teacher led fieldwork using mysteries and assignments, guest lecture

Science-Jam	River walk 4 (urban) (cohort 1-2)	Understanding local water issues and local adaptations / measures Community building Familiarizing with host city	Student led excursion
	Marka hike (cohort 1-2)	Cognitive: understanding landscape formation processes Affective / psycho-motor (hike & view)	Teacher led, introduction & guided excursion. Some student tasks and questions/dialogue
	Field day 4 (cohort 1-2)	Cognitive: understanding historical and natural history/landscape formation of marine peninsula. Be given an introduction to marine biology and environmental challenges. Affective and psycho-motor – explore a beach Walk through tidal lands, pick up material, feel the temperature of the water? Get shoes wet?	Flipped classroom: analogue and digital tools as pre and post-work. The field trip itself – a mix of guided tour, teacher led dialogues and inquiry-based student-driven activities.

Overall, students rated the outdoor activities highly, with average scores ranging from 6.8 to 9.3 on a scale of 1 to 10 (Tables 4 & 5). If we focus on these results and apply the guidelines from the model of Remmen and Frøyland (2017), we find that the excursions with the highest scores fulfil more of the steps in this design model. This involves; the inclusion of situated assignments (point 2), the use of the outdoor arena for its unique purpose (point 4), the formulation of goals that help the students to solve assignments (point 3), and activities with good connections between pre-work, fieldwork and post-work (point 5a).

Table 4: Student appreciation of field activities in Field Week. Average student evaluation score on a scale of 1-10, after outdoor activities in Field weeks 2018, 2019 and 2020

	2018		**2019**		**2020**	
	n	mean	n	mean	n	mean
Landscape fieldwork	22	7.7	22	7.4	30	7.4
Field Day 1-3	21	6.9	22	7.2	30	8.8
River walk 1-3	22	7.9	22	8.2	30	9.2

Table 5: Student appreciation of field activities in ScienceJam. Average student evaluation score on a scale of 1-10, after outdoor activities at the ScienceJam 2018 and 2019. (2020 ScienceJam was virtual due to covid-19 restrictions)

	2018		**2019**	
	n	mean	n	mean
River walk 4 (urban)	22	8.2	22	6.8
Rural trip (with hiking)	21	8.1	22	9.3
Field day 4 Excursion to an island	22	8.3	22	8.2

However, the scores given by the students in the evaluations are not very refined. The question asked how they rated the activity and this rather open-ended question does not distinguish between the cognitive or affective outcomes or between the skills gained and the evolution of their own “pedagogical toolboxes” as pre-service teachers. Looking at the comments supplementary to the ratings gives us a wider perspective on the students’ evaluations.

As we can see from Table 6 the comments are diverse, and cover both the cognitive dimension (content knowledge of river flooding, climate change), the skills dimension (collect shells) and the affective dimension(cool, nice, fun) (Alter & Murty 1997). In addition, the outdoor education covered different aspects of subject specific pedagogical / didactical (PCK=Pedagogical content knowledge) knowledge and methods, and this is reflected in one of the comments in Table 5 – where the student appreciates different examples of how to educate pupils. With this very broad understanding from the students of what was most valuable during the various field excursions on the EduChange course, the variation in quantitative score for the different activities is explained.

Table 6: Some quotes from the students' supplementary comments concerning the field trips (for an overview of different field trips, see Table 3)

Comments to river walk 1 (cohort 1)
- *It was a really interesting topic, but I did not get all the information, due to the language barrier unfortunately* - *Very cool field exercise! Had so much fun learning about how the rivers were adapted to flooding* - *Would be great to do it more interactively* - *I did not really understand the aim of the trip*
Comments to Field day 2 (cohort 2)
- *It did not feel like it was planned very well* - *Too big a group for this, not coordinated fieldtrip* - *Good to have a different perspective on how to educate our pupils* - *Nice and relaxing, interesting guided tour. Nice variation from all the lectures*
Comments to Field day 4 (cohort 1-2)
- *Loved that day, activities were cool* - *Nice calm day. Not educational enough. Took way too much time for little learning.* - *I really really enjoyed it. Because we were outside, saw something of the country and learnt about climate change* - *It was strange... So many stops... I liked collecting shells part, dinner, Information about "the island".. But excursion was not memorable...*
Comments River walk 3 (cohort 3)
- *Fun and actually felt the importance when you see the river and the dike in front of you* - *This fieldwork really helped me to understand certain topics better.* - *Loved it! Very exciting, insightful, and the method motivated me to pay attention and try to understand what we were looking at.* - *Fantastic!*

A simple score for an activity by participating students is only a crude measure for deciding on the quality of such an activity. Therefore, we further reflect on the different types of fieldwork included in EduChange using the guidelines from Remmen & Frøyland, (2017) and the model from Oost et al. (2011). From the outdoor activities we have selected five quite different activities and we present them as five case; A-E.

Case A - Urban field excursion

Role of teacher: Provider of knowledge

Role of students: Listeners

Example: Urban walk (urban field excursion, part of Field day 1) -> teacher led talk and excursion, invited expert as guest speaker.

Table 7: The authors' qualitative evaluation of which learning objectives were achieved during the EduChange urban field excursion. Based on time schedules and personal notes.

Learning objectives	Affective	Skills	Cognitive
	X		X
	New country, new biotopes, new areas		New information from experts of the actual field

This activity was a typical guided tour with the speaker as the specialist and the students as listeners. It started with a brief lecture to introduce the topic. The interaction was open to questions, but the format of a group of more than 30 participants, and urban noise, did not facilitate optimal dialogues involving the whole group. With a quite diverse group of students this format could be challenging with regard to the acquired level of information. One positive outcome was the opportunity to see different systems for the filtration of rainwater in practice, and with an expert guide. Experiencing the differences between how this was carried out in this location and in the students' home countries worked as a starter to many fruitful discussions among the participating students. This type of cross-country discussion was highly appreciated by the students and mentioned in the evaluation as even more valuable than visiting new places/countries in itself. This type of excursion is placed in the lower left corner of the Oost et al. (2011) model (Figure 4). As you can see from the discussion above, this does not mean that this type of excursion necessarily has less value or should be avoided. As with all forms of teaching, the most important aspect is that the teacher is aware of the aims, teaching methods and expected outcomes.

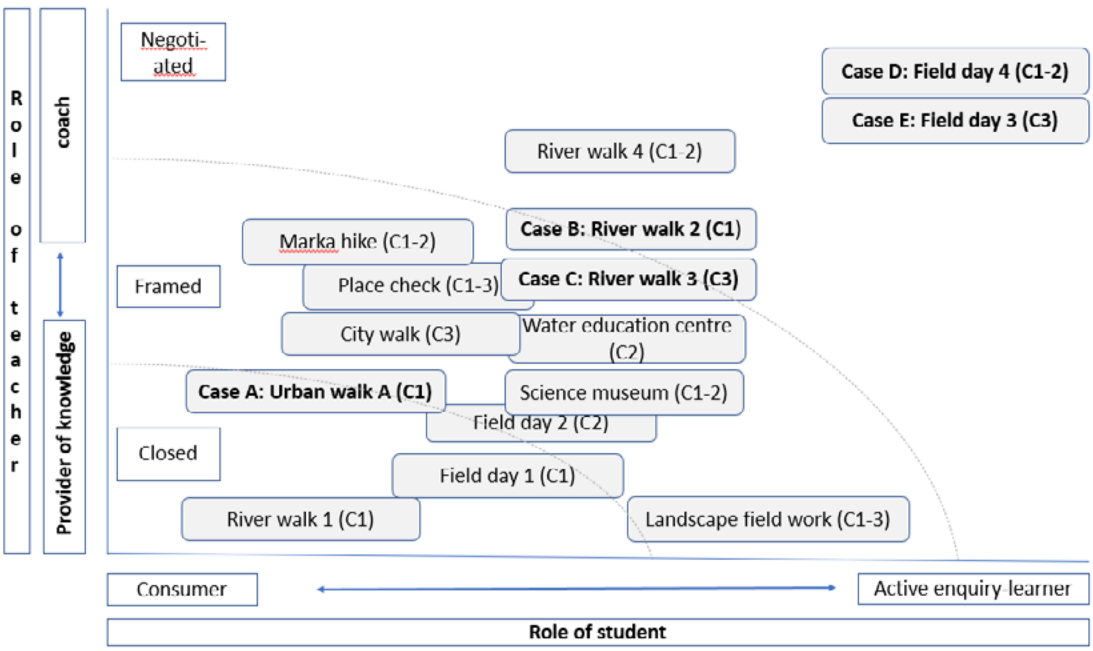

Figure 4. A redrawn version of the Oost et al. (2011) model (Figure 3), with our five cases put into the model in bold, the other activities are from Table 3. C1, C2 and C3 in brackets refers to the three cohort of students.

Case B – Rural field excursion

Role of teacher: Provider of knowledge

Role of students: Listeners and observers

Example: River walk 2 (rural) -> teacher led talk and excursion, with ample time for exploration, reflection, questions and observations.

Table 8: The authors' qualitative evaluation of which learning objectives were achieved during the EduChange rural field excursion – River walk 2. Based on time schedules and personal notes.

Learning objectives	Affective	Skills	Cognitive
	X		X
	New country, new biotopes, new areas		New information from experts of the actual field

This guided river walk created the opportunity for students to experience a new habitat, photograph new species and see new biotopes. The trip was guided by an expert who occasionally provided expert information about the biology and the water system of the area. This type of rural excursion with a big group of approximately 30 people has similar challenges to an urban excursion with big groups, except for the absence of traffic noise. The group was often widely separated, with some students walking slowly and soon lagging behind. On the other hand, the enthusiasm of the lecturer on such trips can be contagious for students, so that through the teacher's fondness for the place students learn to appreciate it. Even if this type of excursion may lack opportunities for optimal learning of skills and cognitive knowledge, it has high quality elements related to the affective domain, and can therefore be used to turn a visit to unknown areas or biotopes into a memorable experience – which explains the value students placed on it. This type of excursion is placed in the lower left corner of the Oost et al. (2011) model (Figure 3).

Case C - Field research:

Role of teacher: Provider of knowledge AND coach

Role of students: Active learners

Example: River walk 3, in rural area, with dedicated student tasks such as assignments and mysteries.

Table 9: The authors qualitative evaluation of which learning objectives were achieved during the EduChange field research. Based on time schedules and personal notes.

Learning objectives	Affective	Skills	Cognitive
	(X)	X	X
	New country, new biotopes, new areas	Procedural – using tools	Tools used to acquire information

The excursion we have chosen as Case C emphasizes student activity to a higher extent than cases A and B, and is in the middle or upper right corner of the Oost et al. (2011) model (Figure 4). The fieldtrips that fall into this category were highly appreciated by the students and from a pedagogical learning point of view this is supposed to give the best long-range learning outcome and, hopefully, provide in-depth learning. It could be a challenge to place enough focus on the subject matter knowledge when introducing tools for exercising fieldwork skills.

This can be solved by providing tasks that place the students in situations where knowledge of the subject matter is needed in order to solve the tasks done by using different tools (digital or analogue). The affective part of an excursion can be lacking if the focus on tasks, skills and knowledge of content matter is too strong.

Case D – Student led guided and enquiry-based field trip (river walk)

Role of teacher: Coach of the student leading the excursion

Role of students: Active teachers (6 member of the group) and active learners (remainder of group)

Examples: River walk 4, urban, with ICT support. Mix of guided tour and field tasks supported by Esri Survey123 mobile app for collection of place-based field data.

Table 10: The authors' qualitative evaluation of which learning objectives were achieved during the EduChange student-led field trip (River walk 4). Based on time schedules and personal notes.

Learning objectives	Affective	Skills	Cognitive
	X	X	X
	New country, new biotopes, new areas	Procedural – field methods	Field methods used to acquire subject matter information

The activities included in case D were enquiry based activities in the middle of the Oost et al. (2011) model (Figure 4), with elements of a guided tour (by one student group) combined with ICT-supported enquiry-based tasks with some frames and support structures. The technology worked well from a technical perspective; however, some participants did struggle with the assignment: not knowing when to collect data and to what purpose. The effective use of such technology is highly dependent on skilled supervisors in the preparation and implementation of the tasks on the tablets. Both the preparation and the guiding were done by the student group. This student-driven excursion was quite different from the rest of the course but was well received by the other students, and the session seemed to be a success.

Case E - Enquiry based fieldwork

Role of teacher: Coach

Role of students: Active learners

Examples: Field day 4 – open-ended investigations of biotopes and landscapes. Island beach assignment.

Table 11: The authors' qualitative evaluation of which learning objectives were achieved during the EduChange enquiry-based fieldwork – Field day 4. Based on time schedules and personal notes.

Learning objectives	Affective	Skills	Cognitive
	X	X	(X)
	New country, new biotopes, new areas	Procedural – field methods	Field methods used to acquire subject matter information

The activities included in Case E are enquiry-based activities in the upper right corner of the Oost et al. (2011) model (Figure 4).

This approach to fieldwork was implemented through an assignment involving a survey of a beach area, including registering plants and animals for nature management purposes. This activity combined the experience of encountering a new environment with the acquisition of knowledge about a subject and with the opportunity to practice survey methods. It was highly appreciated by the students. One important factor in its success was the openness of the assignment and the time dedicated to the task: students had an hour to look and walk around, and this allowed them to move beyond a quick superficial gaze. The cognitive outcome for individual students varied due to practical reasons: the area was wide, and few mentors were available for questions or to stimulate students to continue their search. But a small task to be handed in and a plenary summing-up, where all students presented a picture they had taken, with a biology teacher's comments accompanying each picture compensated in some way for the variance in the biological subject matter outcome in the field. The task was introduced and concluded in the field, but for the second cohort a more extensive debriefing was carried out in class the next day. Here students also reflected on their experiences and what the exercise had meant for them.

Lessons learned: Discussion & conclusion

In this chapter, through the overall description and reflections on the outdoor activities, and the more detailed analysis on the five cases, we have described how we used fieldwork to teach about climate change and to prepare students for their role as climate change educators. We have provided insights into the benefits of fieldwork, but we have also hinted at the challenges teachers will encounter when conducting fieldwork or outdoor learning in an "expanded classroom". Perhaps the main challenge was not mentioned explicitly: **time**. One should not underestimate the time needed for planning, designing, conducting, reflecting on and improving fieldwork and outdoor educational activities.

The other challenges relate to different aspects of the educational designs for outdoor activities and thus relate to the 6 corners of the didactical diamond model or, as frequently used in Norway: the didactical relational model, developed by Bjørndal & Lieberg (1978). These didactical considerations are; learning conditions, setting, goals, content, learning process and assessment. In this last section of the chapter, we will summarise the lessons we learned from the EduChange programme. This discussion comes under four headings which similarly relate to the didactical relational model: learning outcomes, communicational aspects of learning, course design, and setting

Learning outcomes

In the EduChange course our aim was to teach about climate change and water resources. For this purpose, fieldwork can be used to achieve cognitive, affective and psycho-motor learning objectives. A lot of walking was involved in all the outdoor activities and students experienced weather conditions they may have not been used to. Some learned the hard way about the importance of proper clothing and shoes. The acquisition of subject matter knowledge is one of the core concepts of Schulman's (1987) "knowledge base" of teaching (see chapter 1 of this book). We cannot draw strong conclusions concerning the content knowledge that the students' acquired through the field activities as no knowledge tests were included pre and post field activities. The evaluation posed rather open-ended questions about how students valued the learning outcome. Their feedback is quite diverse, which is perhaps not surprising due to their quite different backgrounds in science, geography, environmental sciences, and social sciences. The overall impression from the students' evaluations (Table 4 & 5) of field activities was positive. Even students that were on "home turf" during fieldtrips reported having learned from the interaction with fellow students who were unfamiliar with the place.

Looking back on the five elaborated case studies and the totality of field and outdoor activities in the programme, we can conclude that each cohort of students was able to work on various aspects of learning: cognitive, affective, or skills. The five case studies also show that not all activities in the field were placed in the upper right corner of the Oost et al. (2011) model.

It is crucial when designing outdoor education, as Remmen & Frøyland (2017) state, to be conscious of the aim of the teaching session and the expected outcomes of the teaching. For the lecturers who designed the fieldwork or outdoor activities, the challenge was to connect the use of innovative teaching methods with realistic situations and essential knowledge of the subject matter – to prevent the incidence of "medium drowns message" or of the students just learning tricks (how to use certain tools) without a deeper understanding of the pedagogical content value of an activity or tool or the local climate change issues.

The affective part of carrying out fieldwork is essential (Wilson et al. 2017). To measure this in a valid way requires a much larger sample and a rigid survey set-up, which we did not develop during this project. However, we ensured the students completed a rather open evaluation questionnaire and we held an evaluation session at the end of each international meeting. As the contact between teachers and students during the week was close and open and students also shared their thoughts and experiences frankly during the week. Many of the field and outdoor activities did have a clear affective impact. Students stated that the activities were fun, cool, exiting, enjoyable, nice (Table 6). The importance of first-hand experiences was also noted by students and had an impact on them: from seeing the amount of waste that washes onto a beach, to seeing a neighbourhood that was built below sea level.

Communicational aspects of learning

Whether teaching and learning takes place inside or outside the classroom, the core mechanisms of communication are the same, with some additional challenges related to noise or vocal range in the open air. In addition, there are some differences in the equipment normally used by teachers in the classroom, blackboard, whiteboard or screen, but this is sometimes solved by the teacher bringing big pictures, books, small portable white boards or printed matter such as maps. Regardless of where teaching takes place, the interactive (or lack of it) forms of communication are the same, and teachers should take into account the aims of their communication – whether they strive for real dialogue, monologue, interactive communication or just a message (Scott et al. 2006b). In the EduChange project we saw all these types of communication. The potential offered by more interactive teaching and "probing dialogues" as Scott et al. (2006b) name it, could have been used more often. In their evaluations, some students also noted this potential for "more interaction" – as one student commented regarding one of the river walks.

When planning a course such as EduChange with teachers from four different countries, all educated in quite different disciplines (pedagogy, geoinformatics, geography/geography education and science/education), and in equally varying educational cultures, there is a huge potential for synergy, but also a risk of diverging opinions on education, and language barriers can exist. These differences can hinder communication among team members and in educational settings. However, the experience was inspiring, and we strongly recommend to work in such an interdisciplinary international setting when doing fieldwork about such a wicked problem as climate change and preparing students to teach about climate change. The students seemed to appreciate the variation in styles between the lecturers. Initially some students may have felt a little hesitant to converse in English in the plenary sessions, but the social activities and small international breakout groups eased the awkwardness here.

Course design

Although the overall planning of the course programme was done in plenary team meetings, teachers had a fairly large amount of autonomy when setting up their field activities, and this is reflected in the huge variety of activities undertaken (as Figure 4 demonstrates). This was an important strength of the programme for the participating lecturers, who could also learn from each other. It also led to a varied programme for the week, and to a variety of activities over the three cohorts. There is a sense that after three rounds of designing – teaching – evaluating – redesigning the course as a whole became more coherent and effective; although the covid-19 outbreak did ruin the opportunity to test some redesigned elements of the ScienceJam – such as the overnight stay at a typical Norwegian cottage for extended fieldwork.

Although diversity was a strength of the course, one could wonder why the overarching objective of the course, that of improving climate change education through innovative place-based, playful teaching, was not translated into a common pedagogical view or handbook that grounded the whole programme and would be used to familiarize pre-service students with this method and to train them. On the one hand, we strongly concur with Remmen and Frøyland (2017) that one pedagogical model may not be able to attain such a wide range of objectives. But maybe we could have initiated an early discussion about this among the teachers in attempt to create a greater awareness of this challenge.

This could subsequently have led us to more explicitly explaining the design and purpose of each outdoor activity to the participants. While we strived for participating students to develop their TPCK (see chapter 1), we should not have predominantly introduced or debriefed each field trip with students being treated as participants. Our participating pre-service teachers strongly appreciated it when we shared the design principles and pedagogical groundings of the activities. This adds another dimension to fieldwork; besides the fun, the motivation, group dynamic, the content matter, the field research skills and experiencing new places. To improve this aspect even further, an idea could be to also include students in the preparation of the lessons.

Setting

One of the main premises of the whole EduChange project was to bring together students and teachers from different countries, and to enrich the learning environment through the pluralistic background of the teachers and students regarding culture, language, educational background and educational policy. In their reflections on the course, students highlighted the opportunity to meet students from different countries and different cultures as one of the main benefits. This was also experienced by the teachers who learned a great deal from planning together, and seeing their colleagues teach and interact with students.

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Appendix 1

Table 12: The EduChange programme's spread of types of teaching.

Percentage based on the approx. number of hours dedicated to different teaching activities through the 3-year project Erasmus+ project EduChange. All courses except spring 2020 are based on what was done, the spring 2020 course is based on what was planned, because due to covid-19 restrictions the course was held online.

Activity	2018		2019		2020	
Student managed fieldwork	5%	16%	6%	15%	5%	25%
Guided tours/field excursions	24%	21%	15%	19%	30%	25%
SUM outside classroom	**29%**	**37%**	**21%**	**34%**	**35%**	**50%**
Lecturing (with dialogue and student activity)	18%	27%	23%	29%	10%	12%
Game-based activities (digital and analogue)	8%	7%	5%	8%		
Mini conference with student presentations			10%		8%	
Student work compendium		21%		11%		14%
Other student presentations				6%		6%
Reflection/assessment/evaluation	9%	3%	7%	8%	10%	8%
Administrative orientations	3%	4%	3%	4%	2%	4%
SUM inside classroom	**38%**	**63%**	**48%**	**66%**	**30%**	**44%**
Workshops (student actives and lectures; digital and analogue; indoor and outdoor)	28%		23%		35%	**6%**
Visit to science centres (guiding and activities)	5%		8%			
SUM mixed inside/outside classroom	**33%**		**31%**		**35%**	
TOTAL SUM Hours	**38**	**28**	**40,5**	**26**	**46**	**36**

CHAPTER 4: TECHNOLOGY AND GAMIFICATION DURING THE EDUCHANGE PROJECT

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Abstract

The chapter focuses on examples of how information and communication technology, specifically Geoinformation Technology (GIT), can be utilised in teaching, and not only for geographic topics. The authors focus on mobile applications for both data collection and field education. We will mainly build upon our experience from the EduChange workshops and students´ activities, where technology was used for outdoor education. The goal of the chapter is to present geographic inquiry learning, and the ways in which GIT can support it.

Introduction

The field trip experience and outdoor education have a long history in geography teaching (Ploszajska, 1998). According to Kent, Gilbertson, and Hunt (Kent, Gilbertson, and Hunt 1997, p. 313) *"fieldwork is widely regarded as an essential part of undergraduate education in geography… and field experience is also seen as vital for the development of students as qualified practitioners in all aspects of geography"*. Field education, whether we call it field-work, field-trip or excursion, has changed in order to reflect the developments in technology as well as in pedagogy and practices in the field. Furthermore, the mode of learning has changed from "tourist-like" excursions towards more student-led inquiry (Higgitt, 1996). Experience in the field provides a great opportunity to develop students' skills and to equip them with these skills for research and for work. Students appreciate the novelty of being in a new place and the experience of doing practical work with peers and academics, away from the classroom, laboratory or formal teaching space (Simm & Marvell, 2015). A recent innovation has explored the potential of more "playful" ways of carrying out field investigation that explicitly stresses the importance of creativity and more open-ended exploration, instead of the normative practising of skills (Lammes & Perkins, 2016; Phillips, 2015).

Drawing upon the increasing coverage of the mobile internet, location-based services and gamification of (geography) education, this chapter describes our experience with the implementation of geospatial technologies in outdoor geography education. We have worked with students from four European countries – Czechia, the Netherlands, Norway, and Malta. In 2018, the smartphones coverage in these countries varied from 63% in Czechia (Czech Statistical Office, 2019) to 87% in Norway (Statista, 2020b) and the Netherlands (Statista, 2020a), while Malta was 74%, somewhere in the middle of the group (Hootsuite, 2018). We focused on mobile applications, which can be easily without a charge used by teachers and students in outdoor/field geography education. The chapter also fits into the Technological Pedagogical Content Knowledge (TPCK) framework as described in chapter 1, with more of a focus on the "T" - the technology that (future) teachers will need to integrate into their lessons.

Used applications can be divided into three categories:

1. Applications bringing additional information to students while they are on a field trip
2. Applications allowing students to actively participate in the process of learning
3. Educational spatial games

In the following section, we will shortly describe each of the above categories along with the applications that belong them and that were used. We will characterize the applications' functionality, and explain how we used them during the EduChange project educational activities. The project took place at different places over three years so we had to adapt the use of the applications with regard to place-based conditions.

Applications bringing additional information to the students while they are on a field trip

In order to ensure more student-led inquiry during field explorations a variety of mobile map-based apps can be used. During the EduChange field-courses we mainly worked with mobile versions of various Esri StoryMaps templates, such as MapJournal (Figure 5). Please note that in 2019 pre-defined templates were replaced by a new build of StoryMaps; however, still using the available institutional account.

Using StoryMaps for presenting study materials has become popular in recent years (Kerski, 2015) in such fields as history (Abrate et al., 2013; Coleman & others, 2015), migration (Kerski, 2013) and protection of the ecosystem (Crocker et al., 2015; Fox, 2016). Regarding our EduChange project, the Esri StoryMaps application mainly served as a visual and contextual support for students during teacher-led field courses in order to put the information into a geographical context. Students were also given tasks that required usage of the StoryMaps software installed on their own devices. Usually, it is back in the classroom where students are taught how to create their own StoryMaps. For creating applications that students could use in the classroom and in the field, two Esri products were used – ArcGIS Online and the already mentioned Esri StoryMaps.

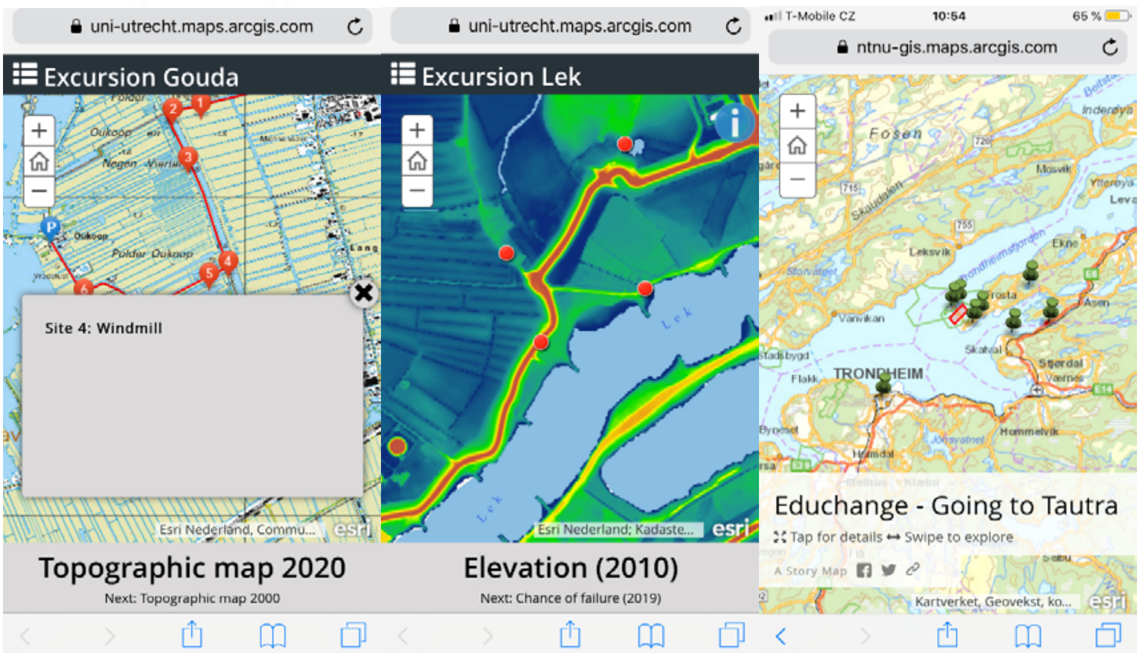

Figure 5: Examples of three various Esri StoryMaps on mobile devices as used during the EduChange project.

Before designing StoryMaps, it is advisable to create an account via ArcGIS Online (as a gateway for the use of other Esri applications). ArcGIS Online is a cloud-based mapping and analysis platform from Esri (Esri, 2018b) that gives users access to workflow-specific apps, maps and data from around the globe.

It also provides the tools to use when mobile in the field (Pánek & Glass, 2018) raising questions about how to integrate and analyse data from multiple users. Collector for ArcGIS allows researchers to gather multi-sensory field data, and is therefore a prospective way to integrate qualitative and quantitative information. We evaluate students' experience using Collector in an exercise that considered the senses of place in a research neighbourhood. Collector proved somewhat effective, yet requires significant technical expertise to integrate into research assignments. We describe the strengths and weaknesses of mobile applications such as Collector, and provide solutions for faculty interested in mobile applications for the field-based capture of multi-sensory (Pánek & Glass, 2018). In order to use ArcGIS Online platform people must have a login, either an ArcGIS Public Account or an Enterprise login (Esri Account). The Public Account is free, but has some limitations (e.g., some advanced services or data upload limitations). It is possible to upload shapefiles that are available as layers (if they have no more than 1,000 features) and the total storage limit is 2GB. On the other hand, the Enterprise login is less restricted, but usually available only to institutional customers who pay for it. Nevertheless, the Public Account for ArcGIS Online is sufficient to work with for learning and teaching purposes.

All data and maps are stored in a cloud, hence they can be accessed from anywhere and at anytime. The interface of ArcGIS Online allows users to upload offline data in the form of shapefiles, CSV files, GPXs or GeoJSONs. Furthermore, online data can be linked to as ArcGIS Online layers, ArcGIS Server web services, WMS/WMTS/WFS, Tile layers, KML files or GeoRSS files. ArcGIS online is not just a tool for creating online maps, it provides users who have limited or no coding skills with the options needed to make web apps or 3D web scenes.

ArcGIS Online is the first step in the process of creating a StoryMap as presented above. StoryMaps let you combine authoritative maps with narrative text, images and multimedia content. They make it easy to harness the power of maps and geography to tell your story. Users can login via an already existing ArcGIS Online account (institutional or public), or it is possible to access StoryMaps by using other logins from such services as Facebook, Apple, Google or GitHub. Once logged in, there are several features, which can be used to create an online map presentation. Below, we will focus on two of the easier templates from the former release of StoryMaps.

During the EduChange project, we mainly used two templates; "Shortlist" and "MapJournal". "Shortlist" presents a set of photos or videos, along with captions, linked to an interactive map. It is ideal for walking tours or when seeing a sequence of places in a specific order. All the author needs to do is to link pictures from an online repository (in the case of a free account) or upload pictures (in the case of an institutional account). If the pictures are geocoded, i.e., they have geographic coordinates included in the picture information gathered, for example, from a smartphone's GPS receiver, they will automatically appear on a map. If they do not contain this information, they can be easily placed on the map manually, by clicking on a picture and then clicking on a place on the map where the picture was taken. Once all the pictures are located, it is possible to edit captions, texts, labels, etc. The final version of the map can be saved in the cloud; there is no need to download anything and it is available online anytime.

"MapJournal" is somewhat more sophisticated than "Shortlist" and allows users to create an in-depth narrative organized into sections and presented in a scrolling side panel. As users scroll through the sections in a MapJournal they can see the content associated with each section, such as a map, a 3D scene, images, videos, etc. Each "page" of a MapJournal is built from two parts; a stage (very often a map) and a side panel (usually a text). Maps in the stage area can be pre-created or they can be created during the process. In the side panel, any text can be inserted in the text into webpages, together with photos, videos or even maps. Using such functionality we prepared StoryMaps for our students. Those StoryMaps included a number of layers (see Fig 6.) and were equipped with site tasks and group activities and questions (Fig 7.). Various layers, usually maps depicting different themes, can then accompany the verbal interpretation of a teacher. As a result, StoryMaps combined with students' in situ experiences (to "see, touch and feel" visited place) and a teacher with expert knowledge ensure that the learning process is comprehensive and still not cognitively overloading.

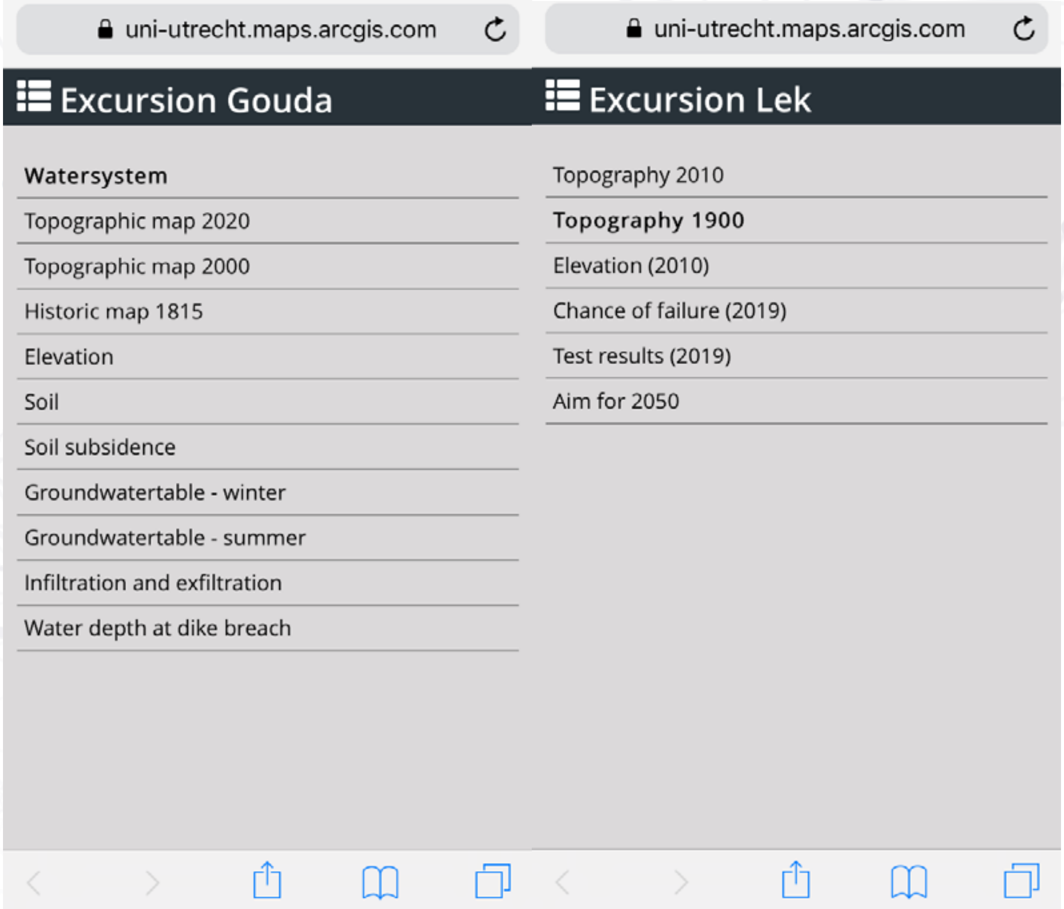

Figure 6: Different layers used to explain two topics during a field-work in the Netherlands.

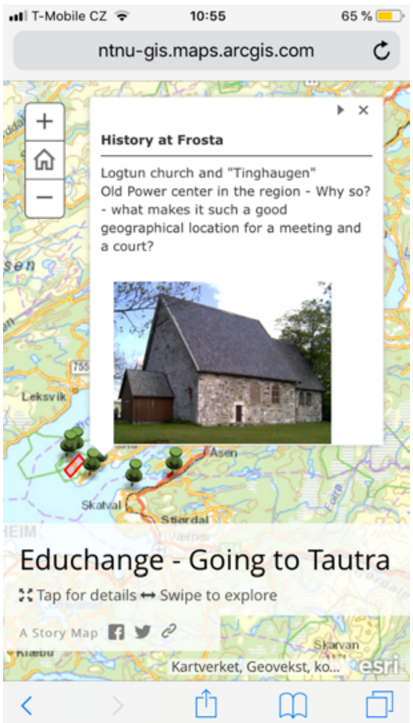

Figure 7: An example of a site task used during the field-work held in Norway.

For the sake of completeness, it is worth mentioning the newest version (as of August 2020) of the StoryMaps software, is known as ArcGIS StoryMaps. After logging in to this new version, users are offered a single one starting template. It is later possible to enhance the functionality of StoryMaps by adding various features such as buttons, images, video or audio (Figure 8). Although the latest version of the StoryMaps software does not contain various pre-defined templates, the whole web-based application is intuitive. Besides text and multimedia, it is possible to embed other webpages, insert maps (either already created in ArcGIS Online or created instantly in the StoryMaps designer), insert sections/blocks to structure the content, and also to change the design in order to customize a story's appearance.

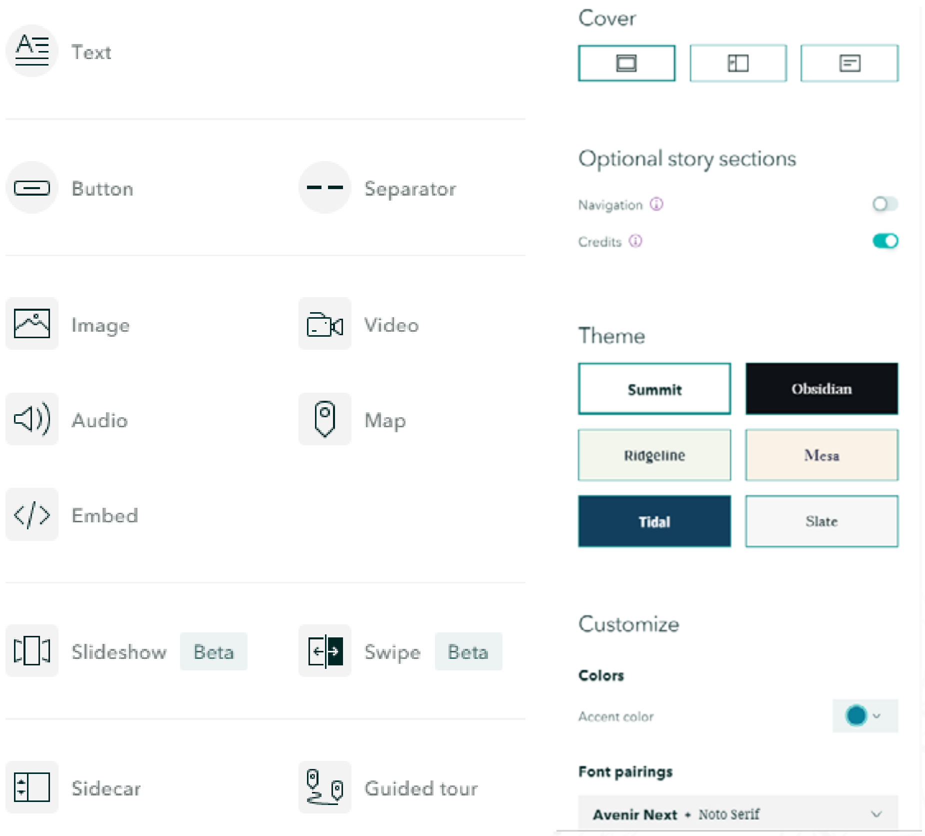

Figure 8: List of functionality and design features in the latest version (as of August 2020) of ArcGIS StoryMaps.

Applications allowing students to actively participate in the process

In the EduChange project, the StoryMaps software was mainly used as a teachers' support tool in field lectures and the students did not actively participate during the process of creation of the Story Maps. In turn, we used Crowdsource, Survey123, Mentimeter, and Kahoot! to directly involve the students in collecting spatial data, and in discussing the topics of the lectures.

Crowdsource and Survey123

We started with the Story Map Crowdsource app template originally released in June 2016. Unfortunately, Esri has decided to focus on narrative and place-based stories in which the content is assembled by the story's author, and the company discontinued the development and support of the Crowdsource template in June 2018 (Esri, 2018a). However, we were able to use the Crowdsource template in the first cycle of EduChange for our workshop on data collection (see example (EduChange, 2018)). The workshop was designed as an introduction to mobile mapping applications that could be deployed in field surveys. The main goal of the workshop was to demonstrate the advantages of digital data collection and how easy it is to use existing mobile mapping applications. Students learnt to set up the mapping campaign and to collect data which they could later use for their own studies or as teachers in their own classes.

In the following years, we used another Esri software Survey123 for data crowdsourcing in the field. Survey123 is a form-centric solution from Esri for creating, sharing and analyzing surveys (Esri, 2020). Survey123 served the purpose of our data-collection workshop. The disadvantage of using Survey123 was that an institutional account is needed in order to create a survey; however, for using a survey already created a free account is sufficient. This erected certain barriers for some students and teacher assistance was sometimes needed to set up a survey. On the other hand, recent changes in the pricing policy of Esri towards educational institutions have made institutional accounts more affordable (see more at www.esri.com/en-us/industries/education/licensing). Another option for field (geo)data crowdsourcing is the application called Collector, also from Esri, nevertheless, this application features some disadvantages, for example, in setting up the questionnaire as discussed (Pánek & Glass, 2018) raising questions about how to integrate and analyse data from multiple users. Collector for ArcGIS allows researchers to gather multi-sensory field data, and is therefore a prospective way to integrate qualitative and quantitative information. We evaluate students' experience using Collector in an exercise that considered the senses of place in a research neighbourhood. Collector proved somewhat effective, yet requires significant technical expertise to integrate into research assignments. We describe the strengths and weaknesses of mobile applications such as Collector, and provide solutions for faculty interested in mobile applications for the field-based capture of multi-sensory (Pánek & Glass, 2018). There are also other open source applications, such as Qfield and Gisella, but none of them were tested and deployed in EduChange so they are not described here.

Mentimeter and Kahoot!

Another group of tools we have used in the classroom and in the field is the mobile apps that allow direct and instant feedback during activities and classroom sessions. There is a number of different apps; nevertheless, we mainly used Kahoot! and Mentimeter. Both apps have also been used in various teaching environments outside the EduChange project (Mayhew, 2019; Wang & Tahir, 2020).

Kahoot! is a game-based learning platform which is used as educational technology in schools and other educational institutions (Kahoot!, 2020). "Kahoots" are user-generated multiple-choice quizzes that can be accessed via a web browser or the Kahoot! app. The app was developed in cooperation with the Norwegian University of Science and Technology in 2012. In the EduChange settings we used Kahoot! as an instant-survey method which gave us feedback from the students, and they used it as playful feature during their presentations.

Mentimeter is a Swedish company that develops and maintains the app of the same name, which is to be used to create presentations with real-time feedback (Mentimeter, 2020). We mainly used Mentimeter to trigger discussions after lectures. It helped students to come up with questions, which were then displayed in a collective settings (Figure 9). This helped us, as teachers, to facilitate and structure the discussion effectively.

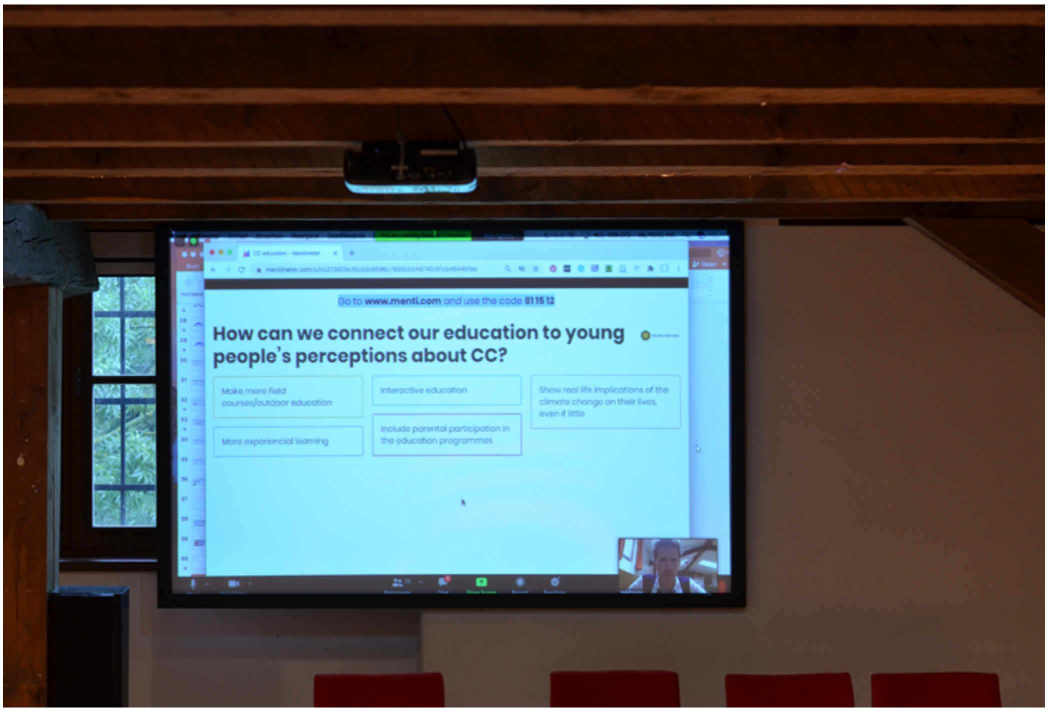

Figure 9: We used Mentimeter to collect concepts that were next collectively displayed to trigger the discussions about climate change education.

Educational spatial games

Besides the mobile apps and platforms introduced above, in EduChange, we used two spatial games – Fishbanks and Y-Floods, to teach about climate change. The main goals were to actively involve students in working in teams and to stimulate their interest in a particular environmental topic.

Fishbanks

Fishbanks: A Renewable Resource Management Simulation (Figure 10) is a multiplayer web-based simulation in which participants play the role of fishers and seek to maximize their net worth as they compete against other players and deal with variations in fish stocks and their catches (MIT Sloan School of Management, 2020). Participants buy, sell and build ships; decide where to fish; and negotiate with one another in order to ensure they make a profit (Ruiz-Pérez et al., 2011; Sala et al., 2016) a well-known fisheries management simulation game, was used to test the effect of institutional settings on the biological and economic performance of fisheries. The game was played by 48 groups of between 20 and 25 undergraduate Environmental Science students in two different time lengths (10 years versus 15 years. The learning/tipping point of the game is the tragedy of the commons (Hardin, 1968) and the exhaustibility of the natural resources (in this case the fish). The game was created by Dennis L. Meadows, the co-author of the Limits to Growth (Meadows et al., 1972). The game is available for free online with all resources needed or the hardcopy desk game can be ordered.

During the EduChange workshop in the first year of the project students were introduced to the game's rules and the basic idea behind the game. The game was played in teams composed of students from different backgrounds. Students had to cooperate with their teammates while competing with the other teams. The feature of competitiveness was one of the most appealing factors in the teamwork process, and the topic of the game (a trade-off between economic profit and environmental sustainability) served as a content-specific learning goal.

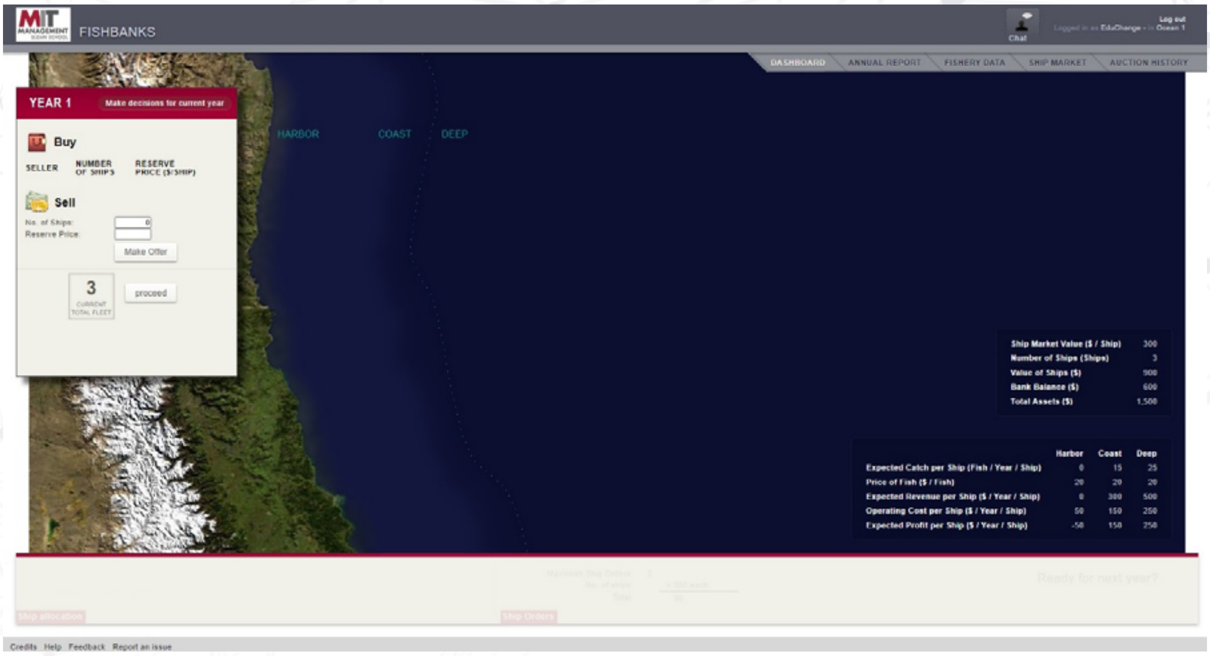

Figure 10: An example of the Fishbanks game environment.

Y-Floods

In contrast to the MIT-created digital game Fishbanks, Y-Floods is a board game created by the first year EduChange participants. The objective of the game is to build a city within a time limit of 20 minutes on a board provided (Figure 12). The main learning outcome from playing the game covers various topics and contexts. Players first have to play the part of city (spatial) planners by thinking of a logical city template (e.g. by placing a school near a residential area). However, at the same time, they need to consider the risk of floods and the resilience of the cards. On top of that, they have to balance the financial and human factors involved in losing a card.

Each team obtains a game board and the same amount of game cards (18 building cards + 4 bonus cards) which should all be placed on the game board. After that floods will come. The aim of the game is to save/protect as many building cards as possible and, at the same time, to minimise losses (see points' allocation below). Building the city has to start near (touching) the river and there have to be at least three building cards placed on both sides of the river (this does not apply to the peninsula). The only requirement regarding the allocation of the cards is that they have to be adjacent to each other – there cannot be any gaps between the cards, so the city will be formed from contiguous "parcels".

Figure 11: An example of the Y-Floods game card.

The building cards have various values (Figure 11). The values come from the resilience level of the building. Furthermore, each building card has a financial value and a "human factor" value. Cards can be distributed as the players like, following the rules stated above and below. There are also bonus cards without financial and human factor values. Bonus cards include "Waterfront" and "Flood control measures", and can only be placed on the sides of the river. They "protect" (meaning they give bonus points for resilience) the building cards which border them and which are not touching the river. The bonus card "Trees" can be placed anywhere on the game board and each building card touching a "Trees" card will get a bonus point (maximum of six cards per "Trees" card can get bonus points). A bonus is not calculated for building cards on the other side of the river (i.e. bonus cards cannot "protect" building cards across the river).

Figure 12: An example of the initial settings (before the flood comes) of the Y-Floods game.

There are 3 types of flood-danger zones on the board (Figure 12). The zones represent how much the incoming floods will affect the buildings in each zone. Building cards in the red zone have no bonus (i.e. the floods will affect these building cards the most), building cards in the orange zone have bonus +1, and building cards in the green zone have bonus +2 towards their resilience value.

After the city is built (usually about 20 minutes), the flood comes. The intensity of the flood is decided by a throw of the dice. Thus, the floods can reach levels from 1 to 6. Each level of floods causes a variety of damage. For example, if a throw of the dice shows a 3, each building card will suffer with -3 points being removed from its resilience value. Similarly, if there is a 6 on the dice, each building card will suffer with -6 points being taken off its resilience value. After the floods, for each building card, the team has to calculate, what the "damage" on the building is. If the resilience value is 0 or less (e.g. -2), the building is destroyed.

Each team counts its score points. Count points for financial value and "human" factor value separately. Teams are ranked in financial aspect and "human" factor aspect. Finally, the team with the highest ranking(s?) composed from both aspects (not from overall point count) wins the game. For each building that is not destroyed, a team gets positive points according to financial and "human" values (i.e. card with values 5/3 -> 5 points for financial aspect, 3 points for "human" factor aspect). For each building that is destroyed, the team will get negative points analogically. If there are teams with the same joint rankings, the team with lower value of "human factor" wins.

Discussion and Conclusion

In this chapter, we briefly characterized mobile applications and games that we used in our EduChange project's workshops and lectures. It is an indisputable fact that the digitalisation and gamification of education has brought many advantages to the learning process, as it increases learners' motivation, engagement and performance (Hallifax et al., 2019).

Regarding our project, with the use of GIT students feel more centred and involved in the classes, which helps them absorb new knowledge and gain new competences. This is not the only reason we tried to incorporate modern teaching elements into the project courses; we also aimed to offer students a broad overview of the learning/teaching techniques and tools. From the feedback we received, students mostly appreciated this approach, which combined classical lectures with digital technologies and playful learning. Many of the students will become teachers and they expressed their intention to include modern educational methods in their future classes. On the other hand, for teachers, the implementation of such digital and playful features in their regular classes, often lasting 45 minutes, means extra time and efforts needed for their preparation. Preparations include lecture design, the application of game pre-settings, and testing / contextualizing the use of technology in the topic of a lecture. Furthermore, often, the technological progress and frequent changes of the apps require teachers to update their lectures constantly.
A certain role may also be played by the still existing digital divide (e.g. Milakovich & Wise, 2019), which could disqualify some students from the learning process. However, we firmly believe that the use of ICT tools means added value in the teaching process, and specifically in the case of the EduChange project on climate change issues.

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CHAPTER 5: TRANSFORMATIVE PEDAGOGIES - A USEFUL THEORETICAL FRAMEWORK FOR PROMOTING ESD

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Abstract

So significant is the contribution that constructivism has made to education, that it has been described by the American Association for the Advancement of Science as a 'paradigm change' in science education (Tobin, 1993). Such changes in education raise political, ethical and moral claims that have consequences that directly affect classroom ecology. These claims are intimately linked with issues such as the "emancipation of student learning" (Jenkins, 2000). Besides such issues, constructivism raises fundamental epistemological issues that have been the cause of many debates (Harding et al., 2000; Jenkins, 2000; Millar,1989; Osborne, 1996; Philips, 1995; Scaife, 2007; Solomon, 1994 & von Glasersfeld, 2000). The first part of this chapter will present a critique of constructivism and some of its exponents.

Following the critique, the manner in which constructivism has linked with critical pedagogy to yield a transformative pedagogy will be discussed. By definition, a transformative pedagogy is an 'activist pedagogy' that empowers people to critically examine their beliefs, values, and knowledge with the goal of developing a reflective knowledge base, an appreciation for multiple perspectives, and a sense of critical consciousness and agency (Ukpokodu, 2009). Finally, this contribution will provide some insights on how characteristics of transformative pedagogy have yielded other pedagogies, such as the eco-justice pedagogy. This pedagogy by its very nature addresses social concerns with the intention of promoting change, both on the micro and the macro level.

Introduction

At times, the realities of the classroom provide the painful realisation that teaching and learning are not being significantly affected by contemporary learning theories or by research work published in educational journals. Teachers seem to helplessly succumb to the traditional education system's demands, and few bother to view these demands with a critical eye so as to question certain practices.

Metaphorically speaking, when students come to class they not only bring their school case, they also bring with them their baggage of experiences, emotions, ideas and values; accumulated during their lives. When the learning process is put under scrutiny, this baggage tends to take centre stage more than the other appendages; digital tools, books, copybooks, pens and pencils. This invisible baggage is part of the picture that many constructivist theoreticians focus on, because it is, or should be, the starting point of any learning process. The old adage of 'going from the known to the unknown' is most often quoted on a practical and 'down to earth' note, rather than a philosophical one. Today, if quoted in the light of constructivist ideas concerning education, this quote would assume deeper implications about knowledge and learning.

The idea of having knowledge as something there to be 'discovered' was challenged at the beginning of the twentieth century (Nussbaum, 1989). This challenge resulted from significant developments in teaching and learning that had shed doubt on the absolute nature of knowledge.

Arguments from the fields of philosophy and psychology provided further views that knowledge is not discovered or objective (Popper, 1959), but it is a human construction. This scenario was catalytic to the introduction of a constructivist era that was to confront the schools of thought of empiricism and rationalism.

Constructivists and their contributions to learning – a critique

So significant is its contribution to education, that constructivism has been described by the American Association for the Advancement of Science as a 'paradigm change' in science education (Tobin, 1993). Such changes in education raise political, ethical and moral claims that have consequences that directly affect the classroom ecology. These claims are intimately linked with issues such as the "emancipation of student learning" (Jenkins, 2000) and "democratic constructivist science education" (Bencze, 2000). Besides these issues, constructivism raises fundamental epistemological issues that have been the cause of many debates (Harding and Hare, 2000; Jenkins, 2000; von Glasersfeld, 2000; Osborne, 1996; Philips, 1995; Solomon, 1994; Millar, 1989).

Solomon (1994) argues that many would agree that Piaget's early book – "The child's conception of the world" (1929) is an early constructivist text. An aspect of his theory that is relevant to learning is the idea of human adaptation through the processes of assimilation and accommodation. Piaget believed that in an adaptive act, the process of assimilation works for the preservation of already existing structures, while at the same time the process of accommodation works for variability, growth and change. Piaget (1970) contends that any adaptive act includes the occurrence of such processes in different proportions so that *"following on from a state of tension or disequilibrium caused by a change of environment, the organism has invented an original solution in terms of combinations, and thus brought about a new form of equilibrium"* (p. 54).

A key idea that is linked with the adaptive act is that learning is a process of construction. Donaldson (1978) states that Piaget insists:

"Knowledge does not come to us from the outside, 'ready-made'. It is not a 'copy' of reality - not just a matter of receiving impressions, as if our minds are photographic plates. Nor is knowledge something we are born with. We must construct it. We do this slowly, over many years." (p. 151)

Piaget's ideas provide food for thought and supports researchers and teachers in understanding the dynamics of the learning process. The fruit of such work is the classroom application of these theoretical insights. One such application is the work done by Duit (2007) who, when systematically studying students' conceptions, created an awareness of these conceptions and of the students' learning. Such researchers not only provided strong evidence that students' conceptions exist and need to be given due consideration when learning is in progress, but they also presented ideas about the cognitive processes that result in a classroom that can support learning.

One frequently quoted criticism of Piaget's studies is that his research focuses mostly on individual learning. This tends to eclipse the consideration that learning in a classroom setting also occurs through considerable social interaction. This aspect of the learning process was given considerable attention by Vygotsky in his ideas on social constructivism. In his studies, Vygotsky focuses on meaning-making, not in terms of the cognitive processes occurring in an individual, but in individuals as they function in social contexts. Vygotsky (1931) explained his ideas about this passage from a social context, such as the classroom, to individual understanding as follows:

Any function in a child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears as an interpsychological category, and then within the child, as an intrapsychological category. (p. 163)

As with Piaget, Vygotsky's ideas are theoretical and difficult to grasp. Teachers trying to grapple with this 'raw material' would probably not find it easy and relevant to their work. Again, the fruitfulness of such theoretical insights surfaces when researchers adapt them for the classroom. Mortimer and Scott (2003) applied these theoretical ideas for classroom practice in a science classroom by rewording them in a more comprehensible manner: First, the teacher must make the scientific ideas available on the social plane of the classroom.

Second, the teacher needs to assist students in making sense of, and internalising, those ideas. Finally, the teacher needs to support students in applying the scientific ideas, while gradually handing over to the students' responsibility for their use. (p. 17)

This process clarifies the ideas presented by Vygotsky earlier on and introduces a second main point of Vygotsky's work, the concept of the Zone of Proximal Development (ZPD). This concept is defined by Vygotsky (1978) as, "*the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more able peers*" (p. 86).

This definition emphasises the connection mentioned above between the social plane and the individual plane, and links the progress of learning of individual students with the role of the teacher and peers in supporting that learning. Besides introducing the concept of ZPD, Mortimer and Scott's quote also raises the point that the development of concepts normally starts at the social plane of the classroom and then is transferred to the personal plane of the learner.

This constructivist scenario, as viewed through the contributions of Piaget and Vygotsky, places an unbalanced emphasis on the cognitive dimension of the participants and in the process fails to acknowledge the students' affective dimension. The interdependence of these two dimensions is very closely linked but, to date, educational research has predominantly focused on students' cognitive processes. Teaching experience provides enough evidence of the need for teachers to attend to the students' affective side. Ignoring this dimension leaves researchers and teachers with an incomplete and fragmented picture of the classroom scenario and provokes one to question the completeness of research on student learning.

Teaching, learning and constructivism - some issues

Bencze (2000) puts forward a rather negative image of what can happen in a classroom when teachers opt to follow a constructivist pedagogy. In his quasi-caricature of the classroom environment he states:

Although pedagogical approaches drawing on constructivist learning theories often place students in environments that are to resemble professional knowledge-building communities, paradoxically, they also orchestrate students' re-constructions in order to harmonise with canons of Western science. Under the cover of social-constructivist epistemologies and Vygotskian pedagogies, students' prior conceptions are denigrated, their experiences regulated, their investigations shepherded, and their conclusions restricted. (p. 847)

Bencze's (2000) words stems from his apprehension that teachers adopting a constructivist pedagogy might pose a threat to the democracy of the classroom and to students' self-actualisation if they do not approach the class well-prepared to adopt this pedagogy. This apprehension is shared by Wertsch (1991) when he argues that teachers in a constructivist environment may find it very difficult to remain neutral during 'negotiations' that might occur during or after their students' inquiries. One can say that Bencze and Wertsch provide a negative scenario of the constructivist classroom environment, yet it is possible that this can be the case. This 'dark side' of the scenario can arise if a teacher ignores the epistemological challenges embedded in this pedagogy, and does not reflect on these **before** consciously accepting and embracing it. This malaise has been a problem whenever innovations have been presented in education.

Constructivism – a contributor to a transformative pedagogy

Constructivism contributes to transformative pedagogies by proposing that teachers and learners develop skills to help shape the world, as opposed to being passive acceptors of others' knowledge and understanding of the world. As stated earlier, Piaget (1970) believed that the learner's process of assimilation works for the preservation of existing cognitive structures, while at the same time the process of accommodation works for variability, growth and change.

Hence, the learner's cognitive processes contribute not only to valuable teaching and learning experiences, both within and without the classroom, but also to the development of a deeper self-awareness and a capacity to contribute to society by accepting responsibility for shaping the world.

Transformative pedagogy also borrows from constructivist research in the context of collaborative teaching and learning (Vygotsky, 1978). A constructivist pedagogy works at developing classroom scenarios that support learners in constructing meaning through interaction and discourse among teachers and students, and by creating dynamic links between school and society. These links need to be forged during the learning process since one of the implications of embracing a transformative pedagogy includes embracing moral and ethical values that support learners as contributors to the common good of society at large.

Insights from constructivism and their inclusion in a transformative pedagogy reduce the possibility of the situation described by Arnowitz and Giroux (1993) when talking about schooling in the USA: *"During these years the meaning and purpose of schooling at all levels of education were fashioned around the principles of the marketplace and the logic of rampant individualism. Ideologically, this meant abstracting schools from the care of democracy and equity while simultaneously organising education reform around the discourse of choice, reprivatisation, and individual competition."*

This dated but relevant quote indicates that promoting learners' critical awareness is not always made a priority when constructing one's meanings and making sense of the world. Knowledge construction should always be informed by moral and ethical values and geared towards personal as well as social transformation.

A second contributor to a transformative pedagogy – Critical Pedagogy

"Transformative pedagogy is defined as an activist pedagogy combining the elements of constructivist and critical pedagogy that empowers students to critically examine their beliefs, values and knowledge, with the goal of developing a reflective knowledge base, an appreciation for multiple perspectives and a sense of critical consciousness and agency." (Khedkar & Nair, 2016)

Combined with constructivism, critical pedagogy is seen as an essential ingredient of a transformative pedagogy. Critical pedagogy aims to analyse knowledge learnt through the lens of diversity and social justice and to prepare students to be agents of change. Teaching and learning processes both within and without formal schooling prompt transformative practices that engage students as active learners and critical thinkers. Furthermore, learners are given the opportunity to become aware of alternative possibilities of social reality.

Freire (1970) and other major contributors to critical pedagogy see it as a pedagogy that supports a person in developing a deeper understanding of the world so that they can see beyond surface level meanings, and perceive contradictions between social and political realities. While content knowledge is important, it has to be actively processed by the students. Freire's notion of joint reflection and action is essential and leads to what one can call 'emancipatory content' presented in a liberatory manner (Freire, 1970). This process would reduce the possibility of learners being presented with empty words that do not challenge them and provide only a standard view of reality. A reality that only encourages the status quo!

Transformative pedagogy – a paradigm shift

Transformative pedagogy has an underlying ethical, moral and social commitment to bring about personal and social transformations by linking teaching, learning and living. It supports learners in developing as whole persons with a sound moral character to uphold democratic ideals and ethical values that sustain humanity. Furthermore, it deconstructs the notion that individualism, money and the values of the marketplace should dictate social and educational discourse and, by inference, what living in today's world means.

A conceptual framework for transformative pedagogy needs to be based on autonomous teaching and learning. In view of its strong social conscience, this pedagogy proposes that more organized and systematic links are created between formal learning in schools and knowledge learnt through interactions in the context of wider society. Furthermore, it argues for the learner's lifestyle to be constantly informed by a moral and ethical stance. In concrete terms, it links teaching and learning processes with living.

Educational programs based on a transformative pedagogy recognize that the challenge in holistic education is more than just instilling new knowledge. Education requires an ongoing process of critical analysis, embracing responsibilities and humane values, and living democratic ideals of equality, freedom, and justice (Greene, 1993). Reflection coupled with dialogue and action can foster a critical awareness by which students and teachers see their experiences situated in historical, cultural and social contexts, and hence recognize opportunities for challenging and changing dominant structures.

Living sustainably involves making daily sustainable choices from the variety of options available, even if it involves going against the grain. Such a radical change in lifestyle requires the development of attitudes and habits that is dependent on adopting critical consciousness as a daily ongoing reality. Based on the characteristics outlined above, a transformative pedagogy can indeed provide a useful theoretical framework for promoting Education for Sustainable Development (ESD), both within and without schools. This theoretical framework which can help support learners in obtaining a deeper understanding of what constitutes sustainable living.

Transformative pedagogy – an essential component for ESD

UNESCO views ESD as a lifelong and life-wide process that *"empowers learners to take informed decisions and responsible actions for environmental integrity, economic viability and a just society, for present and future generations, while respecting cultural diversity"* (UNESCO, nd).
An integral part of quality education (as highlighted in Sustainable Development Goal 4 – particularly Target 4.7), ESD's ultimate goal is to transform society with the active participation of citizens. ESD is essentially "an educational process that is contextually relevant, participatory, emancipatory and leads towards sustainable development" (Pace, 2010). As highlighted above, a transformative pedagogy is the main vehicle through which these characteristics are achieved.

Although they are always a regular feature on the ESD implementation agenda, genuine efforts to formally infuse transformative pedagogies in educational and training programmes in the formal, non-formal and informal sectors have been noticeably lacking. It is quite strange, to say the least, that while educational research and literature laud the benefits for learners, institutions and society in general of a transformative pedagogy, the translation into practice has been very slow. Leal Filho & Pace (2002) identify three possible interrelated reasons for the reluctance to promote this paradigm shift:

Procrastination: based on the false premise that ESD is already being taken care of and therefore there is no real need to change. This reasoning is primarily generated by the misconception that catering for ESD is essentially an issue concerned with which content knowledge is included in learning programmes, and that the skills, attitudes, values and commitment for action are a direct consequence of this increased awareness (Mayo, Pace and Zammit, 2008).

The "better the devil you know" syndrome: educators operating in traditional institutions and structures that are resistant to change develop coping strategies and conform to tried and tested approaches that keep them within the safe confines of the status quo. In that way they can always blame an inflexible system for any criticism that learners are not being prepared for reality.

Threat to authority: with its emphasis on interdisciplinarity and a philosophy of empowerment, ESD can be conceived as a threat to traditional power structures and institutions and to those who 'profit' from them (e.g. academics, education authorities and teachers). Attempts to foster a transformative pedagogy can be hindered by endless academic squabbles and conflicts of interest.

In parallel with the official Rio+20 UN Conference on Sustainable Development Summit in (June, 2012), the Rio+20 Education Group – Thematic Social Forum produced a paper that suggests a more sinister reason for the promotion of transformative education. While asserting that education (and hence ESD) is "a human right that promotes the other rights", the working group claims that:

"We have not only given up training people to be capable of thinking about important political, environmental, economic and social issues of global order, but also education has been stripped of its deep political content and, in particular, its potential to train citizens to imagine a different social and economic order in which it would be possible to overcome the deep and complex crises we are living through. This is reflected in increasing inequality and discrimination and a lack of dignity and justice" (Rio+20 Education Group, 2012).

This implies that the resistance to transformative education is a premeditated attempt by the dominant structures of production, consumption and distribution to prevent active participation by citizens in decision-making that promotes a sustainable future that is more environmentally and socially just.

Conclusion

Upon reflection, the likely mistake in the implementation strategy for transformative education could have been (also a result of the predominant paradigm in educational sectors) that change was expected to come from the top rather than promoting (and facilitating) grassroots initiatives. *"Transforming institutions must be accompanied by efforts to transform people, to create a culture of transformative change"* (UNEP, January, 2016, p.8). Projects such as EduChange that seek to promote change at the level of classroom practice by actively involving and supporting educators and students are a step in the right direction.

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CHAPTER 6: ASSESSMENT AND ESD – WHICH WAY FORWARD?

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Abstract

The objectives of a learning activity can be categorised into three domains (also referred to as the 3Hs): the HEAD (the cognitive processes), the HEART (the affective reactions), and the HANDS (the psychomotor skills). How do we get feedback about learning? This is particularly relevant for Education for Sustainable Development (ESD) and its transformative agenda. To answer this question, we need a good knowledge about the assessment OF, FOR and AS learning. On considering the theoretical frameworks for the assessment of learning, it can be seen that the recommendations are grounded in research about effective learning and the factors that help learners' motivation and self-esteem.

A study by Loughland et al. (2003) indicated that students tend to have either an 'object' perspective or a 'relation' perspective on the environment. In the former the focus is on the environment as a place that contains living things and people. In the relational perspective the focus is on the mutually sustaining relationship between people and the environment. It is normally the case that participants considered in such studies are positioned somewhere along a continuum with the two perspectives at either end. When adopting an ESD task for assessment purposes it would be useful if it was used to help the teacher identify how well the participants had understood the content presented. This can be done through tasks that involve activities such as information processing, evaluation, critical thinking, problem solving, reasoning and communication. Furthermore, it would be beneficial if the assessment also determined where the participants stood on the continuum.

This chapter will discuss how assessment tasks can be designed to help place participants somewhere along the continuum and, in an ESD course, one can think of practices that will prompt participants to look at the environment in a more relational manner, which is more holistic and meaningful.

Introduction

In an effort to provide a holistic, integrated and experiential learning experience, teaching (according to Pestalozzi) should be a unity of the cognitive, affective and psychomotor domains (Gazibara, 2013). Learning objectives can thus be classified into these three domains:

1. The cognitive domain (the HEAD) deals with the cognitive processes that enable an individual to process information in a meaningful way. It focuses mainly on intellectual skills and is the core domain as the other two domains require some form of cognitive thinking.
2. The affective domain (the HEART) concerns attitudes and feelings that spark off motivation, develop values, and generate a willingness to act.
3. The psychomotor domain (the HANDS) involves skills and deals mainly with performing motor activities that are often described as 'hands-on learning.'

While learning can address any one or more domains concurrently (see Figure 13), researchers (like Bruner, 1996) have stressed that quality education and successful education reforms can be achieved by addressing the learner as a complete human being who functions holistically. This implies learning experiences that integrate all the three domains and adopt different styles, strategies and methods to address different learning needs and different learning contexts.

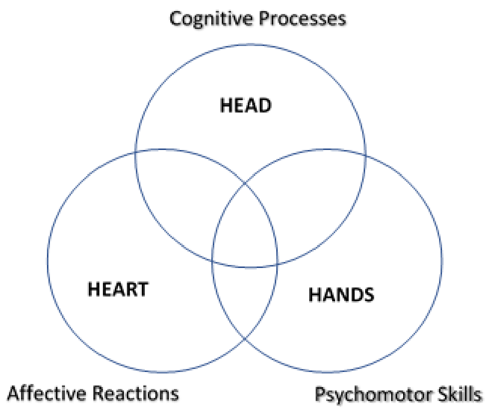

Figure 13: The three domains of learning

Table 13: gives an outline of learning outcomes associated with each of the three domains.

Cognitive domain	Affective domain	Psychomotor domain
Remembering / Recalling	Awareness	Observation / Perception
Understanding	Responding	Guided response
Applying	Valuing	Imitation
Analysing	Organising	Practice / Habit
Evaluating	Conceptualising	Adaptation
Synthesis	Integrating / Internalising	Organisation

Ensuring that educational processes provide experiences that integrate these domains is essential for Education for Sustainable Development (Taimur & Sattar, 2019). Issues related to sustainability are complex involving a multitude of interrelated environmental, social, cultural, economic, and political factors. Finding a plausible resolution to these issues requires an educational process that is coordinated, systemic, collaborative and inclusive. These are the goals of ESD, i.e. a process that empowers learners to become change agents by equipping them with the knowledge, skills, values, and attitudes necessary to become change agents that are critical of current and capable of transforming society (UNESCO 2017). Consequently, the role of assessment in determining the effectiveness of teaching/learning experiences.

Types of assessment

In the classroom, learning is mostly formal, with the main emphasis on the cognitive domain, through teacher-centred learning. The main components at play are content knowledge, students' conceptions and their prior knowledge. Within this framework it is extremely important to consider how to get feedback about learning through assessment, of which there are the following modes:

Assessment of Learning (AoL) reveals what students know, understand and can do. This may then be used for formal certification and to report on levels of progress to parents, apart from judging the teacher and the school's effectiveness.

Assessment for Learning (AfL) also reveals what students know, understand and can do. The process includes the students. It enables the teacher to plan how to help the students progress and develop their understanding and skills.

Assessment as Learning (AaL) enables both the teacher and the students to evaluate the students' understanding of content knowledge through the feedback obtained. Teachers and students monitor the learning, ask questions and use a range of strategies to decide what they know and can do, and how to use the assessment information for new learning.

Considering the theoretical frameworks for AfL, evidence generated by various studies shows that assessment can help teachers to interact more effectively with students on a day-to-day basis, promoting their learning as part of the assessment process. AfL includes any form of assessment in which the first priority in its design and practice is to serve the purpose of promoting students' learning. It should provide information which can be used as feedback by both teachers and students in self-assessment, in order to modify their respective teaching and learning activities. It becomes formative assessment when the evidence is actually used to adapt the teaching to meet learning needs. Such recommendations are grounded in the findings from many decades of research into effective learning and the factors that help build the motivation and self-esteem of learners (Black & Harrison 2004; Black & Wiliam 1998a; Black & Wiliam 1998b; Black et al. 2002; Black et al. 2003; Millar & Osborne 1998; Wiliam 2011).

Teachers are always under pressure to improve their work, to raise their standards and to improve students' test scores and grades. Such pressures may amount to a push to '*try harder*' at the expense of interacting more effectively with students in their learning – which should ultimately be the specific intent for the improvement of education. Research clearly shows that formative assessment can raise the standards of student achievement with significant gains in test performances registered being (Black & Harrison 2001a; Black & Harrison 2001b; Dweck 2016; Isaacs et al. 2013; Wiliam 2011).

The content knowledge of lessons is ultimately determined by national curriculum schemes and by examination syllabi. Infusing ESD within curriculum subjects provides the means by which learners can interact with the world around them and develop ideas about the phenomena they experience. These experiences equip learners with the means to observe and question what is happening, and to work out and predict what might happen if conditions change. In order to be able to learn in this way, students need help in developing processes and values, investigative skills and communication skills to question and discuss findings. Formative assessment fits very well into this learning scenario.

At specific times, learners also have to prepare for examinations. There has to be time set aside near the end of courses for 'examination techniques.' Feedback, peer-assessment and self-assessment all have important roles in this process. When utilised properly, formative assessment can result in large learning gains. It is worthwhile considering the potential of ICT with the many good resources available. It allows time to focus on thinking and provides diagnostic assessment that supports learners and teachers in deciding the next steps in learning (Black & Harrison 2001a; Black & Harrison 2001b).

Principles of learning

Formative assessment is dependent on a free flow of feedback from student to teacher and from teacher to student. In the promotion of classroom dialogue, the teacher can make the initial step by formulating questions to help students put 'on the table' their ideas. Learning should start from where the learner is. Students have to be active in reconstructing their ideas, and not merely add a further 'layer' of new ideas, which leads to poor understanding, if not confusion. Teachers should fashion their interventions to encourage and listen carefully to a range of student responses – whether correct or incorrect – and invite students to talk through inconsistencies and respond to challenges.

Learning is ensured if students are active in the process – learning has to be done **by** them rather than **for** them. Hence it is important that students understand the learning target, what would count as a good quality piece of work, and have a clear idea of where they stand in relation to the target. Students need to achieve metacognition, i.e. the power to oversee and steer their own learning in the right direction, and take responsibility for it. Collaborative learning, peer-assessment and self-assessment are essential as they promote active involvement and provide opportunities for practice in making judgements about the quality of work (their own and their fellow students'). Another principle of learning can be subsumed under 'talking the talk', i.e. in this particular case, when students are talking about ESD, they have to use the language of ESD (Black & Harrison 2001b; Wiliam 2011).

Learning strategies

Some strategies to support all learners involve formative questions used in order to collect evidence of the students' understanding (not only what they know, but also what they partly know and do not know), to guide them to upgrading their 'part-knowledge' to a fuller understanding, and to provide sufficient time for them to find answers to demanding questions. To engage more learners in giving answers, a number of techniques have been developed, such as: jotting down 'an answer' (on mini whiteboards or a piece of paper); a 'no hands up' strategy where everyone is expected to answer; and the use of red and green 'cards' as they listen to their peers' answers, enabling them to complete their own thinking.

Discussion provides the opportunity to bring learners' own ideas and thoughts to the surface, where the teacher acts as facilitator. Questions can be used to encourage learners to reflect both on what they think and on what they have heard from others, which helps in shaping understanding, attitudes and values. During such an activity it is important to sort out wrong ideas and to be 'patient' and wait for the various ideas and thoughts to be revealed, before correcting and curbing the direction of the discussion; the facilitator should not intervene too soon.

Giving Feedback

Feedback is a very important factor in developing motivation and self-esteem of students. Feedback in traditional educational settings tends to categorise students as "good or bad achievers" based on judgement through marks, grades, ranking lists, etc. This form of feedback develops ego-involvement, may have negative effects, discourages low-achievers and makes high-achievers avoid tasks if they do not see 'success'. An alternative form of feedback does not focus on the person, but on the strengths and weaknesses of the given piece of work, and what needs to be done to improve it. This helps develop task-involvement, has positive effects and encourages students to see that they can do better by trying, and that they can learn from mistakes and failures.

Formative assessment focuses on feedback as an activity that helps learning because it provides information for teachers and students to assess themselves and to modify the teaching and learning in which they are engaged. Effective feedback needs to arise from learning experiences that provide rich evidence, so that judgements about the next step in learning can be made. There are a number of ways in which this can be done that are in line with the goals of ESD: challenging activities that promote thinking and discussion; thought-provoking questions; issue-based and problem solving tasks; strategies to support learners in revealing their ideas; opportunities for peer discussion about ideas; and group or whole-class discussions which encourage open dialogue (Black & Wiliam 1998b; Black & Harrison 2004; Wiliam 2011).

Oral or written teacher feedback is an essential part of assessment for learning. Effective feedback should help learners to realize where they are in the learning process and where they should go next: the focus is on improvement. Comments given should be 'useful' and 'effective.' It should be noted that it is difficult to write comments – or there is little to comment upon – regarding 'simple' tasks, where self-checking does not need any teacher expertise. Students should be directed where to go for help, and what they should do to improve. The improving classroom is one where feedback drives formative action, where there is a culture of success that supports and encourages learners. There must be a clear understanding of what is wrong, of appropriate targets, and of the means for achieving those targets in the short term.

Students need to be able to self-assess – which is not a simple task – and students need to have a clear picture of targets that would allow them to become more committed and effective learners. Peer-assessments help students develop their self-assessment skills. Students can look at some samples of work, reach judgements about levels and give guidance about the next steps. It should be emphasized that the use of investigative work involves individual and collective planning, observing, measuring, analysing and evaluating, as well as general skills such as decision-making and communicating findings. Once again these are essential features of any educational process purporting to promote ESD.

The following factors should also be considered. Items from summative tests can be fruitfully used as tools employed formatively in the classroom. The teacher can deal with serious gaps in understanding, while smaller gaps can be closed through peer activity. The pace and content of teaching should be matched to the students' needs, which leads to better learning. It is imperative to keep in mind that evaluation is a vital part of any plan, and can be done through activities such as mutual observation, sharing of ideas and resources, and dissemination (Black & Wiliam 1998b; Black & Harrison 2004; Wiliam 2011; Isaacs et al. 2013).

Assessment and pedagogy – what connections?

Any discussion on assessment cannot be done in isolation from the learning context. What leads to assessment is the presupposition that learning has occurred and it is normally the case that this learning was prompted by teaching. The art and science of teaching, commonly referred to as pedagogy, is an academic discipline that involves the study of how knowledge and skills are exchanged in an educational context. Pedagogy also considers the interactions that take place during learning. Pedagogy in the formal setting of the school is focused mostly on the cognitive side of learning.

Yet learning in the context of ESD requires a widening of this view of pedagogy so that it includes not only the learning of concepts, but also the internalisation of values following the learning process. Consequently, a more appropriate term that can be used to describe this shift in pedagogy in a more complete manner is the term Transformative Pedagogy. As stated in a previous chapter, this pedagogy encourages teachers to consider a fusion of constructivist pedagogy with critical pedagogy.

Transformative pedagogy can be defined as an activist pedagogy that empowers students to critically examine their beliefs, values, and knowledge with the goal of developing a reflective knowledge base, an appreciation of multiple perspectives, and a sense of critical consciousness and agency (Ukpokodu, 2009). Any ESD activity may involve communication, creative thinking, enquiry, evaluation, information processing, problem-solving and reasoning, but it needs to consistently encourage critical thinking, the individual's understanding of 'choice and consequence' and the internalisation of values.

Designing activities that include some or most of the tasks mentioned is commendable and essential. Yet considering critical thinking, the concept of 'choice and consequence' and the exposure to a value system prompts the question: How can one assess the learning involved in such a context?' or more directly: How can one assess an ESD activity so that the educator gets useful feedback about the learning that has occurred?'

(Killingsworth & Palmer, 1992)

A good starting point to refer to when considering assessment in ESD can be inferred from a research study (Killingsworth & Palmer, 1992) linked to children's conceptions of the environment. This study revealed the learners' conceptions and hence their prior knowledge about how they perceive the environment. The researchers suggested that children's environmental orientations could be placed on this continuum:

One further study (Loughland et al, 2003) that also takes up this idea focused on a research project in which 2,249 young people aged from 9 to 17 in New South Wales responded to the statement: "*I think the term/word environment means …*". Their responses were analysed and categorised into the six distinct conceptions listed in Table 14.

Table 14: Young people's conceptions of environment (Loughland et al, 2003)

Object focus conception	Relational focus conception
1. The environment is a place.	1. The environment does something for people.
2. The environment is a place that contains living things.	2. People are part of the environment and are responsible for it.
3. The environment is a place that contains living things and people.	3. People and the environment are in a mutually sustaining relationship.

Yet again, these children's conceptions of the environment suggest that environmental orientations could be placed on a continuum (shown below) where the children's conceptions of the environment are localised at a point on the spectrum.

Challenges and concerns linked to ESD assessment

Several UNESCO documents (Biasutti & Surian, 2012; Michalos et al., 2012; Olsson, Gericke & Chang Rundgren, 2015) provide assessment scales that measure students' competences, attitudes and behaviours regarding Sustainable Development (SD). The study by Olsson et al (2015) developed a Likert-scale questionnaire to evaluate the sustainability consciousness of young learners. This scale is based on UNESCOs (2005) pillars of SD: environment, economy and society. These pillars are seen to be linked and they are referred to in several research studies (Giddings, Hopwood & O'Brien 2002; Walshe, 2008).

Although it is essential to consider these pillars when talking about SD, they do not provide the complete picture. Education is an important dimension that is, regrettably, at times left out of some studies related to SD evaluation. Education needs to be considered as an essential component of SD because the educative process contributes considerably to supporting learners in developing humane values and attitudes that are consistent with SD. Education is in some way an assurance that citizens can be invited to embrace a sustainable lifestyle. Furthermore, to promote the effective participation of citizens in policy-making, participants' learning experiences need to be nourished through constructivist and critical pedagogies, as these have the potential to produce an improvement in the quality of knowledge and attitudes that promotes sustainability (Biasutti, 2015; Scoullos, 2013).

Different theoretical backgrounds, such as the Model of Ecological Values, 2-MEV model (Schneller, Johnson & Bogner, 2015) and the New Environmental Paradigm (NEP) (Dunlap & van Liere, 1978; Fleury-Bahia et al.; 2015), were used to develop the different assessment instruments in this area. To date there are no widely accepted and used assessment instruments available to examine the learning outcomes of ESD (Waltner et al., 2019). ESD assessments or evaluative tools have mainly come from researchers aiming to explore learners' knowledge, beliefs, values, attitudes and behaviour towards ESD, and from educators who wish to determine the effectiveness of teaching interventions. Past research studies indicate that most of these tools were developed in an educational setting, primarily for elementary or secondary schools (Dijkstra & Goedhart, 2012; Karpudewan, Roth & Chandrakesan, 2015; Olsson, Gericke & Chang Rundgren, 2015). There are however, few studies concerning the environmental attitudes and knowledge of college students (Biasutti, 2015; Shephard et al., 2011).

It is understandable that such tools have significant value and usefulness. They are good indicators of a learner's standing in a particular ESD scenario, yet they have been tailor-made for a particular scenario and context. It is understandable therefore, that when one is to apply them to other scenarios, it is the educator's expertise that needs to ascertain whether such a tool can be used in that context in a valid and reliable manner. Overall, it seems reasonable to state that a 'one size fits all' evaluative system exists only in theory. Such a tool, if proposed, would meet with significant resistance from the ESD community of educators, who might hold different views. The best one can do in this situation is to choose from the available set of well-designed flexible tools that are available.

Continuums and assessment in ESD?

As stated earlier, assessing whether or not outcomes have been achieved needs to be done through techniques that allow for the assessment of the learners' knowledge of content matter, the learners' development as regards critical thinking, behaviour, understanding of 'choice and consequence', and the learners' values involved and their internalisation. As opposed to the summative assessments that characterise assessment of learning in formal settings, assessment in ESD requires more qualitative and creative approaches used to evaluate changes in mindsets and in the behaviours of learners (Yiu, 2015). This assessment demands flexible strategies that are rooted in assessment for learning. This type of assessment allows educators to consider, in a holistic manner, the quality of the educational experience (Yueh, Cowie, Barker & Jones, 2010).

In deliberating on how the set of continuums described above can help in this assessment, one may ask: Can following a learner's progress along a continuum help an educator to assess learning in ESD? These continuums are a potentially useful starting point for educators who wish to guide their students to work towards and embrace a sustainable lifestyle. In identifying the position of a learner's conception of the environment on the focus conception continuum (outlined above), useful and valuable information about learners can be revealed. Furthermore, this information, coupled with a well-chosen assessment strategy, can provide pointers to where an educator should direct her/his future teaching activities so that the learning experience is guided by outcomes that are realistic, achievable and ESD oriented.

Concluding reflections

ESD is not just a knowledge base related to the environment, a country's economy and society at large. It addresses mindsets, learning skills and values that need to be internalised and that will eventually guide and motivate people to seek sustainable livelihoods. It is therefore essential to have assessment protocols that monitor the diverse teaching interventions that constantly surface in this field, so that feedback on the effectiveness of these interventions is reflected upon and made use of, to provide more focused learning experiences.

Assessment needs to gauge how well ESD activities prompt humankind to reflect once again on the common good and challenge the individualistic mentality that has permeated our world, so that people's involvement in local and global issues is encouraged. All educators are collectively responsible for ESD and, to encourage sustainable lifestyles, they must be prepared to internalise and believe in the values they are seeking to transmit.

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CHAPTER 7: POSTERS AS A LEARNING METHOD TO PROMOTE EDUCATIONAL RESEARCH LITERACY

A CASE STUDY OF STUDENTS WORKING WITH CLIMATE CHANGE ISSUES: CREATING POSTERS

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Abstract

Poster sessions are currently one of the most common tools used to present scientific knowledge at academic conferences. The process of creating a poster as a tool for learning can also provide students with a valuable academic experience.

Problem-solving and the ability to understand and apply scientific knowledge are said to be skills that depend on the ability to ask scientific questions, handle information literacy, understand, evaluate, and appraise scientific knowledge and statistics, and, last but not least, conduct evidence-based reasoning.

As part of EduChange, 24 students participated in the task of making scientific posters. The posters concerned the effects of climate change and were mainly focused on each student's country, although they had the freedom to choose any problem which they felt needed to be solved within the field of climate change. The students worked in pairs, and this included carrying out a peer review of an abstract of another group. The whole process was facilitated by one of the project staff. The project culminated with a student symposium; students presented their posters orally, much like a poster presentation at a conference.

In this chapter, different learning outcomes from the process of making the posters are reported, based on questionnaires completed by the students. Furthermore, an analysis of their posters is conducted using a framework created by the author and inspired by D'Angelo (2010).

Introduction

During EduChange, one of the tasks the students had to complete was a poster on a subject of their choice related to climate change and water issues. The students were given a webpage with practical information about the task and with themed subject content regarding climate change and water issues as well as didactic information on how to learn and teach about these issues.

The students were asked to form pairs and define their own problem to be solved concerning water issues related to climate change; preferably inspired by their own region. They had one week to write an abstract of 200-300 words presenting their poster as if it was a proposal to a conference. The abstract was then reviewed by the staff and by another student group before being sent back to the authors. Each group made their poster and sent it to the staff one week before the EduChange field course. The staff printed the posters in A0 format and made a booklet of the revised abstracts (i.e., a book of proceedings). Each student group presented their abstract as a poster presentation, with five minutes for speaking and ten minutes for discussion and questions afterward. The whole process of choosing the theme, devising the research question, writing the abstract, and creating the poster was done in as similar way as possible to the procedure involved in making a real poster for a scientific conference.

This chapter seeks to discuss the process of making these posters and their possible learning outcomes. To do this, the research question for this chapter is "To what extend is making a scientific poster in pairs and presenting it, a favorable way of learning and reflecting upon content knowledge?"

This question will be answered based on existing papers about the use of posters for learning and using a case-study from the EduChange project. This will hopefully inspire readers to use posters in their teaching and learning situations.

Introduction to posters and research as learning

Academic posters are, based on the opinion of poster-presenters and their audiences, seen as valid means of communicating academic knowledge (Rowe & Ilic, 2009). One reason for presenting knowledge in the format of a poster is to broaden the communication between the communicator and the learner, expanding it from only textual communication to multimodal text communication (D'Angelo, 2010). Visual and textual information are mutually dependent on each other. This increases the degree and complexity of communicated content (Anstey & Bull, 2010).

Poster creation could methodologically follow the drafting of academic research (Kendlin and O'Brian, 2017). Brew (1988, p. 2) states that "Research is learning. […]". A brief literature review shows that there is limited research on the use of posters as a means for educational research literacy. Posters are mainly described as a platform for communicating research at conferences. However, there is some literature on this matter, and it is briefly discussed in this introduction.

While McNamara, Larkin, and Beatson (2010) argue that poster presentations are an innovative approach for authentic assessment with special emphasis on work-integrated learning, argues Lynch (2017, p. 638) that letting students make their posters is *"a creative way helping students crystallize their own arguments and help to scaffold knowledge in preparation for final submissions."* Conducting research in pairs after having submitted an abstract might be an approach that prepares the students for the academic work of attending conferences. Another study by Harsono, Rosanti, and Seman (2019) assessed whether the development of posters as a teaching activity increased the learning outcomes for 35 senior high school students in Indonesia, with a control group of 36 students. In the study, students created their posters following the 4D model (Thiagarajan and Semme, 1974), which includes the stages of defining, designing, developing, and disseminating: this is very similar to the process of poster creation studied in this book chapter. Their results showed that the group working with the posters had an improved learning outcome compared with the control group. The same trend was found by Primavera (2017), Larasati, Cindy, and Harsono (2017), and Lynch (2017). Most students will never work in academia, but the mental aspect, practical aspect, or both aspects of conducting research overlap with elements from the 4D model. Whether or not students work in academia in the future, learning these aspects is a core skill related to the majority of workplaces that students with a master's degree will go into (McNamara et al., 2010). This skill needs to be practiced as it will prove useful in society.

Based on studies in multiple fields of science, Berry and Houston (1995, p. 22), defined the reasons for using posters as a mean for learning. They write that posters

- (i) are an excellent alternative medium for developing communication skills;
- (ii) involve students in the assessment process;
- (iii) encourage students to investigate a topic thoroughly;
- (iv) provide opportunities for peer-learning;
- (v) promote a positive attitude in students.

Favier, van Gorp, Cyvin, and Cyvin (2021) presented data from the poster project that took place during EduChange, as discussed in this book-chapter, but their data pertains to the following year, namely 2020. They analyzed the posters using the ten characteristics of wicked problems. The work of Favier et al. (2021) shows that posters can also be assessed in the manner of specific themes, in this case the degree of wickedness. They investigated to what extent students presented specific characteristics of wickedness within the field of climate change in their posters.

This chapter seeks to discuss whether the poster method is valuable for the students and, if so, which part of the process is worth focusing on when creating learning activities to maximize the learning outcome. It aims to analyze the knowledge communicated through the posters and discusses how posters can be assessed by quantifying the qualitative evaluation of each poster. The data presented do not have a reference group, and the goal is not to compare poster creation with other learning activities because a range of diversified learning methods is desirable for students (Midtaune, Cyvin, Rød & Panek, 2018).

Method

An analysis of two separate datasets was conducted to answer the question of whether the creation of posters, as an activity for students, provides them with content knowledge. The data material consists of a poster assessment and a questionnaire given to the students. Posters were analyzed using a matrix inspired by D'Angelo (2010). In the questionnaire, the students were asked about their perceived learning outcomes from the poster creation process. Questionnaires with questions on methods, concepts, global versus local,[3] statistics and spatial knowledge related to the process of making the posters were given to the students eight months after the course; they had a sliding scale of one to five for their learning outcomes. All the questions were centering around the knowledge before and after the process of making posters at EduChange 2019. The questions given were:

1. Rate your learning outcome from none (1) to a lot (5) when it comes to climate change.
2. Rate your learning outcome from none (1) to a lot (5) when it comes to presenting at the student symposium.
3. Rate your learning outcome from none (1) to a lot (5) when it comes to your learning outcome from listening to the other presentations during the student symposium.
4. Rate your learning outcome from none (1) to a lot (5) when it comes to giving feedback on others' abstracts and/or posters.
5. Rate your learning outcome from none (1) to a lot (5) when it comes to getting feedback on your abstract and/or poster from other students and the teachers.
6. Rate your learning outcome from none (1) to a lot (5) regarding the whole student symposium work.

Underneath each of the six questions the students rated their learning outcome related to methods, concepts, global versus local, statistics and spatial knowledge.

The results are given in table 16. A matrix for poster analysis allows the researcher to explore the content of each poster based on different variables (Figure 4) inspired by D'Angelo (2010; 2011). The score of each variable was chosen by the author, and the result is biased of this classification. As an example, the possible total score of a poster would change if the score range of "eye-catcher" was increased from 0-1 to 1-15. The poster would possibly also be given a higher score if it used appealing visualizations (Table 15. and Figure 14.).

Visual elements were graded as less important than "reflections on content," "contextualization," "use of sources," and "communication of content knowledge" (see Figure 14), and the possible score range was chosen thereafter.vA digital questionnaire was sent out to the students eight months after the poster symposium. Sixteen out of twenty-four students answered the questionnaire, which had questions on their self-perceived learning during the different phases of the process involved in making the posters. Due to privacy rules, a survey tool that does not save IP addresses was used and results were anonymized. This makes it impossible to connect the results from each questionnaire to its author. The results are therefore aggregated for analysis and evaluation, using the average ang general variation of each answer (e.g., variations among the ability to communicate reflections upon content in the different posters). The 11 variables used to classify the posters are presented in more detail in Table 15.

[3] *Global versus local perspectives related to climate change.*

Table 14: Matrix for the analysis of posters. Inspired by D'Angelo (2011).

Content Variables, theme	Name of variable	Description
Visual	Visible colors	Visibility of the elements of color included in the poster. For example, is it possible to see the text on top of a background color?
	Eye catcher	Pictures, illustrations, or other elements that make a poster interesting to look at before you have started to read it and looked more closely at the content.
	Color contrast	The contrast of the colors. An example is the green colors on the map in Figure 14. Here, it is a little difficult to distinguish the light green color from the dark green, and the contrast could have been higher when presenting a small map.
Analytical skills	Foreground and background	Refers to whether the poster has elements in the foreground and background. An example could be a background picture representing the theme of the study.
	Thematically relevant pictures	Are the pictures thematically relevant and, as such, do they provide information that is not given in the text and/or support the text?
	Contextualization	Is the poster able to make connections between the theme and the communication of this information? Does the poster present the core themes on the issues to be addressed?
	Reflections on content	How the poster presents the authors' reflections on their sources. Do the authors replicate knowledge or use it in a way that demonstrates higher-order thinking (Lewis and Smith, 1993).
	Dimensions	Measures if the content is presented at different levels, such as from global to local, and how it makes connections between spatially different areas.
Theoretic content knowledge	Content	Refers to the content knowledge presented in the poster: Is it relevant, correct, and does the poster contain an appropriate amount of content knowledge?
	Sources	Refers to the use of references in the text and the provided citations. The list of references and the relevance of the different sources used.
	Answering the problem to be solved	Does the poster present a solution or a comprehensive explanation of the group's specific problem to be solved?

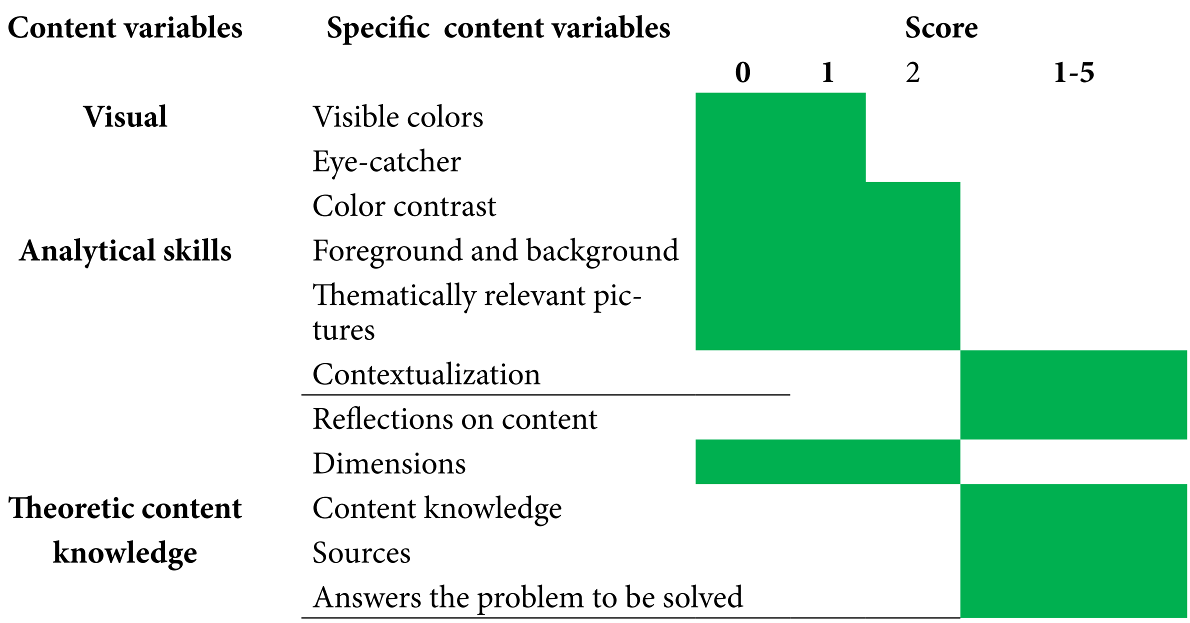

Figure 14: presents the range of the score given to each element presented in each poster. Maximum score of 34.

Eleven posters were analyzed; these were all the posters made during the EduChange course in 2019. Figure 15 presents one of the posters. The poster is presented in agreement with the students and the analysis of the poster is presented in Table 15.

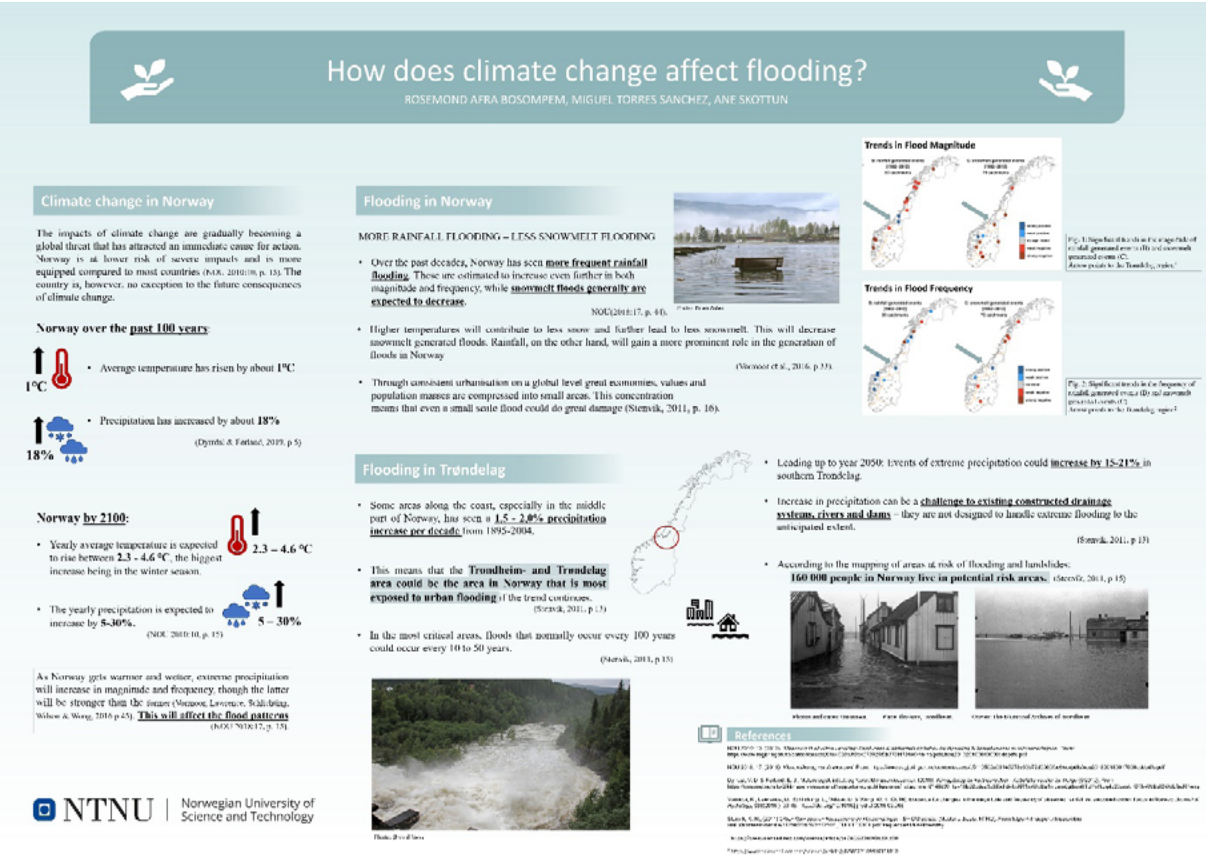

Figure 15: A poster made during the project in 2020. Presented with consent from the students. This poster is only used as an example in this chapter, due to its creation in 2020, not 2019.

Table 15: Analysis of poster visualized in Figure 15.

0-1	0-1	0-2	0-2	0-2	1-5	1-5	0-1	1-5	1-5	1-5	Sum
Visible colors	Eye-catcher	Colour Contrast	Foreground and background	Thematically relevant pictures	Contextualization	Reflections on content	Dimensions	Content	Sources	Answers the problem to be solved	
1	0	1	1	2	5	4	1	4	5	4	28

Results

The results of the questionnaire are presented in Figure 16. The students gave the highest score to the category of gaining knowledge on the "global versus local" perspectives of climate change, while they gave the lowest score to "statistics (graphs, plots)."

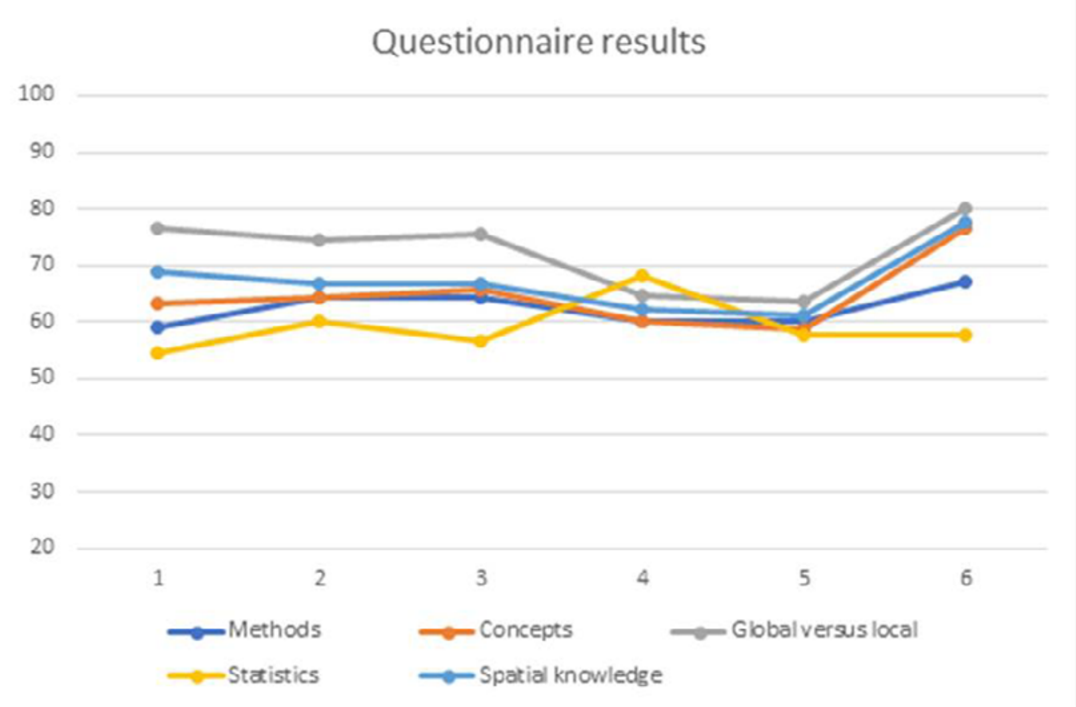

Figure 16: Results from the questionnaires given to the students eight months a er the posters were finished and presented. X-axis: Question 1-6. Y-axis: Average score. (learning outcome on climate change, presenting, listening to presentations, giving feedback on abstract, getting feedback on abstract and the whole symposium work) described in Method.

Except for the "statistics" category, the variation in student scores among all variables, ranged from 1 to 4 or from 2 to 5. Regarding perceived learning outcomes about "statistics," the score ranged from 1 to 5. The percentage standard deviation ranged from 13.7% to 26.5%.

There was the least variation in perceived learning outcomes of learning from the whole student symposium, and the highest consensus among the students was for the "global versus local" outcome. Based on the average of student scores, it does seem that the process of creating posters and presenting them gave the most knowledge with special emphasis on global versus local issues.

The score from all (methods, concepts, global versus local, statistics and spatial knowledge) was rated higher for the question "*Rate your learning outcome from none (1) to a lot (5) regarding the whole student symposium work*" than for all the other elements of the poster creation process.

The posters were assessed as described in Table 15 of the method chapter. On average, the category of "foreground and background" had the lowest score, while the "visibility of colors" and "dimensions" had the highest scores. The use of an evaluation like the one presented in Table 14 could be completed as a part of a formative assessment before the product is finished. This would give students guidelines for what needs to be done and what has been achieved so far. The category "reflections on content" had an average score of 56%. This category should have been considered more and could be seen as assessing how the students communicated their evaluations of the content presented through their posters. The variations between the groups was high (1-5), and this is maybe a category that could have had more detailed grading, especially in the context of a summative assessment.

Table 16: Assessment of posters group A-K, 2019.

Score range	0-1	0-1	0-2	0-2	0-2	1-5	1-5	0-1	1-5	1-5	1-5	Sum
Group	Visible colors	Eye-catcher	Color contrast	Foreground and background	Thematic relevant pictures	Contextualization	Reflections on content	Dimensions	Content	Sources	Answers the problem to be solved	
A	1	1	0	1	1	4	2	1	4	5	4	24
B	1	1	2	1	2	5	4	1	5	5	5	32
C	1	1	0	0	1	5	3	0	2	2	2	17
D	1	0	2	1	1	4	4	1	4	2	4	24
E	1	0	2	1	2	4	4	1	4	3	5	27
F	1	1	2	2	2	3	2	0	3	2	3	21
G	1	0	2	0	2	3	2	0	2	1	2	15
H	1	1	2	0	2	5	3	1	4	5	5	29
I	1	1	2	0	0	4	3	1	5	4	2	23
J	1	1	2	0	0	3	3	2	4	4	3	23
K	1	0	1	2	1	2	1	1	1	1	1	12
Sum	**11**	**7**	**17**	**8**	**14**	**42**	**31**	**9**	**38**	**34**	**36**	**247**
Max score	**11**	**11**	**22**	**22**	**22**	**55**	**55**	**11**	**55**	**55**	**55**	**374**
% achieved	**100**	**63**	**77**	**36**	**63**	**76**	**56**	**81**	**69**	**61**	**65**	

Limitations of these results could be that there are language barriers for international students answering the questionnaire and that a significant amount of time had eclipsed since the course finished (eights months); for the poster assessments, evident limitations include the authors' preferences, personal limitations, and the qualitative evaluation of the content.

Discussion and concluding remarks

Within the "analytical skills" category, the highest scores were given for the "contextualization" and "dimensions" questions (Table 14). For their perceived learning outcome (from the questionnaire), the "global versus local" question achieved the highest score (Figure 16). It appears that the students learned a significant amount about climate change as it related to the difference between local and global levels. Their "reflections on content" concerning their knowledge presented, was less visible in the posters. Maybe the poster task did not ask specifically enough to communicate reflections rather than facts and information about the chosen theme.

The results show a high level of ability in communicating the different dimensions of the content among the student groups. This could be connected to the fact that there was a large proportion of geography students in the course who thus had been focusing on geographical dimensions, such as the global versus local and north versus south, throughout their studies.

The "reflection on content" achieved a score of 55%. This could be related to the students' ability and understanding of the task. Four posters had a score of 1 or 2 (out of 5). Perhaps those students perceived the posters as a platform for communicating the content rather than as a comprehensive research-based platform for communicating a theme or showing the results of a small research project. The standard deviation ranged from 18.7% to 27.1%, showing that there was a significant variation among the different groups. The highest standard deviation was for "answer the problem to be solved" (27.1%) and "content" (24.7%; Table 16).

There is an evident difficulty in balancing open, self-driven, and reflective tasks with closed, teacher-defined ones. A teaching philosophy of "research as learning" would preferably aim to use open questions and provide tasks in which students can identify their interests and the method they want to use to conduct in-depth analysis. Due to the high standard deviation in "content" and "reflections on content" (Table 14), it may also be fruitful to implement more "closed" teacher-driven questions: this would trigger students on the "reflections on content" and work against posters only *presenting* content.

For future studies, it would be preferable to track the students and compare their answers on learning to their poster results. It was not possible to do this in this study. Studies on students who created mind-maps found that highly skilled students completed some of the easiest and non-complex mind-maps, possibly because they did not need more than the keywords to express themselves (Johnstone & Otis, 2006).

There is a correlation between the self-assessment scores the students gained as a group (i.e., those on their perceptions of their learning outcomes) and the classification of the posters. It does seem that all students feel they have learned a considerable amount from the whole process, regardless of whether they self-assessed their poster positively or negatively.

I have argued that poster sessions are a good form of learning during the process of carrying out research. This is in accordance with Brew (1988), even though more research is needed on which elements of the poster creation process are most important for learning and on how to improve the framework of the students' research to maximize their learning outcomes.

The results of this poster creation process show that posters are a stimulating way to do real research; the process can be qualitatively interpreted as increasing the knowledge of the students with self-evaluated learning above 50 % average (score) for all five themes (methods, concepts, global versus local, statistics, and spatial knowledge) concerning climate change (Figure 16). Poster creation can easily be performed in a collaborative way, where knowledge is constructed through dialogue with one's surroundings (Crotty, 1988, p. 8). The reported high learning outcomes from creating posters align with previous studies by, among others, Harsono et al. (2019), McNamara et al. (2010), Lynch (2017), and Favier et al. (2020).

From the author's point of view, our form of assessment of posters is a positiv and reliable way to assess the students' final product. The result of this study is that assessment based on a range of criteria is fully possible and it gives interesting information on the knowledge that has been communicated (supported by McNamara et al., 2010). The differences in the results of the analysis also show there are several possibilities for using posters: they can be used as a multimodal text and as a summative assessment in higher education.

In relation to the open-ended and student-driven tasks, it is interesting to compare with the contradictory results of Johnstone and Otis (2006), in which the most-skilled students created the simplest mind maps. Is this also a case for poster creation? If so, must the oral presentation also count as part of a possible summative assessment of posters? Perhaps the multimodal text does not reflect the knowledge and learning processes of the students creating it?

If research equals learning (Brew, 1988) – why is the learning in schools and universities, to a great extent, based on the communication of knowledge and not on explorative work? Indeed, a good communicator of science can engage and inspire, but maybe we are too focused on communicating our knowledge, instead of focusing on the learner. Posters are one of the many methods in which research can be carried out by students and active student-focused learning can be achieved.

The method presented here was not an objective measure of the quality of the posters but could give an idea of how the students performed; it might also be a tool for students trying to enhance the quality of the posters they are developing or a tool that can be used for teachers to perform a formative and/or summative assessment of posters.

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CHAPTER 8: CLIMATE DATA SOURCES FROM A GEO-SPATIAL PERSPECTIVE

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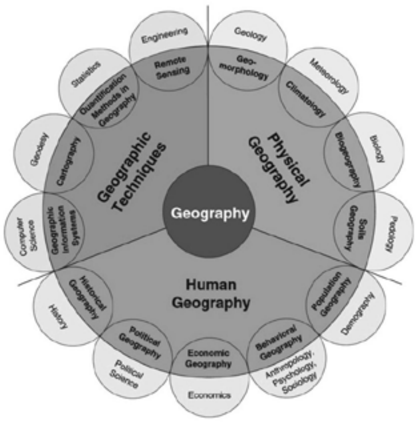
Abstract

This chapter provides a general framework of (geo)information workflow as regards climate data - from data sources, through its analyses to a visual presentation of results. In the first part, the European Union's Copernicus programme is introduced with a focus on its flagship products from Sentinel satellites. In a step-by-step guide, three possible way of handling Sentinel data is demonstrated. Secondly, a global source of data from NOAA is presented with an example of non-spatial visualisation of the obtained dataset. Lastly, specialised NASA website with build-in analytical functionality is explored. This chapter represents a detailed tutorial on spatial data usage with an emphasis on the data-driven analytical tools. All mentioned data sources on Earth's climate are useful for scientific purposes as well as for education.

Introduction

In this chapter, we briefly focus on the introduction of elemental data sets connected to climate change and related issues. There have been many discussions in scientific, political, or general public worlds about climate change. Today, the majority opinion is that climate change is real. Further discussions are about whether climate change is human-made or a natural process, and how much do humans cause climate change. We mostly aim at spatial datasets or data sets that could be processed in GIS (geographical information system). Many researchers and academicians understand the geographical information system as a part of geography. However, as indicated in Figure 17, the role of GIS might be understood differently. It belongs to techniques that are used for geographical research, especially for geographical data storage, analysis and visualisation. In this chapter, we also deal with remote sensing; another geography-related field that inevitably ties with geographical research – whether it is satellite imagery or other derived products (such as atmospheric gases analyses, ocean temperature measurements, pollution, vegetation indices and so on).



Figur

Figure 17: GIS and geography with related disciplines (from Johnson et al., 2014).

Copernicus programme

Since the EduChange project deals with climate change in European contexts, the most important data sources overview should start with the European Copernicus programme. According to Copernicus official website (www.copernicus.eu), the Programme is the European Union's Earth Observation Programme, looking at our planet and its environment for the ultimate benefit of all European citizens. It offers information services based on satellite Earth Observation and in situ (non-space) data. The Programme is coordinated and managed by the European Commission. It is implemented in partnership with the Member States, the European Space Agency (ESA), the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), the European Centre for Medium-Range Weather Forecasts (ECMWF), EU Agencies and Mercator Océan.

Copernicus offers several types of data to the public – satellite images (data from the Sentinel satellites), and information and data from the Copernicus services. The services provide the vast array of products, based on a combination of data delivering information on various topics (e.g. sea surface temperature, land use and land cover, air quality, vegetation, forecasts etc.)

There exist ten main data access points available under the Copernicus programme. Four of them provide access to the satellite data (imagery) themselves and six data access points from Copernicus services as the added values products (already processed imagery). The four imagery access points are managed equally by ESA (Copernicus Open Access Hub and Copernicus Space Component Data Access – CSCDA), and EUMETSAT (EUMETCast and Copernicus Online Data Access – CODA).

We take a closer look at the primary data source, which is Copernicus Open Access Hub (formerly Scientific Data Hub) available at https://scihub.copernicus.eu/dhus/#/home. In Figure 18, a user interface of the Hub is print screened. Through this web-portal, we can freely access the data from Sentinel satellites, and at the moment, there are three active Sentinel missions (out of 12 planned). Sentinel 1 focuses on radar monitoring of land and ocean, Sentinel 2 aims at high-resolution optical imaging for land services, and Sentinel 3 provides high-accuracy optical, radar and altimetry data for marine and land services.

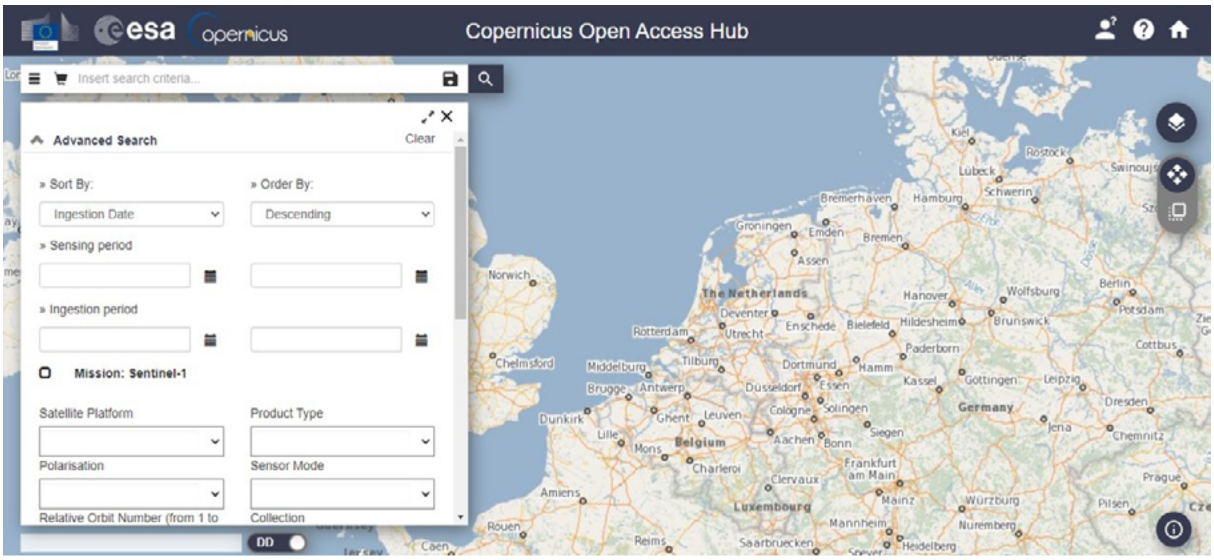


Figure 18: Copernicus Open Access Hub user interface with search options and map.

The first step to getting access to data is to create an account for Copernicus Open Access Hub. The procedure is very simple, and it does not take much time. Once the account is created, the user has to sign up to be able to search for satellite data. Via the Hub interface, it is possible to search for data based on sensing or ingestion period (ingestion period means the time when the product is indexed in the Hub), mission (Sentinel 1 to 3) and other specifications, such as satellite platform, product type, cloud cover or sensor mode. In the following example, a near-natural colour satellite image from Sentinel 2 and its download and processing is demonstrated. Figure 19 shows what search criteria were set, and Figure 20 indicates the results of the search with highlighted selection.

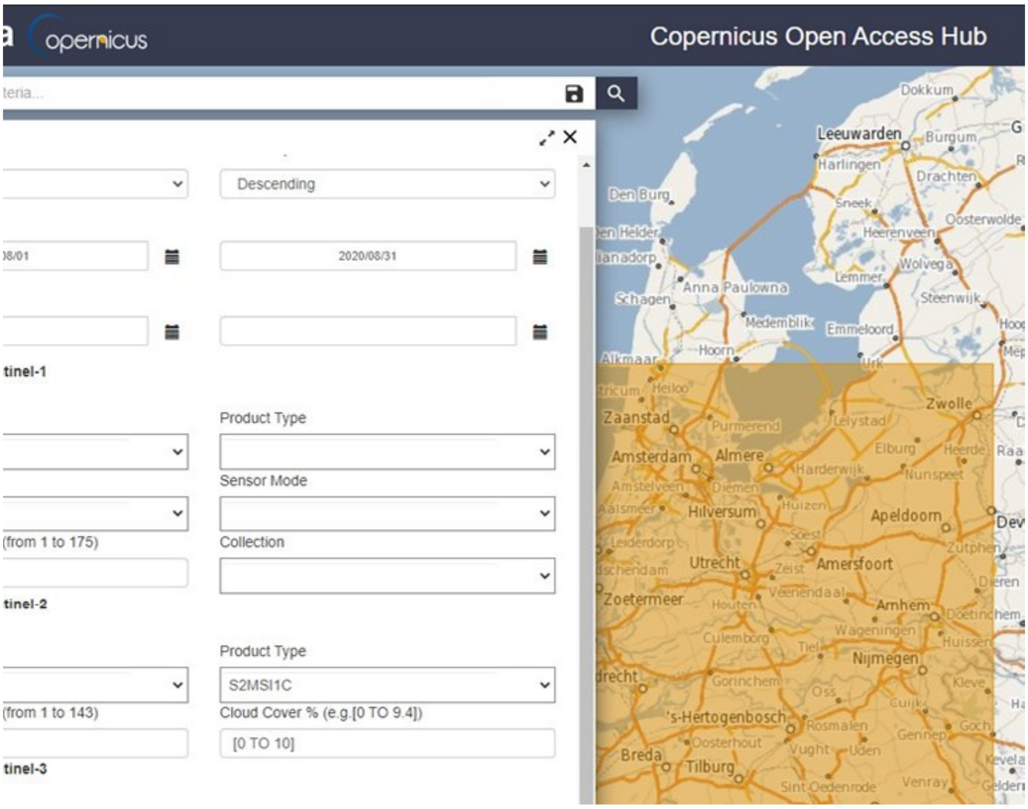


Figure 19: Copernicus Open Access Hub search criteria as regards the image source and spatial bounding box defining a focus area.

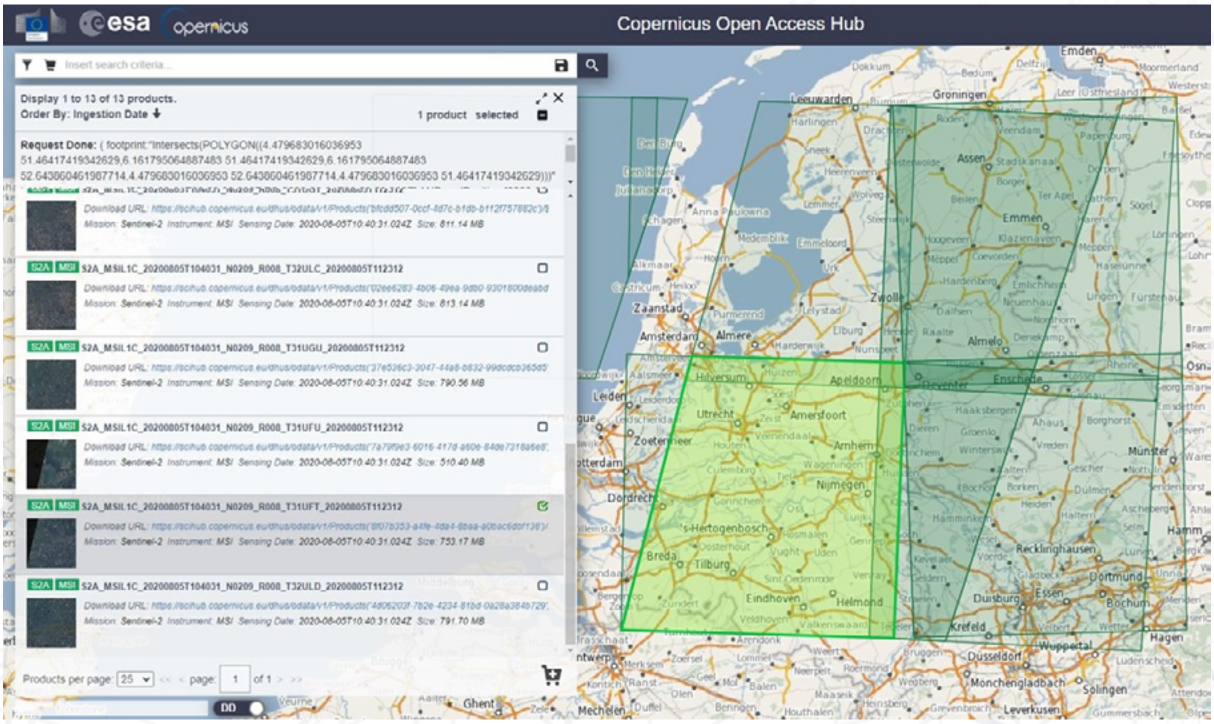


Figure 20: Results from the search with selected images in the central Netherlands (highlighted by light green background colour in the map and grey box in the list of results).

Once the selection is made, it is possible to free download the chosen product by hovering the mouse over the selected product in the list and clicking on the download icon. Since specifically this product (satellite image see Figure 21, and auxiliary files) is approximately 750 MB .zip file, it takes a while to download it. Then the .zip file has to be extracted to be used in GIS software capable working with raster data (however, software SNAP does not require unzipping). In this example, we use QGIS that is freely available to download (https://qgis.org). The images themselves in .jp2 format are located in GRANULE subfolder in IMG_DATA target folder. Since the Sentinel uses 12 wavelength bands to "capture" the Earth surface, there are 12 .jp2 files in that target folder. They can be displayed individually with the use of any graphic software, but we usually work in geography with a combination of available bands.

Figure 21: Downloaded satellite image preview.

To stack those 12 bands together, we need to install the Semi-Automatic Classification Plugin (SCP) to QGIS sw. The set up of QGIS and how to install plugins is not in the scope of this section; therefore, it will not be described here, but it is possible to find Youtube videos on the internet. Country borders, as a background reference map, from Eurostat's GISCO database, could be used (https://ec.europa.eu/eurostat/web/gisco/geodata). Once we add all the data to QGIS we can see the images in individual bands together with country borderlines (Figure 22), we can use the plugin to stack all the bands together in order to be able to perform some analysis.

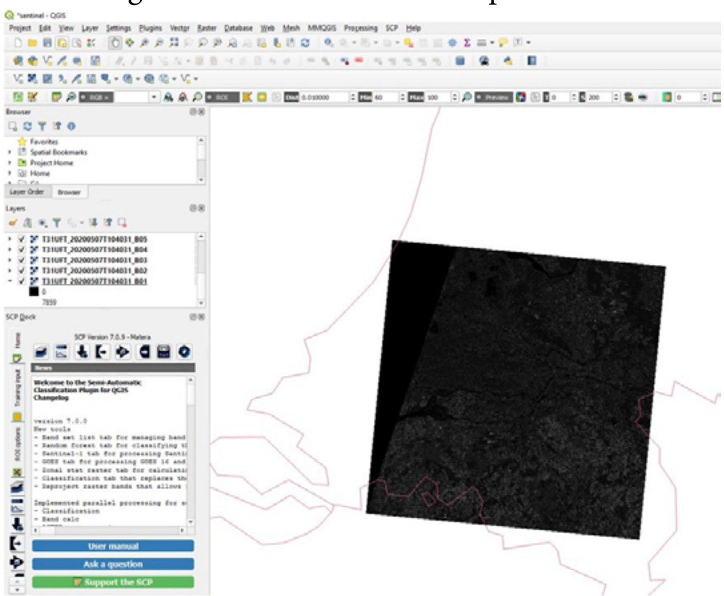


Figure 22: Downloaded satellite image bands and borders of focus area in QGIS.

To combine individual bands, we have to use plugin's tool Band Set in the settings pictured in Figure 23.

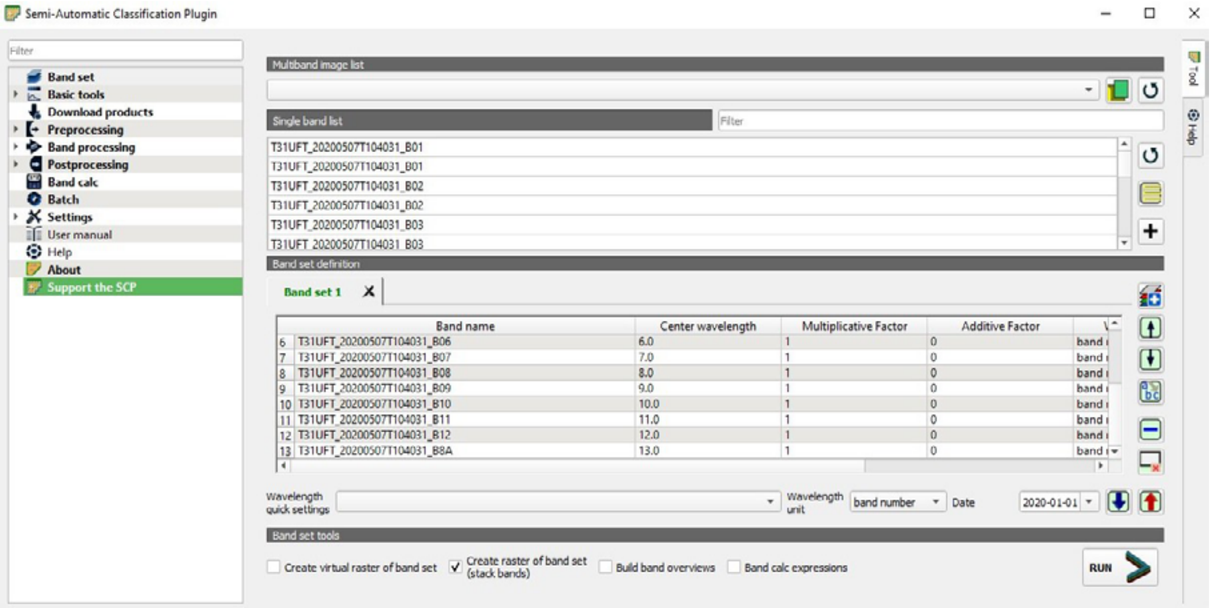


Figure 23: Band set raster creation in Semi-automatics Classification QGIS plugin.

As a result, the plugin creates a raster file (.tif), and with the use of RGB band combination 4-3-2 in the plugin toolbar, we got satellite image close to natural colours (Figure 24a). We can now analyse the image just only by changing the combination of wavelength bands. Table 17 shows usual combinations of Sentinel 2 bands applied for various geographic information enhancement (more information about channels combination can be found in the Index DataBase, 2020).

Table 17: Combinations of Sentinel 2 bands and their typical use.

Type	Band combination	Type	Band combination
Natural colours	4-3-2	Vegetation analysis	11-8-4
False colour infrared	8-4-3	Atmospheric penetration	12-11-8a
False colour urban	12-11-4	Natural colours (atmospheric removal)	12-8-3
Short-wave infrared	12-8a-4	Land/water	8-11-4
Agriculture	11-8-2	Bathymetric	4-3-1
Geology	12-11-2	Vegetation index	(8-4)/(8+4)
Healthy vegetation	8-11-2	Moisture index	(8a-11)/(8a+11)

Natural colour type uses red, green and blue channels of Sentinel 2 and displays imagery almost the same way we see the world with our eyes (Figure 24a). Figure 24b shows the near-infrared channel (channel 8), which helps to emphasise pixels reflecting chlorophyll. Therefore, this combination is suitable for detection of healthy and unhealthy vegetation, dense vegetation, or vice versa – for urban (artificial) areas identification. Figure 24c depicts a combination of three channels useful for vegetation analysis. It takes channel 11, which is sensitive to lignin (a key structural material in wood creation), starch (end-product of photosynthesis), and forest aboveground biomass, together with channel 8 (ordinarily used for leaf area index) and channel 4, which wavelengths are ideal for maximum chlorophyll absorption analysis. Interpretation of such combination might be tricky. However, orange patches indicate dense and vegetation rich land cover, and yellow colours represent green but not fully grown-up greenery (mostly grass). In contrast, cyan colours refer to non-green land cover (urban fabric or ploughed/bare agriculture land). The last example, in Figure 24d, displays the Utrech area in a combination of channels commonly used for agriculture analysis. It is suitable to monitor crop health and dense vegetation, which appears green. The pink colour in the image highlights either dry and bare soil or industrial areas. The blue colour is useful for urban fabric (houses) detection.

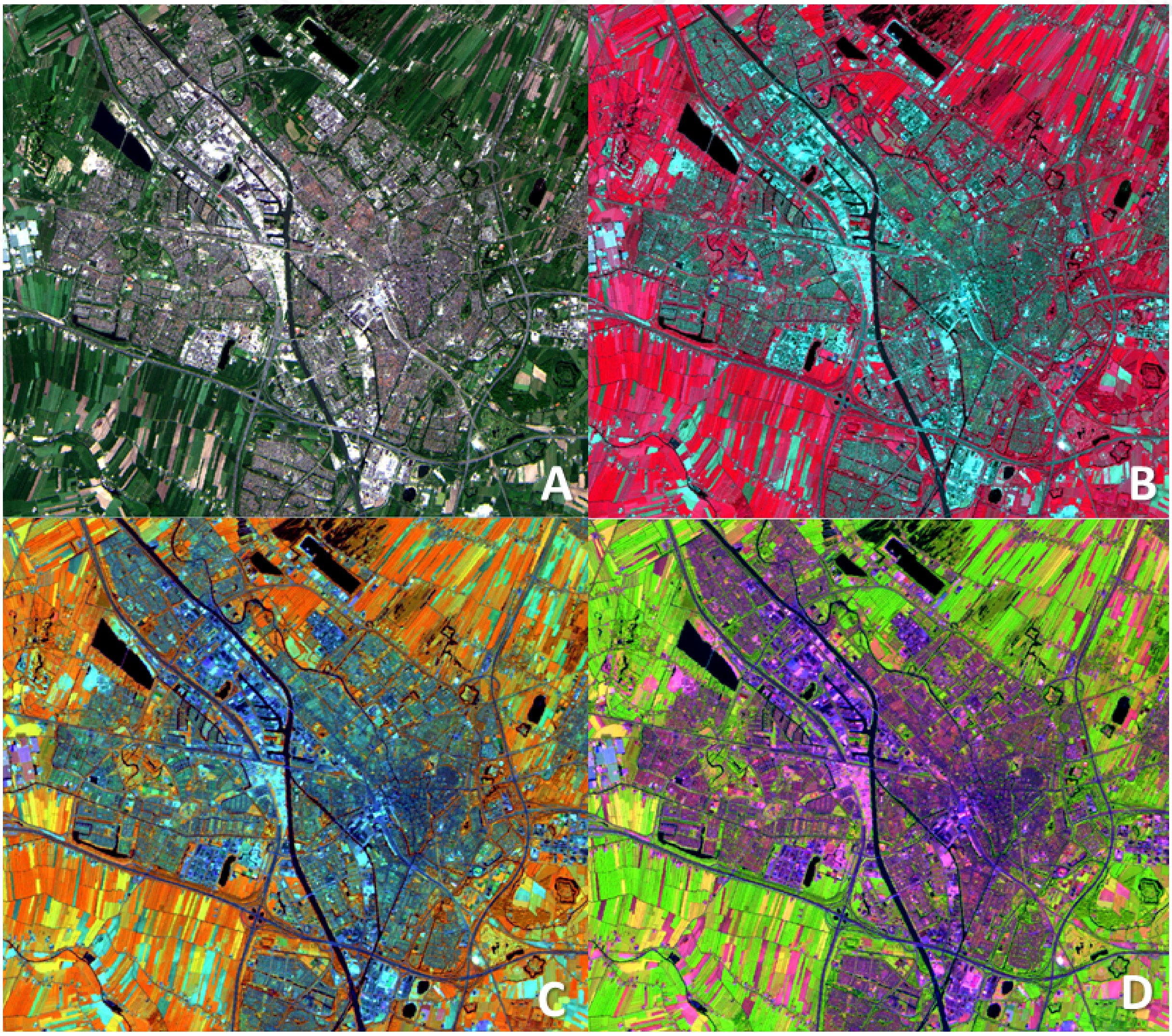


Figure 24: Resulting band combinations of Sentinel 2 satellite imagery of Utrecht area (Netherlands).

Another example of the satellite data use, their derived pre-processed product respectively could be from Sentinel 3 (with the use of SYNERGY instrument for vegetation analysis). First, similarly to the previous data search (Figure 20), it is necessary to download the data. In this example, we aim at NDVI product (Normalised Difference Vegetation Index), which is commonly used for detection of live green vegetation (for more details see, e.g. Pettorelli, 2013). The area of interest is selected as Malta, and we explore August 2020. Please, note that the search will be quicker if the only area of interest is selected, and Sentinel 3 products are picked in the search tool. The resulting selection is from the SYNERGY category (Figure 25). By clicking on the eye symbol, we can see the description of the product, including individual product items that can be downloaded separately (Figure 26).

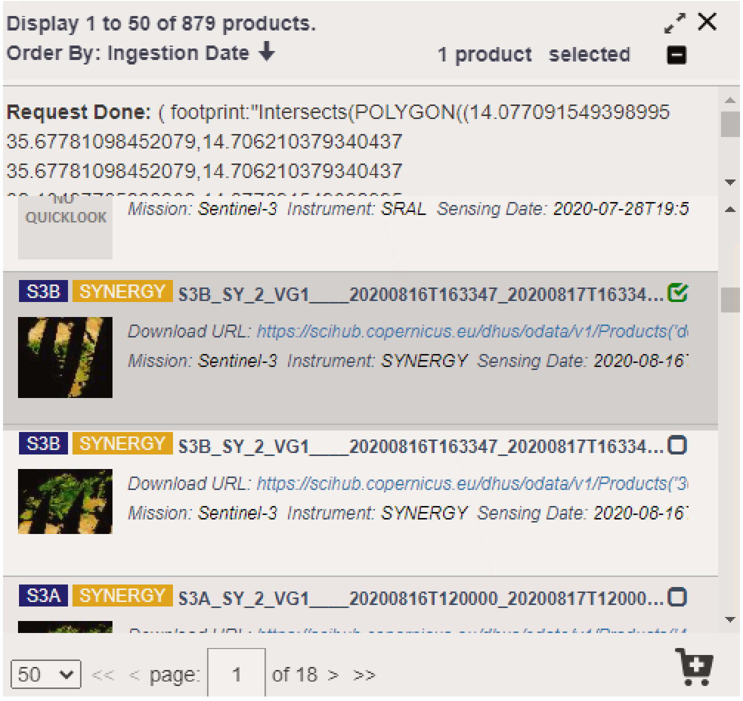


Figure 25: Search results of Sentinel 3 data (for Malta).

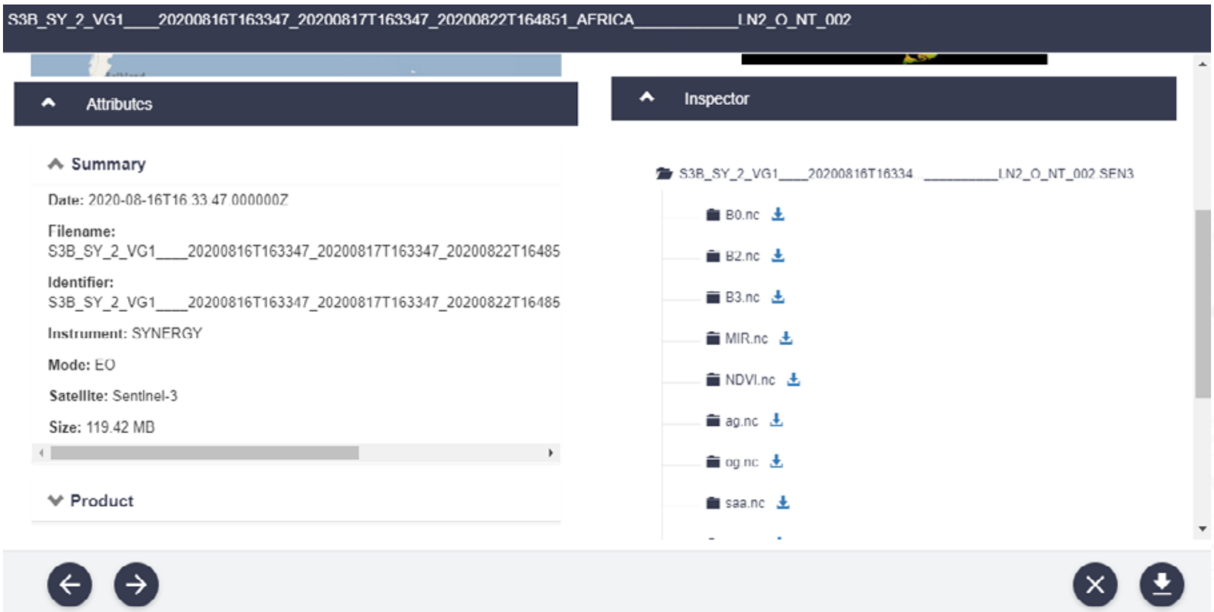


Figure 26: Detailed information (metadata) of selected Sentinel 3 imagery with an expanded list of NetCDF files available to download.

The Sentinel 3 products are usually in NetCDF format (.nc), which could be, however, easily imported to GIS. In this demonstration, we selected NDVI.nc file to download. For consequent data processing, we use ArcGIS Pro and its tool "Make NetCDF Raster Layer" tool for data import (Figure 27). After the data is imported, we can display it on the background map and modify the appearance of the layer for visualisation. Theoretically, NDVI ranges from -1 to 1, when values around 0 and lower indicates land with no or very little (life) vegetation; while values close to 1 stand for rich and healthy live green vegetation. However, normally NDVI is positive, although very close to zero. During the data processing in ArcGIS, it is important to bear in mind that appearance (e.g. colours range) is dynamically adjusted to the current view, so the legend and colours are not valid. This fact might lead to the misinterpretation of the data.

Therefore, geographic or remote sensing basic data literacy is inevitable (for more see, e.g. Juergens, 2020). Nevertheless, this problem can be overpassed by either clipping the raster data to the area of interest or changing the display settings of the raster. Figure 28 shows NDVI for Malta within the range of the whole dataset and cropped to the area of interest with a stretched colour palette to a minimum and maximum value (helping to emphasise relative differences between the live green vegetation and other areas).

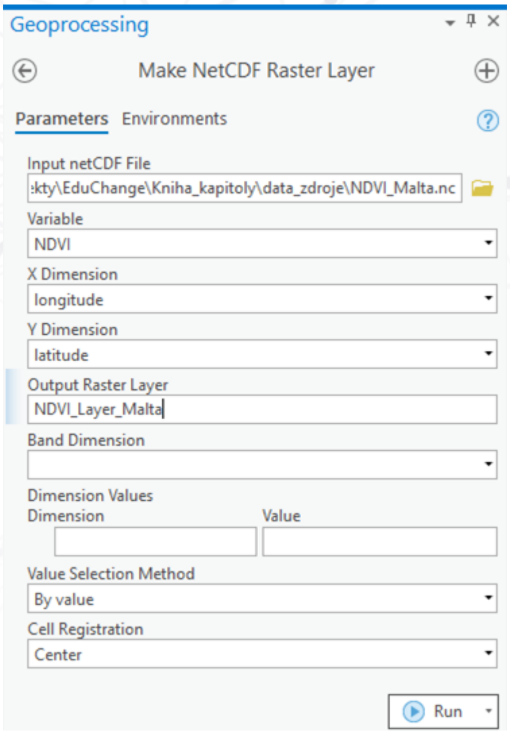


Figure 27: NDVI data import settings in ArcGIS Pro environment.

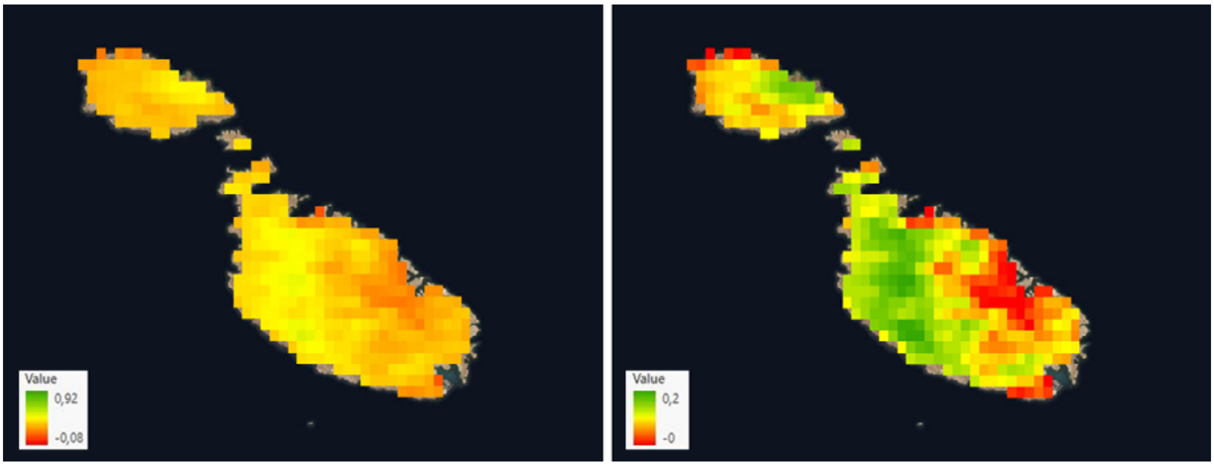


Figure 28: NDVI of Malta in the context of the whole dataset (left) and clipped to visible-only values using the same colour ramp (right).

As mentioned above, the higher value of the index, the more live green vegetation is present. Since the data in this example captures Maltese vegetation in August (the driest season of the year), the NDVI values are generally low (Figure 28 left). When we stretch colours only to the range for Malta, we can clearly distinguish areas with relatively fresh vegetation (western part of the main island), and, on the other hand, with almost no green vegetation in densely urbanised parts of Malta (e.g. around Valletta) or industrial areas (e.g. Malta Freeport). Analogically, one can use any other available product from the Copernicus Open Access Hub by following steps introduced above.

The last step-by-step example presents the easiest way to analyse and display Sentinel-2 data; however, it requires ArcGIS Pro software licence. Sentinel-2 data views can be displayed and analysed in ArcGIS Pro as an Image service provided by the Esri company (ArcGIS Pro developer). Albeit there are rather limited options for postprocessing of the Sentinel-2 data provided via ArcGIS Pro services, it is the easiest way to get straightforward access for Sentinel-2 imagery. Moreover, the Image service within ArcGIS Pro offers to pick a pre-set combination of the Sentinel-2 channels.

First, we have to open the Catalog window in ArcGIS Pro and on the Portal tab, we go to Living Atlas option. In the search bar, we type "sentinel" to obtain a list of the Sentinel-related product. Since we focus on Sentinel-2 products, we choose and load "Sentinel Views" Image service (Figure 29).

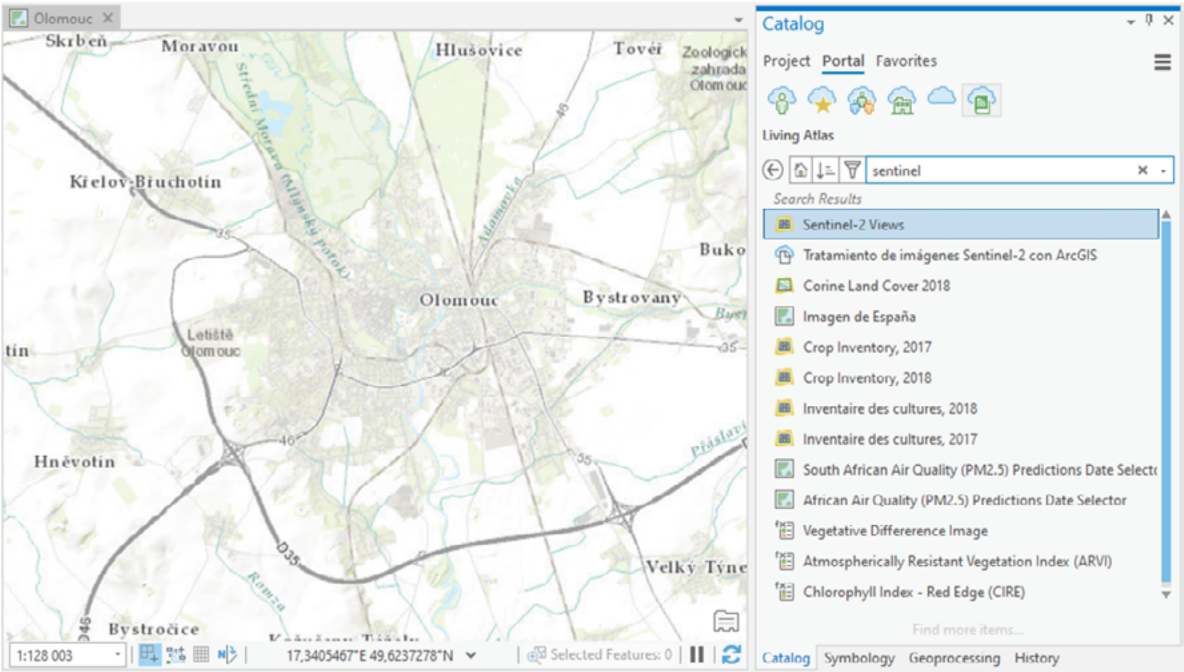


Figure 29: Search results within Living Atlas in ArcGIS Pro Catalog.

After we add the Sentinel-2 Views Image service into the current Map, we can choose a processing template (a pre-set combination of the Sentinel-2 channels) in the Content pane by displaying properties of the Sentinel-2 View layer (Figure 30). We can choose from pre-set types listed in Table 17. Figure 31 shows four examples of selected products in the area of Olomouc (Czechia). First, we displayed Olomouc and surroundings with natural colours (Figure 31a), which is closest to what we see by the naked eye. We intuitively distinguish urban areas (residential and white-coloured industrial buildings). At the same time, vegetation such as parks or grass/green fields appear green, and bare soils are in green to yellow shades. If we processed the image with the agriculture type (Figure 31b), built-up areas are displayed with purple tones, and vigorous vegetation is bright green, stressed vegetation dull green and bare areas as brown. Figure 31c depicts the area using short-wave infrared type, which shows vegetation in various shades of green (darker shades of green indicate denser vegetation). Brown is indicative of bare soil. Finally, we applied the Normalized Difference Water Index with adjusted colour ramp and 2% per cent clip of histogram (Figure 31d). These settings help us to distinguish moist areas (in blue-green shades) from built-up areas with a street network (white colour).

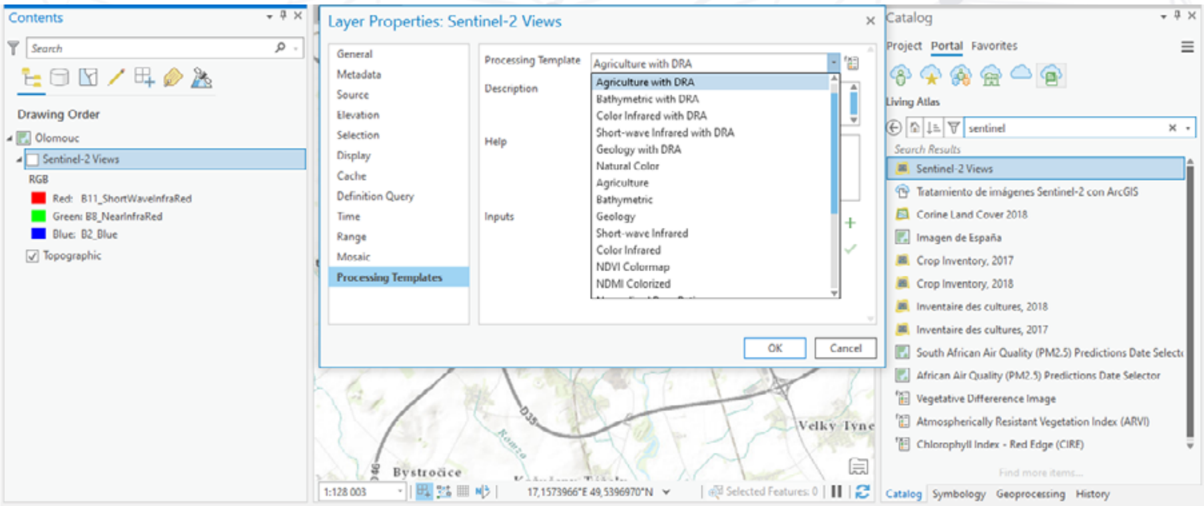


Figure 30: Search results within Living Atlas in ArcGIS Pro Catalog.

Table 17: ArcGIS Pro Sentinel-2 Views Image service types and their use

Type	Use
Natural color*	Displays the surface in „normal „colours with low in contrast and vague due to the scattering of blue light in the atmosphere.
Agriculture *	Vigorous vegetation is bright green, stressed vegetation dull green and bare areas as brown.
Bathymetric *	Useful in bathymetric mapping applications, changing lands and marine environmental monitoring and others.
Color infrared *	Healthy vegetation is bright red while stressed vegetation is dull red. Useful for vegetation, plant health, land cover and environmental monitoring.
Short-wave infrared*	Useful for vegetation, plant health, land cover and environmental monitoring.
Geology *	Highlights geologic features, useful for changing lands, land cover, and environmental monitoring.
NDVI Colormap	Useful for vegetation, land cover, plant health, deforestation and environmental monitoring. Green represents vigorous vegetation, and brown represent sparse vegetation.
NDMI Colorized	Normalized Difference Moisture Index displaying wetlands and moist areas in blue, whereas dry areas are represented by deep yellow and brown colour.
Normalized Burn Ratio	Highlighting burned areas, estimate fire severity and useful for environmental monitoring. The NBR raw index is the most appropriate choice to detect burnt areas (larger than 2 square kilometres).
Normalized Difference Built-Up Index (NDBI)	Useful for watershed runoff predictions, tracking urban expansion and land-use planning. The NDBI highlights urban areas with higher reflectance in the short-wave-infrared (SWIR) region, compared to the Near Infra-red (NIR) region
NDVI Raw / NDVI VRE only Raw / NDVI with VRE Raw	The same usage as NDVI Colormap, however, displayed in Raw mode, or with VRE (Vegetation Red Edge) - the spectral zone where reflectance abruptly increases from red to infrared and is sensitive to minor changes in canopy foliage content, gap fraction and deterioration
NDWI Raw / NDWI with VRE Raw	Normalized difference water index is useful for water scarcity and marine environmental monitoring, and mapping of water bodies, droughts, boundary evaluation. Water bodies have strong absorbability, and low radiation within the visible to infrared spectral ranges and this index is based on this phenomenon.

* These types are available either with DRA or without DRA. The abbreviation DRA stands for Dynamic Range Adjustment, which allows for stretching the pixel values within the display extent, i.e. not using pixel values from the whole dataset.

Figure 31: Resulting visualisation of various types of pre-set combinations of Sentinel-2 channels in ArcGIS Pro Image service (Olomouc, Czechia).

It has to be mentioned that Sentinel satellites visit the same spot on Earth every five days and Image service in ArcGIS Pro is regularly (daily) updated.

National Oceanic and Atmospheric Administration datasets

One of the leading programmes concerning research on climate and atmosphere represents the National Oceanic and Atmospheric Administration (NOAA). NOAA is a scientific, governmental agency of United States Department of Commerce focused on the oceanic and atmospheric research. NOAA's main goals are to understand and predict changes in climate, weather, oceans and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources. Scientists in NOAA use cutting-edge research and high-tech instrumentation to provide citizens, planners, emergency managers and other decision-makers with reliable information they need when they need it. Full details about the agency are available at https://www.noaa.gov.

As the agency has been researching for decades, they possess a rich data sources, which are available through the National Centers for Environmental Information (NCEI, formerly known as National Climatic Data Center - NCDC). Their product range is considerably wide and offers information and data on topics:

- Air Temperature and Atmospheric Properties
- Arctic and Sea Ice
- Ecosystems and Natural Resources
- Geomagnetism
- Global Climate
- Gulf of Mexico
- Maps
- Marine Geology and Geophysics
- Natural Hazards, Disasters and Severe Weather
- Ocean Climate
- Ocean Exploration and Research
- Ocean Profile
- Paleoclimatology
- Precipitation
- Satellite Oceanography
- Space Weather
- U.S. and Regional Climate

When accessing datasets from NCEI websites (https://www.ncei.noaa.gov/access), it is possible to browse data via Discovery Tools and Tools for Developers. Discovery Tools consists of NOAA OneStop tool designed to explore data from across scientific disciplines, formats, time periods, and locations; and Data Access application offering a wide variety of download and subsetting options for a growing collection of environmental data (at the time mostly weather and climate information). Moreover, there is also Geoportal and Product Index available as an alternative search within NCEI's Discovery Tools. As a more advanced option, Tools for Developers offers data access trough various APIs (Application Programming Interfaces), map services to access GIS-tailored datasets, and Climate Data Online service.

If we take a closer look at the Climate Data Online portal (https://www.ncdc.noaa.gov/cdo-web), we discover a large number of data access points to historical weather and climate data. It is possible to discover data through four main access points/buttons – Browse Datasets (…/cdo-web/datasets), Search Tool (…/cdo-web/search), Mapping Tools (https://gis.ncdc.noaa.gov/maps/ncei), and Data Tools (…/cdo-web/datatools). The last access point allows to search for data across multiple datasets (by finding a specific station, or by location), or within a single dataset for all available stations by selecting a common topic (e.g. air temperature and precipitation normals, daily weather records or marine data). In the next example, we will demonstrate how dataset search for multiple datasets works by selecting a station by its location. On the main portal webpage, we go to Data Tools, and in a Search Across Multiple Datasets we choose Select a Location (…/cdo-web/datatools/selectlocation). It is then possible to select a dataset, whereas daily, monthly and yearly global summaries are available for countries around the world, and normals (annual, seasonal, daily, hourly), precipitation and radar data can be downloaded only for some countries (USA and Canada are always available). In this example, we select daily summaries from Czechia and pick a weather station that is in the NOAA's network (Figure 32).

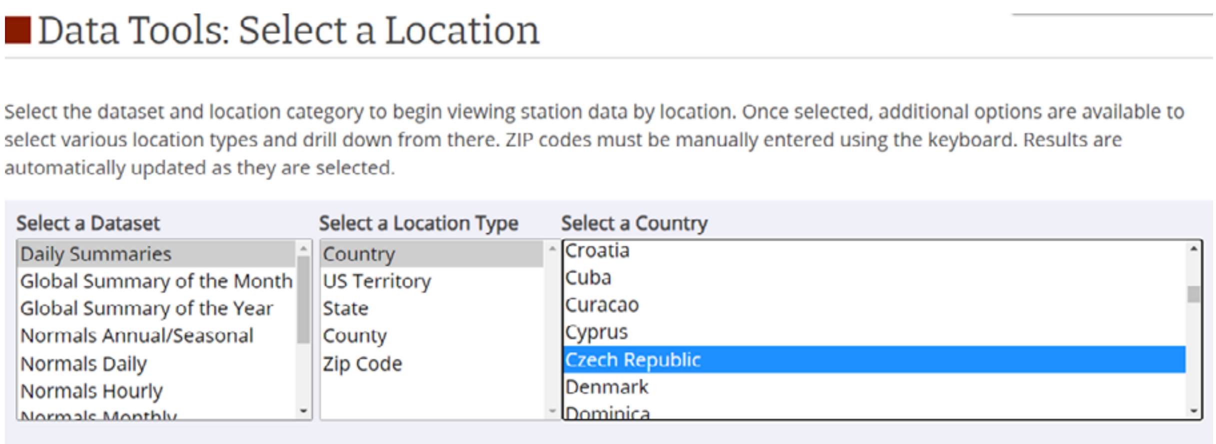


Figure 32: Selection of dataset within the Data Tools interface of Climate Data Online service.

Afterwards, a list of available weather stations appear, and we have to add to cart selected one. Then the process is similar to "normal" online shopping – we go to the cart and customise the dataset by defining data format, time range, station details, units, and phenomena (Figure 33) and proceed to check out selected items. All the data with no charge is then sent to your email address.

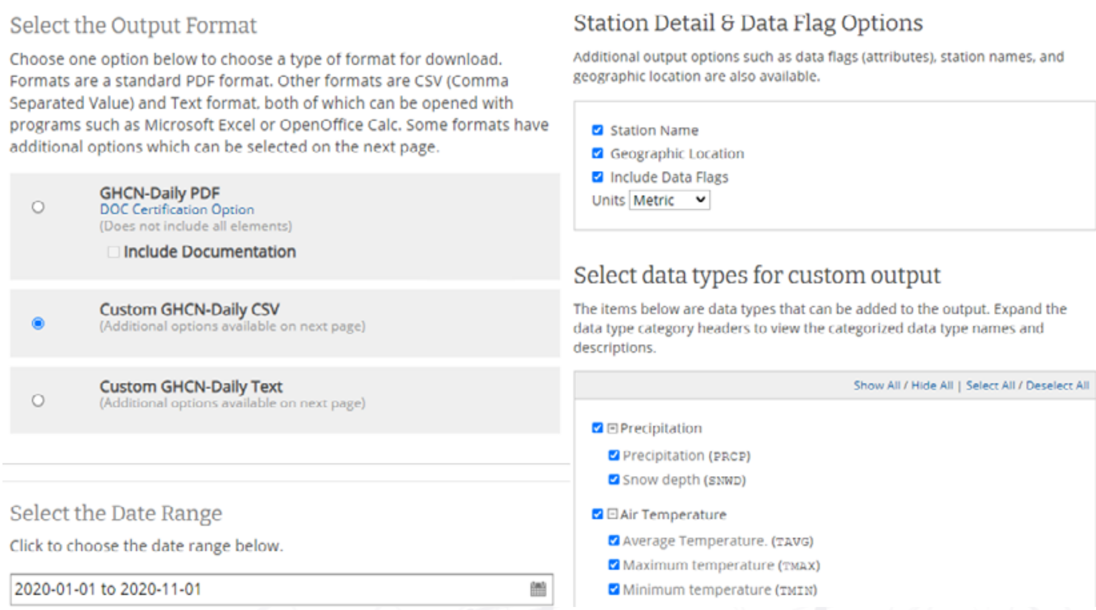


Figure 33: Customised selection of the output dataset.

As depicted in Figure 33, we selected CSV (Comma Separated Value) format, which can be easily imported to MS Excel – on Data tab in Excel, click on Connect to External Data, choose from the Text File, browse for your CSV data and import it. The data time range from 1st January to 1st November 2020, so we can visualise the data by charting average daily temperatures and precipitations directly in Excel from the selected station (Figure 34).

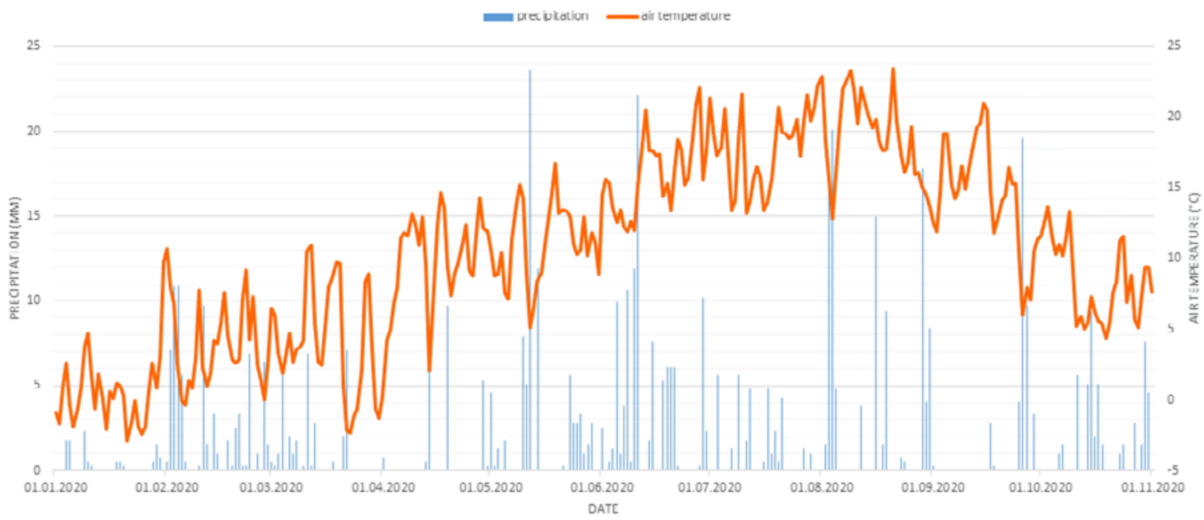


Figure 34: Resulting chart from downloaded data (station Kocelovice, Czechia).

NASA Earth Observations datasets

Another valuable and easy-to-use source of data about the Earth's climate comes from NASA Earth Observations (NEO, https://neo.sci.gsfc.nasa.gov/). The main goal of the NEO initiative is to help people picture climate and environmental changes as they occur on Earth. At the NEO websites, user can browse and download the imagery of satellite data from NASA's constellation of Earth Observing System satellites. Over 50 different global datasets are represented with daily, weekly, and monthly snapshots, and images are available in a variety of formats including JPEG, PNG, Google Earth, and GeoTIFF.

The website contains datasets in five main categories – Atmosphere, Energy, Land, Life, and Ocean – with more than 70 individual products (Table 18). Besides that this website is designed as an interactive visualisation tool with custom user settings, it also offers to download the data in various formats.

Table 18: Categories of datasets and their content available at NASA Earth Observations.

Category	Datasets
Atmosphere	Aerosol Optical Thickness, Aerosol Particle Radius, Carbon Monoxide, Cloud Fraction, Cloud Optical Thickness, Cloud Particle Radius, Cloud Water Content, False Color (MODIS), Nitrogen Dioxide, Ozone, Rainfall, True Color (MODIS), True Color (VIIRS), Water Vapor
Energy	Albedo, Average Land Surface Temperature [Day], Average Land Surface Temperature [Night], Average Sea Surface Temperature (AVHRR, 1985-97), Global Temperature Anomaly, Land Surface Temperature Anomaly [Day], Land Surface Temperature Anomaly [Night], Land Surface Temperature [Day], Land Surface Temperature [Night], Net Radiation, Outgoing Longwave Radiation, Reflected Shortwave Radiation, Sea Surface Temperature (AVHRR, 1981-2006), Sea Surface Temperature (MWOI, 1998+), Sea Surface Temperature (MODIS, 2002+), Sea Surface Temperature Anomaly (AMSR-E, 2002-11), Solar Insolation, UV Index

Land	Active Fires, Albedo, Average Land Surface Temperature [Day], Average Land Surface Temperature [Night], Blue Marble: Next Generation, False Color (MODIS), Global Temperature Anomaly, Greenland / Antarctica Elevation, Land Cover Classification, Land Surface Temperature Anomaly [Day], Land Surface Temperature Anomaly [Night], Land Surface Temperature [Day], Land Surface Temperature [Night], Leaf Area Index, Net Primary Productivity, Permafrost, Sea Ice and Snow Extent (Northern Hemisphere), Sea Ice Concentration and Snow Extent (Global), Snow Cover, Snow Water Equivalent, Topography, True Color (MODIS), True Color (VIIRS), Vegetation Index (NDVI), Water Equivalent Anomaly (2002-17)
Life	Chlorophyll Concentration, Land Cover Classification, Leaf Area Index, Net Primary Productivity, Population, Vegetation Index (NDVI)
Ocean	Average Sea Surface Temperature (AVHRR, 1985-97), Bathymetry, Blue Marble: Next Generation, Chlorophyll Concentration, Global Temperature Anomaly, Sea Ice and Snow Extent (Northern Hemisphere), Sea Ice Concentration and Snow Extent (Global), Sea Surface Salinity (2011-15), Sea Surface Temperature (AVHRR, 1981-2006), Sea Surface Temperature (MWOI, 1998+), Sea Surface Temperature (MODIS, 2002+), Sea Surface Temperature Anomaly (AMSR-E, 2002-11)

The functionality of the NEO website will be shown on an example of oceanic chlorophyll concentration dataset. By selecting the product, comprehensive website is displayed with a graphical overview of the data (Figure 35 – A), option for the time period usually varying as 1-day, 8-days, or 1-month display in a selected year (Figure 35 – B), and also a description of the dataset/indicator in three variants – basic, intermediate, advanced (Figure 35 – C). After this customisation is done, there is a download window (Figure 35 – D) allowing users to choose from various formats and spatial resolution (pixel size). Format options include JPEG, PNG, GeoTIFF (ideal for direct use in GIS), KMZ (for Google Earth application), and non-graphical formats such as CSV. Some datasets are available to download as raw data. Moreover, the websites allow to perform a comparative analysis of at least three selected datasets – the analysis tools include interactive queries on pixel values, generating of a scatter plot, histogram, or plotting user-defined transect; with all results displayed on the fly (Figure 36).

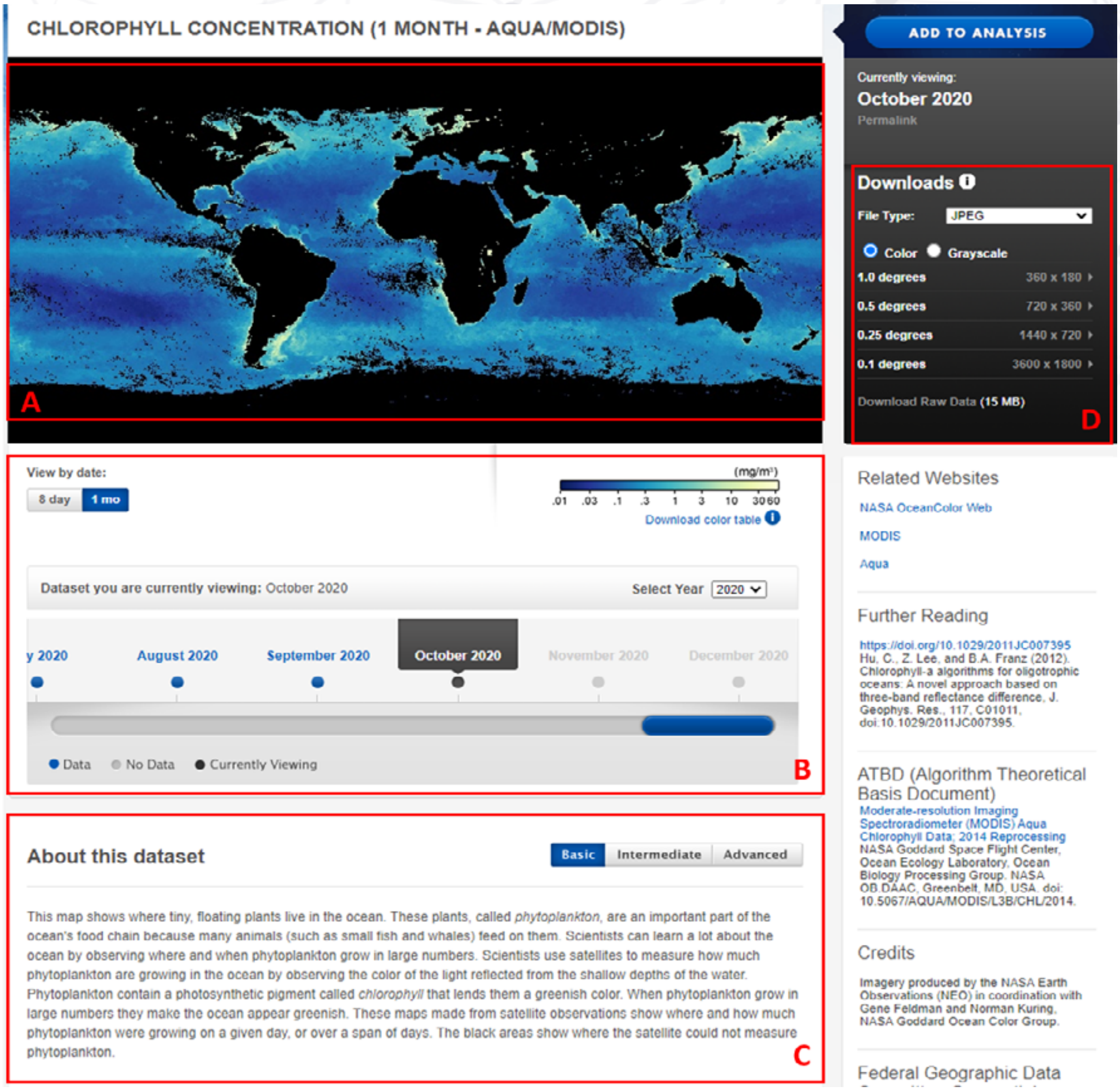


Figure 35: NEO website overview of custom functions for data download.

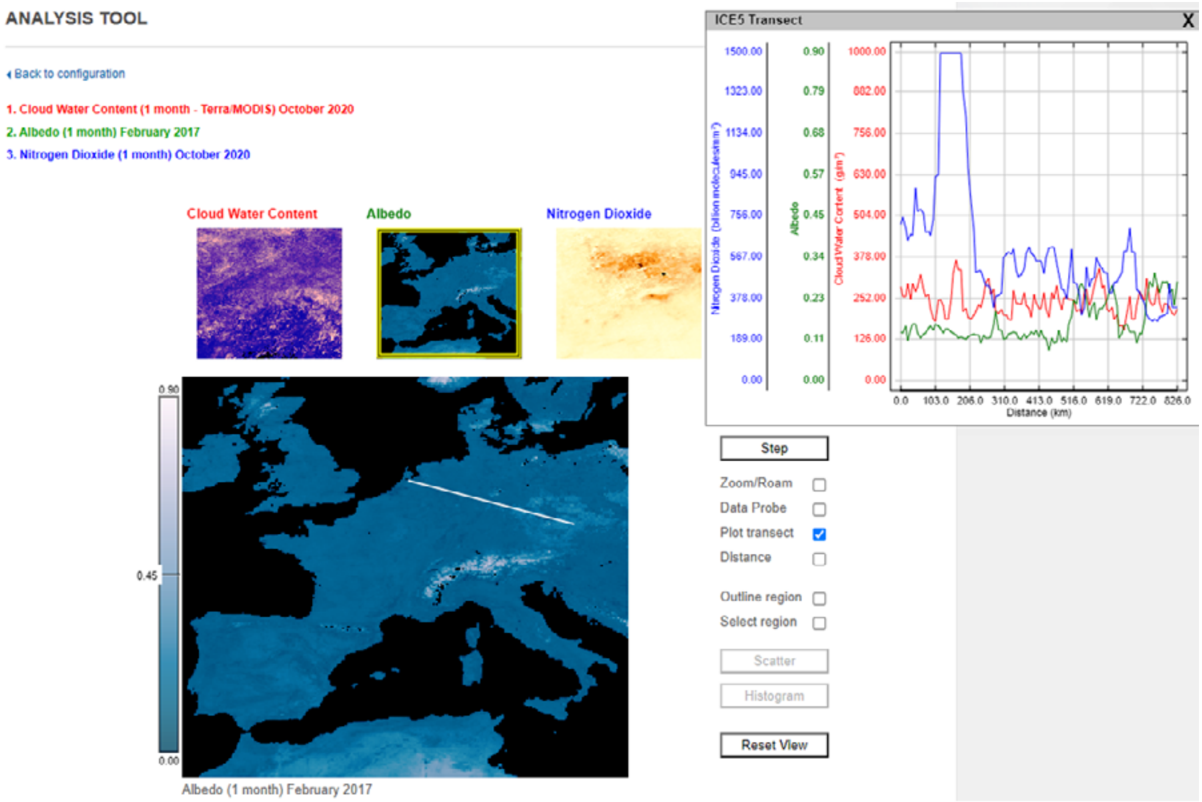


Figure 36: A snapshot from the Analysis Tool within NEO websites.

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CHAPTER 9: PHOTO STORIES – EFFECTIVENESS THROUGH COLLABORATIVE IMAGE CREATION

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Climate change education needs to focus on values and attitudes rather than knowledge if it is to be effective. A number of studies from around the world indicate that behavioural change does not come directly through an increase in the knowledge domain but mainly through factors that touch upon emotions, attitudes and values.

In the EduChange project, a novel and simple approach to achieve changes in attitudes and to instill a sense of ownership in the contextual environment was the development of photo stories, specifically within a sustainable development framework. Photo stories allowed students with little or no experience in photographic techniques to take pictures in situ and then to collate them as a group and produce a presentation that could have an impact on their intended audience. The future student teachers from the four participating countries were instructed in the production and use of photo stories and they started to create their own. The study also utilized a number of fieldwork sessions in which the participants had to create a thematic photo story that focused on climate change awareness-raising within the particular context studied. The students then presented their results through interactive sessions which were also evaluated by their peers.

This chapter gives an overview of how the photo stories were carried out and how they can be incorporated into teaching and learning about climate change. It also highliughts effective methodologies used within the different thematic photo stories.

Overall, photo stories were found to be very effective in increasing the knowledge, awareness and attitudes of the students towards climate change. The collaborative photo story was seen as being highly effective in nurturing the skills required by future teachers and their students in doing climate change education. The study identifies the photo story methodology as an effective means of developing teachers and students who are not only knowledgeable and aware of climate change, but who are also able to positively influence the knowledge, attitudes and behaviour of students towards the environment in general and climate change in particular.

Introduction to Photography

Photography is a method whereby information in the form of light associated with a particular subject is recorded, stored and analyzed for subsequent interpretation and evaluation of the real subject at a later time. Good photographs come from developing an eye for a picture - not from using banks of powerful studio lights, digital cameras or two foot long telephoto. Success requires no more than the ability to make the essential creative leap from what is seen to what will work as a photographic image.

It is important to note that photographs are not the real subjects, but rather records of the appearance of a subject based on light emitted, reflected or transmitted by the subject. Therefore, photography is generally not considered an invasive or destructive recording medium since the contact between the record and the subject is simply one associated with light. As such, photography is inherently dependent on image formation principles associated with the field of optics.

Photo story theory and practice

In photographic practice, visual storytelling is often called a 'photo essay' or 'photo story'. It is a way for a photographer to narrate a story through a series of photographs. Captions are also an integral part of a photo story that should help the viewer understand each image. In the EduChange project the notion of the photo story was defined as a series of photographs, which are then connected together and the 'captions' are in the form of a real live commentary by the students. This simple idea was explored because the future teachers involved in EduChange would always have a 'captive' live audience; when facing a class of pupils. Real, live narration is much more effective than a recorded message or a written caption.

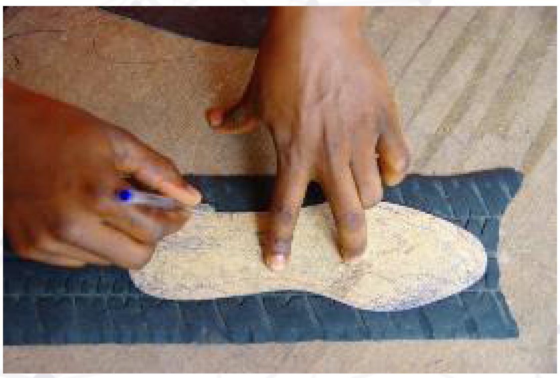
An example of a photo story used in the workshop with students.

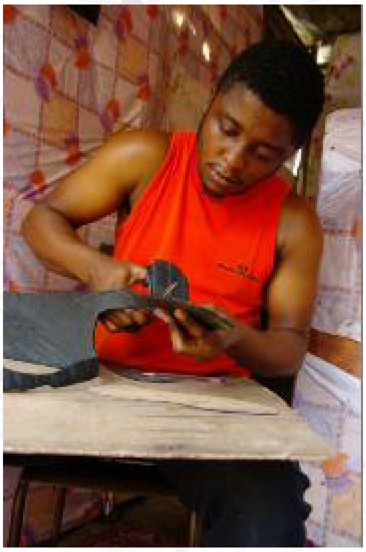
A man producing shoes in Cameroon. In this case the story is a simple and effective way of weaving into the discussion with students ideas concerning the following:

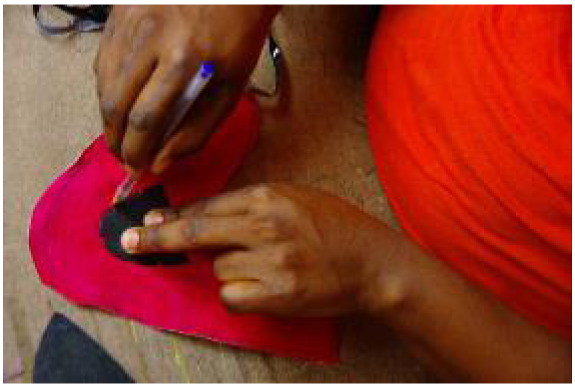
- the issue of poverty (SDG 1)
- using discarded materials to recycle and make saleable products (SDG 12)
- lack of sewage and water services – relation to disease (SDG 6)
- livelihoods and family (SDG 8)
- living conditions (SDG 10)
- energy production (SDG 7)

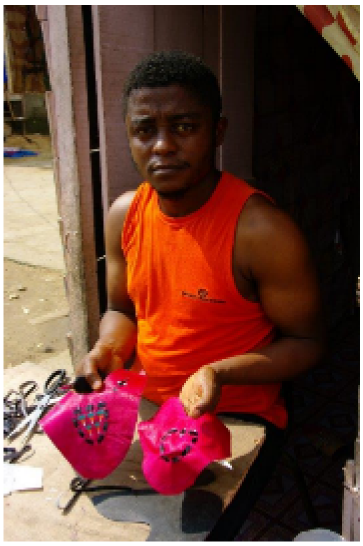


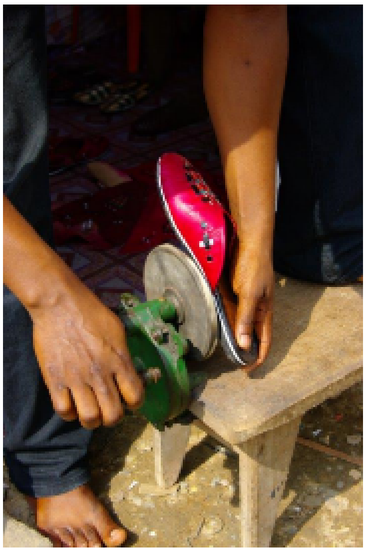


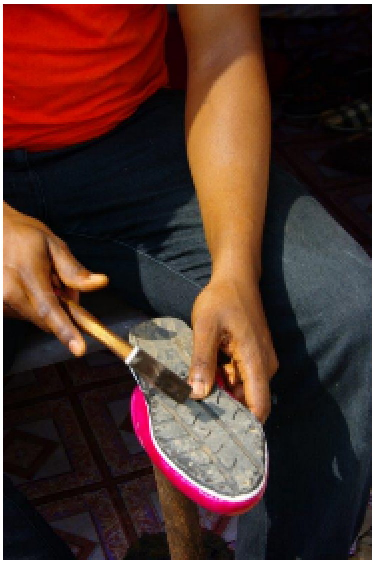






Workshop Methodology

In order for the students to produce an effective photo story they were given the opportunity to attend a workshop in which the principles of a photo story were defined and explained. Students were also given a number of technical and artistic guidelines in order to increase the immediate impact of their photographs on their audience.

Workshop Objectives and Content: The workshop helped students to understand the science of photography and to use their new skills to improve teaching episodes.

The workshop aimed at introducing students to the basic concepts of photography, including: camera types, lenses, depth-of-field and field of view, and digital technology. Through practice the students were also exposed to aspects of various photographic techniques, including the use of: lighting, tripods, shutter speeds, rule of thirds, diagonals, photomacrography, simple supplementary lenses, filters, scanning, interpolation, storage media, and photo editing and photo stories.

Following the workshop and practical sessions, students were asked to put into practice what they learned about the science and art of photography. They produced a photo story based projects and present their respective projects during a seminar session.

Study Skills Acquired: Use of a camera, photoeditors and photographic techniques. Critical analysis of photographs, application of theoretical principles to improve practice.

Technical Aspects Covered during Workshop

To enable students to get the best out of a photograph, the workshop provided insights about the nfollowing technical aspects of cameras and photography:

Area 1 – Focusing and Sharpness

Focusing means simply adjusting the distance between the lens and the film to form a sharp image of the subject on film. This can either be done by the photographer (Manual focusing) or it can be done by the camera (Autofocusing). It is to be noted that autofocusing is extremely accurate and fast but is not suitable for such applications as closeups, underwater and low light photography. To focus manually most cameras have a focus control ring that moves the lens away or closer to the camera body. Manual focus does not need batteries to work and you can use it creatively. Some cameras are labelled as being focus free. Avoid these cameras as they are neither autofocus or manual focus. They just have a fixed lens.

Area 2 – Shutter speeds

The shutter is the basic picture taking control on the camera. The shutter speeds are actually exposure times or the time duration in which a film is exposed to light. There are different shutter speeds and their selection affects both sharpness and exposure.

Slow speeds: 30s, 15s, 8s, 4s, 2s, 1s, 1s, 1/2s, 1/4s, 1/8s 1/15s

Medium speeds: 1/30s, 1/60s/ 1/125s

Fast speeds: 1/250s/ 1/500s/ 1/1000s, 1/2000s.

A safe working speed for handheld shots with a normal lens is 1/125s – fast enough to stop camera shake and freeze all except rapid motion.In practice the choice is often limited by the lighting. In dimmer light longer exposures are needed, and this makes it difficult to freeze movement. With speeds below 1/60s a camera support such as a tripod is required.

Area 3 – Depth of field

Lenses have zones of acceptable and unacceptable rendering of the visual perception of sharpness or, have limited “depth-of-field” (zone of acceptable sharpness). This zone of acceptable sharpness can, however, be controlled by selection of the lens aperture or diameter: the larger diameters producing the least depth of sharpness in a scene. The smaller the f# the “faster” the lens, meaning the images it produces are brighter than a lens with a larger f#. “Fast” lenses are important when photographing under adverse lighting situations. By convention the following set of f/’s has been standardized. Starting with f/1 the progression is: f/1.4, f/2.0, f/2.8, f/4, f/8, f/11, f/16, f/22, f/32, f/45, f/64. These f’numbers increase or decrease the illumination level of the image by a factor of 2 as one goes from one number to the next.

Area 4 – Lenses

Interchangeable lenses allow a photographer to remove a lens from a camera body and attach another one. The primary reason for interchangeable lenses is to have the ability to use lenses of different focal length. As the focal length of a lens is changed the camera’s field of view will be altered. With a subject at a particular distance from the camera a change in the field of view will make the subject appear to be larger in the viewfinder of the camera as the focal length is increased, and smaller as the focal length is decreased. Lenses are generally designated as normal, wide-angle and telephoto or long-focus.

The distance between the lens and the image plane when the subject is located at infinity is known as “F” or the focal length. Knowledge of a lens’ focal length allows the photographer to determine various outcomes associated with the use of a given lens in various applications.

All 35mm, most large format, and some digital and APS cameres can be fitted with interchangeable lenses.

Our eyes have a field of view similar to a 50mm lens.

Wide angle lenses, 20mm, 24mm, 28mm, 35mm – good for shots inside buildings and landscapes.

Normal lens: 50mm – cheap lens, can be used in most situations (a jack of all trades)

Telephoto lenses: 100mm, 200mm, 400mm, 600mm – excellent for sports and bird photography and big mammals such as tigers.

Zoom lenses: have varying focal lengths: 28-80mm, 100-300mm. - convenient lenses that have more than one focal length. Convenient for holidays so the photographer can carry less luggage but there is a reduction in image quality.

Artistic aspects covered during Workshop

The workshop presented different photographs and students were asked to express the feelings and emotions that the photographs provoked. The workshop later explored the artistic aspects (outlined below) that could enhance a photograph's message and impact.

Area 1 – Camera Use

Keep Your Camera Ready

How many once-in-a-lifetime pictures have you missed because you didn't have a camera with you? It's easy to avoid that frustration by keeping a camera handy. Spontaneous moments make priceless pictures. To capture them you need to have a camera with you. If your regular camera is too large to carry conveniently, consider a low-cost pocket-sized model as a standby.

Hold Your Camera Steady

Sometimes good pictures are missed because people overlook the basics. Holding the camera steady is vital for sharp, clear pictures. When you push the shutter button, press it gently rather than jabbing it. Even slight camera movement can rob your pictures of sharpness. Use a brace to steady your arm or use a tripod if available.

Area 2 – Subjects

Keep People Busy

When photographing people, keep them busy! Your pictures will have a feeling of lively spontaneity. To avoid stiff, static poses, prompt your subjects to be active. Their expressions will be more relaxed and natural.

Place the Subject Off-Centre

There is nothing wrong with placing the subject in the centre of your viewfinder. However, placing the subject off-centre can make the composition more dynamic and interesting to the eye. You can use the rule of thirds as a guide in the off-centre placement of your subjects. Here is how it works. Before you take the picture, imagine your picture area divided into thirds, both horizontally and vertically. The intersections of these imaginary lines suggest four options for placing the centre of interest in ordere to achieve good composition. The option you select depends upon the subject and how you would like that subject to be presented.

Area 3 – Backgrounds and Foregrounds

Use a Simple Background

A simple background focuses attention on the subject and makes clear, strong pictures. Take control and move your subject or your camera to find a simple, uncluttered background.

Include Foreground in Scenes

When taking scenic pictures, try including objects in the foreground. Elements in the foreground add a sense of distance, depth, and dimension.

Area 4 – Composition

Rule of Thirds

The rule of thirds is a guideline which proposes that an image should be imagined as divided into nine equal parts by two equally spaced horizontal lines and two equally spaced vertical lines, and that important compositional elements should be placed on the intersection of the lines.

Get Close

As a general rule, the closer you get to the subject, the better your pictures will be. Being close eliminates distracting, unnecessary backgrounds and shows the subject clearly. Think about showing just enough of the scene to make the picture clear and interesting. Be sure to check your camera manual to learn the closest distance at which your camera takes sharp pictures. Many point-and-shoot cameras cannot focus closer than a few centimetres from the subject.

Simplicity

An important guideline is simplicity. Look for ways to focus attention on the centre of interest in your pictures. One way is to select uncomplicated backgrounds that will not distract from your subjects.

Area 5 – Good Lighting

Adequate lighting is essential to expose film, but good lighting can make your pictures more interesting, colorful, dimensional, and flattering to the subject. Strong sunlight is only one of many types of good lighting. Some people are surprised to learn that cloudy, overcast days provide the best lighting for pictures of people. Bright sun makes people squint, and it throws harsh shadows. On overcast days, the light is soft and flattering to faces.

Examples of Student photo stories produced during workshops.

The Water cycle – an insight into water

A photo story created by students in less than an hour, illustrating the water cycle. In this case the story is a simple and effective way of weaving into the discussion with students ideas concerning the following:

The importance of trees.

Life in water

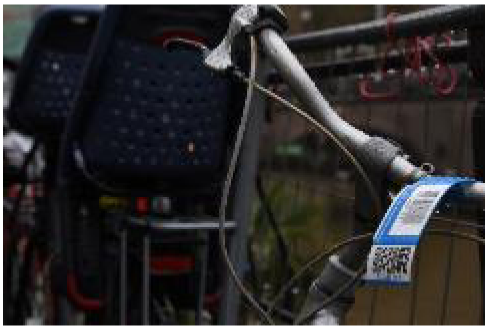
Humans and the water cycle

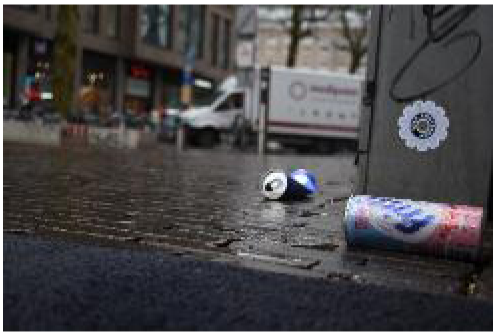
Flooding and drought

Waste Management

A photo story developed by students in less than an hour illustrating waste management. In this case the story is a simple and effective way of weaving into the discussion with students ideas concerning the following:

- Sustainable consumption.
- Marketing
- Energy costs of recycling
- Transportation as a means of reducing waste
- Percieved and planned obsolescence





Conclusion

Photo stories are an effective way of weaving value laden themes into climate change discussions and they can act as aids for students when collaborating to create new resources. The stories help bring the human element to environmental issues and can increase understanding of local communities, thus facilitating sustainability. Photo stories are also about empowering people and making them feel appreciated and needed within society. Appreciation also comes through working with younger generations. Nonetheless, the techniques required take time to be acquired and polished, and it is visually apparent that students would benefit from increased exposure to workshops and further practice, in order to hone the techniques required.

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CHAPTER 10: HOW TO DESIGN AND CONDUCT FIELDWORK LESSONS WITH LOW-COST VR

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Nowadays it is possible to apply Virtual Reality (VR) in classrooms at relatively low costs, following a Bring Your Own Device approach in which students use their own smartphones in combination with cheap polyester or cardboard VR glasses. This offers students in secondary and higher education the possibility to study e.g. climate change and water issues at far-away places without leaving the classroom. Also, it allows students to visit several places in a short time, and compare how these places are affected by climate change.

Several fieldwork approaches can be followed with VR. In a *VR excursion*, the teacher guides students from one 360-degree photo to the other, and explains what can be seen. In a *VR field research*, students work in pairs on tasks in a fieldwork booklet, and put their VR glasses on and off. In *exploratory VR fieldwork*, students explore a predetermined selection of 360-degree photos about a specific issue, and are stimulated to ask enquiry questions. The teacher then engages in a discussion with the students, and provides extra information when needed. Besides the three approaches for VR fieldwork lessons listed above, VR can also be used as a *preparation* or *debriefing* of real outdoor fieldwork.

Teachers (and students) can use the free VR Tour Creator (vr.google.com/tourcreator) to develop their own VR content[4]. With this application, they can upload photos taken with a 360-degree camera, or search 360-degree photos in Streetview and add them to a tour as *scenes*. Students can view the tour on their smartphone with the help of the free Google app 'Expeditions' or 'Google Poly'. It requires surprisingly little technical skills to develop VR content. The main challenge is, however, to find a good approach to teach about climate change and water issues with VR.

In the EduChange field week, pre-service teachers participated in a VR workshop which introduced them to VR as an educational tool, and how to design VR content for education about climate change and water issues. After the workshop, interviews and surveys were conducted. This chapter discusses how (pre-service) teachers can design and conduct VR lessons. Also, the chapter discusses thoughts and reflections from the students on how VR can, should or should not be used in climate change education will be discussed.

Real fieldwork and virtual fieldwork

Well-designed, planned, conducted and debriefed fieldwork activities can have a positive effect on students' learning (Rickinson et al., 2004). Fieldwork can be seen as activities taking place outside the classroom in which students engage in experiencing and studying phenomena in the real world by engaging in activities such as observing, measuring and interviewing (Oost, De Vries & Van der Schee, 2011; Foskett, 1997; Hill & Woodland, 2002; Scott, Fuller & Gaskin, 2006; Witham Bednarz, 1999).

The advantages of fieldwork are widely acknowledged. However, in many countries, fieldwork is not conducted as frequently and systematically as teachers would like (Oost et al., 2011).

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4 Google stops supporting the Tour Creator and Google Poly per 30 June 2021. By the time of writing, there are several other platforms that offer the possibility to view VR content. It is likely that in the future, some of these platforms also allow the possibility to develop content by including 360 degree photos.

In practice, there are often constraints such as fixed school timetables, costs and concerns about the safety of students. Also, it takes considerable time and effort to plan a fieldwork. Finally, some teachers do not feel confident and experienced enough to design and conduct fieldwork.

A *Virtual Reality fieldwork* can be a good alternative when real fieldwork is not possible (Favier & Booden, 2019a; Minocha, Tilling & Tudor, 2018). The world around us is brought into the classroom with the help of *VR technologies*, which create a three-dimensional virtual world that one can immerse into and interact with (Lee & Wong, 2008; Boas, 2014). Teachers can let students study a series of 360-degree photos of places, called *scenes*. The VR device tracks the motions made by the user, and constantly modifies the images. For students, it is as if they are actually standing near a melting glacier, in a dry cropland or in the floodplains of a river. This connects to the idea of *telepresence* (Draper, Kaber & Usher, 1998). Students can learn through "being and exploring" in the virtual environment, rather than perceiving information about the effects of climate change and water issues from a lecture or textbook. In such a way, VR can offer students a first-person experience.

VR fieldwork can have not only practical advantages over real fieldwork, but also advantages for teaching and learning (Favier & Booden, 2019a; Bambury, 2019; Gutiérrez et al., 2017). First, VR allows students to visit places that are difficult to access, such as the Greenland ice sheets or the tundra plains in Siberia. Also, large distances can also be covered in one lesson. In just half an hour, students can travel from the North Pole to the Equator and see how the effects of climate change vary between places. This is called *global teleportation* by Bambury (2019). VR can also offer students more than a snapshot visit. If scenes of different years are available, students can investigate how places have changed over time. They can study, for example, how glaciers are retreating. VR can therefore be a sort of *time machine* (cf. Bambury, 2019).

VR technologies

There are roughly two technological ways to implement VR in classroom settings (Favier & Booden, 2019A and B). The high-end option uses *headsets* that include an LCD screen, motion sensors and other technology. They are easy to use, for teachers as well as students, as they offer strong processors, easy access to the screen and sharp images. Also, teachers can easily connect them to the teacher device, and can prepare them before the start of the lesson, which saves time and a hassle. Unfortunately, headsets are pricey (they start at around 200€), and a classroom set is out of reach for most schools. The low-end option uses students' smartphones in combination with polyester or cardboard *VR glasses (Figure 37)*, which cost between 5 and 20€ each. Although the *Bring Your Own Device (BYOD)* approach is much cheaper that the high-end approach with headsets, it is far more challenging for teachers. Students bring in a variety of smartphones, and also a variety of potential problems. Think about batteries that run low, and smartphones with settings that are difficult to adjust. Some smartphones are not suitable for studying scenes in the stereoscopic mode, and students with such smartphones have to put off their VR glasses and switch to the monoscopic mode (*Figure 38*). Additionally, there can be nuisances such as notifications of social media apps and suddenly decreasing brightness of the screen. It helps to tell students to prepare their smartphones before the start of the lesson, but this can be a hassle.

Figure 37: Examples of a headset, polyester insert VR glass, cardboard insert VR glass, and click-on VR class.

Figure 38: scenes on a smartphone, in the monoscopic VR mode (above) and in the stereoscopic VR mode (below).

VR applications

Several platforms can be used to develop and conduct VR fieldwork. The Google applications offer many possibilities, and are available without costs (Favier & Booden, 2019a). There are two options: The first is to use the Google app 'Expeditions', which can be downloaded from the iOS app store (iPhones) or Google Play (Android devices). The app has a library with more than 1,000 *tours* that consist of a series of scenes. There are a couple of tours about climate change, such as 'climate research on the ice sheet of Greenland', and 'climate change and droughts' and 'ocean acidification and coral bleaching'. The scenes in the tours are enriched with textual information that can be opened in pop-ups, so-called '*points of interest*', which explains what can be seen.

Teachers can also create their own tour, with the application *VR Tour Creator* (vr.google.com/tourcreator). With this application, teachers can upload their own photos made with a 360-degree camera. Alternatively, teachers could also search Streetview for a suitable scene and add interesting scenes to their tour. Next, teachers can add points of interest and include additional information or questions. When finished, teachers can publish their tour, share it with students, and opened it in the app 'Expeditions' or in a browser as a so-called *Google Poly Tour*. The app generally works best (*Figure 39*). In order to save time, it is advised to instruct students to install the app and to download the tour before the lesson.

Expeditions	**Google Poly**
Pro: Can be used fo VR excursions as well as VR field research	Con: Can only be used for VR field research
Pro: The tereoscopic VR mode worked properly on more than 90% of the smartphones	Con: The stereoscopic VR mode worked properly on about 50% of the smartphones
Con: Starting the tour is a hassle - requires students to install the app and search for and download the tour	Pro: Starting the tour is easy. Students just enter the URL in the browser
Pro: Does not depend on WiFi in the classroom. The tour can be downloaded before the start of the lesson	Con: Does depend on WiFi in the classroom.
Con: Navigation between photospheres by students is dificult	Con: Navigation between photospheres by students is dificult

Figure 39: Pros and cons of the app Expeditions and Google Poly.

Using the app or the browser, students can view tours in three different ways on their smartphones. In the *desktop mode*, students to pan through the scenes using their fingers, similar to panning with a mouse on a laptop or PC. This is the easiest way, but offers a non-immersive experience. When students switch to the *monoscopic VR mode*, they can move their smartphone, and the image adjusts automatically. Alternatively, they can switch to the *stereoscopic VR mode* and put their smartphone in a VR glass (*Figure 38*). The high degree of immersion can result in a wow-effect: in just one second, students enter a completely different world. However, it can also lead to physical discomfort, especially when using a non-optimal smartphone.

VR fieldwork approaches

Empirical-oriented fieldwork emphasizes systematic data collection and cognitive processes, while *experience-oriented fieldwork* puts emphasizes the use of multiple senses and affective processes. Compare for example the questions “How is this place affected by climate change?” with “How do you feel about this place?”. VR fieldwork can cause affective incenses, just like real fieldwork. Various authors (e.g. Ballantyne & Packer, 2002; Entwistle & Smith, 2002; Kwan & So, 2008; Marton, Hounsell & Entwistle, 2005; Nundy, 1999; Oost et al., 2011; and Rickinson et al., 2004) argue that a fieldwork approaches that address both cognitive and affective learning processes are most effective to develop deep understanding of issues, as the processes can reinforce each other. When we tested the VR tour about climate change, we noticed an emotional response in some students.Several approaches to empirical-oriented fieldwork can be distinguished (Favier & Booden, 2019A, *Figure 40*), which match with approaches for real fieldwork (Oost et al., 2011). The approaches are discussed below.

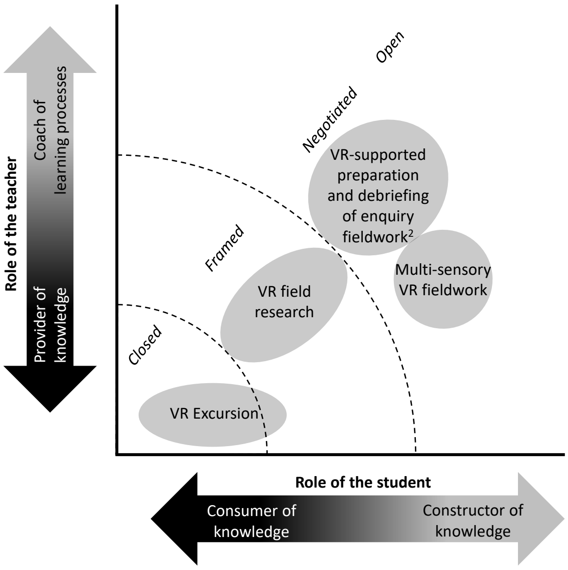

Figure 40: Approaches to VR fieldwork (Favier & Booden, 2019a,b).

VR excursion

The *VR excursion* is a closed fieldwork approach, similar to a traditional excursion in which a teacher with local knowledge guides students through a landscape. Every student needs a VR device, which should have the app ‘Expeditions’ (Google Poly is more difficult to use in this case). The teacher starts the tour on the teacher device in the ‘guiding mode’, and invites students to join the tour in the ‘following mode’. When the students are connected to the teacher device, he or she can take them simultaneously from one scene to the next. Students can look around, but the teacher can also make students focus attention of specific objects in the scene, and explain what can be seen or ask questions to the students. Interaction can be difficult though, as students are blocked off from the classroom.

Van der Meer & Booden (2019) argue that VR excursions shouldn't take longer than 20 minutes, as students may get a headache or eye strain when they use VR too long.

Starting a VR excursion following the BYOD approach can be challenging. Teachers have to wait until all students are connected to the teacher device, and for all students to have started the app and put on the VR glasses. A single problem can be a fatal obstruction for the entire lesson. It's off course not desirable when a student cannot join because he or she has a problem with his or her smartphone.

VR field research

In the second approach, *VR field research*, students work on tasks in a fieldwork booklet, and can go from one scene to another in their own pace. It is advised to let students work together in pairs, and to them only one VR glasses per pair. Students can then alternate between reading the instruction and tasks in the fieldwork booklet, and viewing the scenes in VR. This forces them to explain what they see to each other. Meanwhile, the teacher can walk through the classroom and offer help if needed.

Visiting a series of fieldwork sites and doing observations can be interesting for students, but the VR fieldwork can be more relevant when it is organized around a main enquiry question. The selection of scenes and activities (such as guided observing, comparing places, comparing moments in time, drawing cross sections, matching concepts to objects, etc) should be relevant to answer that main enquiry question.

There are several possibilities for sequencing the scenes of the fieldwork sites. For example, teachers can choose for a *spatial structure*, studying the effects of climate change on different regions going from the North pole to the Equator, or studying water management issues following a river from its source to mouth. Another option is to follow a *problem-solution oriented structure*, first studying photo's that show the causes of climate change (emission of greenhouse gasses), then the effects (such as heavy rains and subsequently high river discharges) and finally solutions (such as dike construction). As it is important that students get an overview of the area where they are performing their virtual fieldwork tasks, it is advised to include a map that shows the different sites in the fieldwork booklet.

Starting a VR field research is easier than starting a VR excursion. Students don't have to wait for other students, but can start right away. Also, as students work pairs, technical problems are less frequent. In case one of the two smartphones doesn't work, they can always use the other smartphone. Also, the chance that students suffer from a headache or eye strain are much lower in the VR field research approach, as students put their glasses on and off. The problems are negligible in case teachers let students study the scenes in the monoscopic mode.

When students work with VR, it is necessary to give technical instructions at the beginning of the lesson. It works best when the teacher shows students how to start the tour, how to switch to monoscopic and stereoscopic VR mode and how to put on the glasses and adjust them. When following the VR field research approach, students have to navigate between scenes themselves. This can be difficult, and it is therefore also advised to give navigation instructions.

VR enquiry fieldwork

In the third model, *enquiry fieldwork*, a problem is identified around a topic selected by the teacher, ideally from the students' own experiences in the field. Students are stimulated to formulate enquiry questions, conduct observations or gather appropriate data in the field and visualize the geodata in geographic representations. They should subsequently process the observations and representations to answer their enquiry question. Findings are shared, evaluated, and sometimes used to design actions.

VR can be used in enquiry fieldwork for some topics such as geomorphology, in which the landscape analysis is done by looking around and analyzing what can be seen. The analysis can be supported by including details in vegetation and soil structures in pop-ups in the scenes.

It is also possible to let students make their own VR tours and either use them to explain the results of their (virtual) fieldwork to other students or the teacher. Students can choose scenes they made in the field themselves with a 360-degree camera (which start at around 150 Euros) or scenes they selected in Streetview.

For most topics, however, it is also questionable to what extent students are able to answer self-formulated enquiry questions by studying scenes alone. Answering enquiry questions often requires data collection via measurements, smell, touch, surveys and interviews, and this is not possible with VR off course. The use of other secondary sources, such as texts, figures and photos in the tour or in the fieldwork booklet can be a way to partially overcome these obstacles.

Exploratory VR fieldwork

A limited version of VR-supported enquiry fieldwork is possible, in which students freely explore a predetermined selection of scenes about a specific issue, and are stimulated to formulate enquiry questions. This approach is called '*exploratory VR fieldwork*'. The teacher can then engage in a discussion with the students, and provide extra information if needed. On the basis of interviews with teachers who had conducted VR excursions, Minocha et al. (2018) conclude that teachers especially value the lessons because they raise higher order enquiry questions.

Preparation or debriefing of real enquiry fieldwork

Virtual Reality can also be used in the preparation or debriefing of real fieldwork. Teachers can let students study a scene of the fieldwork site before they go there, in order to familiarize them with the site and to think about possible enquiry questions and plan methods to answer their enquiry questions (Minocha et al., 2018). Also, teachers can use VR to re-visit the site in a debriefing of an outdoor fieldwork, by showing the scenes on the digiboard, and discuss students' findings.

VR glasses

There are various types of low-cost VR glasses. A main distinction can be made between *insert glasses* and *click-on glasses* (Figure 37). The first are closed cardboard or polyester glasses where students can put their smartphone in, while the latter are open polyester glasses that students can click on their smartphone. The choice for a specific glass depends on the fieldwork approach (*Figure 41*).

	VR excursion	*VR field research*	*VR exploratory fieldwork*
Learning goals	Geographic content	Geographic content and thinking skills	Geographic content and formulating inq. questions
App	Expeditions	Expeditions or Poly	Expeditions, Poly or Streetview
Glasses	Closed insert glasses	Open click-on glasses	Closed insert glasses or open click-on glasses
Grouping	Individual	Pairs	Individual or Pairs

Figure 41: Characteristics of the three approaches to VR fieldwork.

Insert glasses and VR headsets are especially suitable for VR excursions. They block off distractions in the classroom, and offer a high degree of immersion. However, the drawback can be that students may feel unsafe, as they cannot keep an eye on their environment. Another disadvantage is that students can suffer from motion sickness.

When following a VR field research approach or exploratory VR fieldwork approach, open click-on glasses are more appropriate than closed insert glasses. This is because students have to go from one scene to the other by clicking on the screen, and their smartphone is much more accessible when using open click-on glasses. Another advantage is that students can show their findings to each other, which makes it easier to discuss the content. It is necessary to mention that VR can result in headaches, eye strain and motion sickness if used for long times, and that it is not recommended to use VR in classes with kids younger than 13 years.

Furthermore, national regulations apply to the use of VR in education. We encourage new users to read the chapter "Health and safety" in the PDF book "Children and Virtual Reality" (Yamada-Rice, 2017).

Experiences of EduChange participants

During the EduChange field week, six students attended a three-hour workshop about VR as a tool for education about climate change and water issues. In the workshop, students watched a climate change related VR film made by BBC. Students subsequently made short videos with small 360-degree cameras and watching these videos in VR afterwards. Next, we discussed practical issues and design principles for developing appropriate VR educational materials. Students subsequently studied existing tours and fieldwork booklets, and then made tours themselves with the Google Tour Creator. At the end of the workshop, we discussed the strengths, weaknesses, opportunities and challenges of VR as a tool for education.

Telephone interviews were conducted with five of the six students after the workshop. The two following questions gave interesting reflections about their view of VR for education.

Question 1: What is your impression of VR as a tool for educational purposes?

When asking the students what they thought about the possibilities of VR for education, one student answered "I would use it. I would recommend to use it during the classes and for the educational programs." The student further highlights the importance of an introduction and debriefing when using VR in class "[…] I think it is important to have before, some lecture about the topic, not just give the kids (the VR tool, ed.) […] before like, as we had it – like the conversation; like we really need to introduce the technology, introduce the topic before, like prepare them how they would use it, have a time to not just like have 10 minutes and give them the thing and like a reflection on how did you […]".

What makes VR such a great tool for supporting education? One student referred to the power of immersion: *"[…] feel like more being there, not just like…. Because you are totally in that picture"*. Two other students mentioned the possibilities of VR for crossing large distances and comparing places: "*I think it will open up discussion in the sense that you do really experience how things are like in a totally different place and you could for example let students discuss the differences between their one place they can see by just going out, and exploring other places, for example I don't know in Tanzania or in the Arctic, […]* and "*I thought of it as really cool as a mental tool with a lot of potential in the educational system, to look at places you cannot go to around the world"*. Another student mentioned the benefit of "visiting distant places". She also focused on the importance of the sound during the virtual tour. *"[…] and then you hear the sound of those places or hear someone telling about the place […]."*

Question 2: How do you think VR can be used to teach about climate change?

In one of the EduChange lectures, the climate change paradox was discussed: most students in secondary education are convinced that climate change is happening and know how it can be mitigated, but they don't want to adapt their own lifestyle to reduce carbon emissions. After the workshop, we asked the participants how the think VR can be used to deal with this issue. One student said: *"[…] feel like more being there, not just like…. Because you are totally in the picture. Totally in the video, not like sitting way back looking to the screen and seeing the classmates ahead of you like [you are] fully concentrating on the video"*. The BBC video was mentioned *"I have in mind the video about climate change we could see with you, and I like – because it was really, really well filmed you can really see and hear ice is melting, and see the people how they are working there and what kind of technology the use to measure and connection between ice-melting and impacts in another country"*.

Another student shared some of the same thoughts: "*The added value of this is that you can actually sort of experience it. You can actually look around, you could hear the sounds that are associated with it too so it's a bit more of an experience compared to a documentary*". The importance of doing real outdoor fieldwork was also mentioned: *"[…] although I think that actually being in a place is also very valuable so I think VR for education purposes cannot really replace physical fieldwork,* […]". All students were positive about VR as a tool for supporting learning, but they also mentioned technical obstacles. One of the students was sceptical to use VR in large classes: *"If you want to organize something like that you, maybe you would have to do it in smaller groups and with more teachers so you can have a good way to let them learn what you want them to learn".*

Summarizing remarks

Conclusively, we have seen that VR can be used in separate lessons about climate change and water issues, and also to support real outdoor fieldwork. Our experience from the EduChange program highlights that the future teachers were eager to use VR themselves in their education. It's best to start simple, using students' smartphones or tables and free tools such as the Google Tour Creator and the app expeditions.

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CHAPTER 11: PLACE-BASED EDUCATION IN AN INTERNATIONAL ENVIRONMENT: REFLECTIONS ON PARTICIPATING IN THE 2019 EDUCHANGE PROJECT FROM A STUDENT PERSPECTIVE

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Introduction

Teaching students about the complex global problems of humanity and nature is daunting. Climate change is one of the biggest challenge's humanity needs to solve, and teaching about it is difficult. Even the most experienced teachers and scientists in the field are confronted with the difficulties of this topic. Key to why teaching about climate change is challenging, is the fact that it concerns complex processes that (1) play out on different scales and (2) span different disciplines and dimensions (Tilbury, 1995). Pertaining to the former, teachers for instance need to reflect on how climate change is driven by increased greenhouse gas emissions at the *global* scale, whilst its impacts and the strategies to react to those impacts vary at the *national* and *local* scales. Regarding the latter, teachers have to present interdisciplinary arguments and facts when teaching about the causes and effects of climate change components. These can vary, amongst others, from the subjects of physics to global politics, and from chemistry and geography to hydrology.

The EduChange project aimed to bring together both students and teachers from a variety of countries and professional backgrounds. They were invited to 'make knowledge together' about innovative ways to teach about climate change. In doing so, the project adopted a place-based approach to education. Place-based education (PBE) can be seen as a transdisciplinary teaching and learning method characterized by inquiry-based instruction, an inherent connection to place, and civic engagement with the environment (Lowenstein, Grewal, Erkaeva, Nielsen, & Voelker, 2018). PBE is a tool for relating to and transforming students' perspectives on 'place', comprising all those localities that students *"have imbued with meanings and personal attachments through actual or vicarious experiences"* in their lives (Semken, Ward, Moosavi, & Chinn, 2017, p. 542). Through so-called 'field courses', the EduChange project hoped to capitalize on the qualities of PBE to improve the participating teachers' abilities to engage with climate change as a topic in their classrooms. We are here presenting our own reflections about the EduChange course 2019 as participating students.

A reflective exercise

In this chapter, we – five students and one teacher who participated in the 2019 edition of the EduChange project – reflect on our own experiences during the field courses that took place in Malta (Feburary 2019) and Trondheim, Norway (May 2019). As a reflective exercise, we asked ourselves what we have learnt from being engaged in place-based educational activities in an international environment. In doing so, we hope to shed light on the extent to which the EduChange project has been able to contribute to our teaching capacities, especially in the field of climate issues and place-based education. Besides that it gives an image of the professional and/or personal development of the participants. Two questions guided our reflections in particular:

1. To what extent is place-based education an effective method for improving teaching and learning about the impacts of climate change?
2. What is the value of working on and learning about teaching climate change in an international environment?

Our reflections show that the student exchanges and participation in place-based learning were important as this unfolded various realities that each country faces and to see how realities change regionally and nationally. Moreover, meeting and collaborating with students from other countries and with different skills and backgrounds was vital in getting a richer experience that can improve teaching about climate change.

In what follows, we first briefly introduce the activities that we have engaged in. Second, we provide a brief methodological note. Third, we present our individual reflections on the two questions outlined above. We then analyze our personal reflections, identifying commonalities and differences. Last, we present general reflections and conclusions that follow from our analysis, making links to theoretical work on place-based education in particular.

EduChange 2019 in a nutshell

During the spring semester of 2019, a group of 24 international students met in Malta (February) and Trondheim, Norway (May). The participating students were all following bachelor or master degrees related to teaching or communicating about climate change at Utrecht University (The Netherlands), Palacký University Olomouc (Czech Republic), University of Malta (Malta), or Norwegian University of Science and Technology (Norway).

The field courses in Malta and Trondheim provided the students with place-based knowledge of and a wide perspective on how the effects of climate change are dependent on context-specific factors such as latitude, altitude and local climate conditions. Through various workshops, a student poster symposium, and a focus on innovative practical teaching methods and learning styles, students gained knowledge and experience on how to teach about these complex global issues. In between the two field courses, the students designed educational activities which they performed in classrooms in their respective home countries. They presented their activities and the outcomes thereof during the so-called ScienceJam in Trondheim.

Methodological note

The authors of this chapter are five volunteers from the group of students that participated in the 2019 edition of the EduChange project, supported by one of the teachers. The students—who are from the Netherlands, Malta, and the Czech Republic—responded to an email that was sent out by the teacher—who is from Norway—to all participants from the 2019 program asking for five people to take part in writing a chapter. It is therefore good to note that the authors' interests and abilities to write this chapter do not necessarily mirror the rest of the group regarding knowledge, social abilities or engagement; the reflection notes from the students reflect personal opinions and do not necessarily represent those of the other participants.

The theme of this chapter and the two guiding questions were developed during two Skype phone-calls. Each of the five students then wrote down their personal reflections on the two questions. As a group, we qualitatively analyzed the produced reflections.

The workflow of this analysis was facilitated by the staff author and was based on the model by Vaismoradi, Jones, Turunen and Snelgrove (2015, p. 103). The analysis consequently involved (1) defining classes for analysis, (2) classification of reflections, highlighting citations from the pieces of text, and (3) discussing the classified citations. Defining the classes for analysis was done by all authors. The results of the classification were then interpreted by the first author, who synthesized the findings and sent them to the other authors for review.

Personal reflections from Guido, Martijn, Karolina, Fiona and Nadia

1. Below are the authors' personal reflections on the following two questions:
2. To what extent is place-based education an effective method for improving teaching and learning about the impacts of climate change?
3. What is the value of working on and learning about teaching climate change in an international environment?

Guido (participant 1)

"As a geographer you are often confronted with big spatial issues. These issues are important to discuss because they also have an influence on every individual in a community. In the project that is discussed in this chapter the central issue is climate change. We can establish with certainty that this is one of the major issues of the present time. But that does not bring us to the importance of place-based learning, or place-based education. In short, place-based education is teaching in a certain environment, such as the environment of the school where you teach. From this living environment you will look at various issues. It brings you close to recognizable issues.

Place-based education is more than just learning about your own environment. It also gives you the skills to look at other environment in a different way. As a Dutchman you are often confronted with high water levels and how we should protect ourselves against them. We learn about dikes, dunes, flood defenses and other objects that protect us from the water. Because in your own environment this is something you learn about, you can also look critically at similar characteristics in other areas. Therefore, awareness of a certain environment also helps you to look critically at other areas. When you look at a specific process in a specific location, it is always important to realize that this process also occurs elsewhere.

A major issue such as climate change can also be related to one's own environment. If you do not throw rubbish in a bin, it will remain in the environment. This has a harmful effect. Yet there is waste in almost every environment. And there are many more elements that you can find in the environment that have a positive or negative effect on the climate. This way you can see where sustainable energy is generated or how many cars go to the gas station in half an hour. All these elements from the region in which you are studying can ultimately allow you to find links to the context of a larger issue."

Martijn (participant 2)

"Place-based education (PBE) is, in my opinion, a highly useful approach to teaching and learning about the impact of climate change. Most importantly, the emphasis on studying the specific characteristics of places in their local contexts that is an integral part of PBE, lends itself particularly well to the exploration of local consequences of global climate change. Since the global processes of climate change play out differently on the local level, context-bound knowledge is crucial for understanding how various areas across the world will be affected. Moreover, such context-specific knowledge is also needed when devising strategies to address the local impact of climate change.

Furthermore, in teaching it is important to directly address students' personal interests and frames of reference. Making connections to such 'personal geographies' of learners has been found to be an effective teaching strategy. In this regard, the application of educational strategies that relate directly to local places provides ample opportunity for the incorporation of con text-bound, personal geographies. This might in turn enhance students' learning about (the local) impact of climate change.

I believe internationalization can stimulate a richer and more diverse exploration of not only the local impact of climate change, but also the teaching strategies that could be employed to address climate change issues. The students and teachers participating in EduChange came from multiple national and local contexts in Europe. Each of the participants therefore constituted a 'source' of context-specific knowledge about the impact of climate change. The different educational backgrounds and specializations of the participants further added to the diverse base of knowledge.

Additionally, the EduChange project brought together participants who were familiar with learning or teaching in a range of national educational systems. Exchanging thoughts, ideas, and best practices regarding teaching about climate change-related issues was insightful for the participants. This 'pooling together' of personal experiences created an extensive 'reservoir' of didactic and pedagogical knowledge in different educational contexts (Bernstein, 1999). During the activities of the project participants were able to draw from this reservoir to enrich their own 'teacher repertoires' (Bernstein, 1999). Internationalization could therefore lead to more competent and effective teaching about climate change issues."

Karolina (participant 3)

"One's own experiences are much more memorable than hearing about someone else's secondhand. The brain can make many more associations with the atmosphere of a place and with the weather, temperature, mutual discussions and any other factor affecting a group of students. Therefore, students are able to create stronger and longer term memories that will ensure their permanent presence in their minds and be a lasting incentive for further curiosity in a field that really interests them.

So for me, as a regular participant in such methods of education, yes - it's a tool that will definitely enrich students. It is about the real experience of knowing the past and potential future changes caused by climate change. When the right place is selected students can draw on the knowledge holistically and can feel through their own senses how the historical, geographical, environmental and social components of a particular region mutually touch, overlap and affect each other. If a student is an explorer and observes a place (in our case in relation to the impact of climate change), he/she is the one who decides what to pay attention to and from this we can deduce his or her larger personal participation, enthusiasm and commitment. It is also a very good accompanying exercise to perceive the importance of choosing your own perspective and the uniqueness of your own decision - choosing which way to take and what research strategy to choose, which is also excellent for the development of creativity. Although, while all students focus on the same task, such as estimating the future evolution of the surrounding ecosystem and its adaptable capabilities in relation to climate change, the individual findings can be different and can enrich each other. Again this develops the ability to communicate and work as part of a team. Learning in this way was really a valuable experience for me. During our field trips I especially appreciated printed and online (tablets) aids, which served as navigation tools with suggestions for how to look at a topic.

Collaboration in an international group offers a larger sample of people with different personal experiences and attitudes towards climate change and its mitigation. Students can share and discuss the adaptation measures taken in different countries. Personally, this collaboration has brought me contacts to like-minded people, some of which have already enriched my future career opportunities. And since communication is international, there is the bonus of training the brain in English and the challenge for the brain to absorb a lot of new information because, as I wrote, the source of knowledge was not only lecturers, but also my foreign co-participants who come from various fields of studies. So we enriched each other and complemented our existing horizons."

Fiona (participant 4)

"Place-based learning provides a framework for learners to see the bigger picture in a story and become engaged in the learning process, thus activating various senses that make this experience more effective and encompassing.

It supports a deeper learning methodology by putting the facts in context with an environmental, social and historical analysis of the background. Studies also show this type of education empowers students and motivates them to become more socially active (Promise of Place, 2010).

Teaching about global issues like climate change and how it affects countries differently is a highly complex issue. Having the chance to participate in an international educational exchange program and see the reality each country faces, while meeting and sharing experiences with a group of international students and lecturers made this issue more real. It was interesting to note that some issues are transcendent of location, mainly the space-distancing issue, with a majority of teenage students not really believing they will be affected by climate change.

Countries will have different problems related to climate change. Semi-dry countries such as Malta will become drier and there will be a greater problem of finding fresh water. This was highlighted during the day trips held on Malta. Moreover, thanks to the poster my colleague and I developed we found that the economy of Malta would have huge problems due to even a small rise in sea level. The artery roads, major industrial areas, tourist sites, agricultural areas and others would be flooded, leading to a disruption of life on this small, highly populated island. Other countries will experience specific site-related issues depending on their distance from the sea and their current weather. This might involve the flooding of huge flat lands as in the Netherlands and changes in biodiversity and the browning of rivers as in Norway. Experts in each country are trying to find how to mitigate these effects but unfortunately we noticed that this is not on the main political agendas of most countries.

The contacts made during such trips can be used for further projects such as 'e-twinning', or interviews through skype calls. As a teacher it was also inspirational to see how other 'teachers' or 'lecturers' tackled lessons and field activities related to climate change, often with insights into new technology and how it can be used in my pedagogy. Finally, I believe that for students to get a thorough understanding of complex issues such as climate change, one needs to link it to their everyday lives, giving them hands-on activities and the opportunity to analyze and evaluate their findings. Being able to widen this perspective and see what people in other countries are experiencing gives it a three dimensional perspective and a deeper meaning, and with it comes the hope that our jobs as educators will be more life-changing.

The main questions I keep thinking about are; how can we as educators open teaching about climate change to a wider level, and in reality how much are authorities willing to take the necessary measures to mitigate the effects of climate change and stop this massive problem? Finally, is space-distancing a 'teenage' state of mind or is it more a 'modern' egocentric way of thinking and behaving?"

Nadia (participant 5)

"Place-based education gives learners the power to immerse themselves deeper in learning through hands-on experiences in the environment around them. It is a learning model whereby learners can have a real and meaningful experience because they can see things first-hand, not just in books and theories. This type of learning model can take place by travelling to other places or countries, or by staying in one's own community.

As a teacher and a master's student, I saw Edu change as a fruitful experience in which the participants had the opportunity to share and discuss issues about climate change and how it affects each of us differently. For example, when the exchange took place in Malta, students could see how vital water is on a small island where rainfall plays a huge role, while in Norway rainfall is not an issue, but the rise in sea level is, and it affects both countries. EduChange also brought international groups together to engage in hands-on activities and to get an insight into how technology such as Virtual Reality or simple apps on a mobile can add a new dimension to teaching and learning. This can be vital in classrooms, especially when learning about the effects of climate change in other countries. As teachers, we can transform teaching and learning into something more engaging and personalized. In this way students can observe, evaluate and analyse their findings/results. This can also lead to inquiry-based learning, as students ask relevant questions, make predictions and, if possible, find solutions.

I believe in this type of learning mode as it makes learning cross-curricular, where students can apply what they learn to a range of individual subjects."

Analysis of reflections

To what extent is place-based education an effective method for improving teaching and learning about the impacts of climate change?

Bringing students 'closer'

Some of the authors understood place-based education (PBE) to be a specific approach to education that "emphasizes studying the specific characteristics of places in their local contexts" (participant 2). According to participant 1, analyzing climate change-related issues in a familiar context, such as the students' school environment, can bring students "*closer*" to these issues and their larger-scale context. In this regard, "*the application of educational strategies that relate directly to local places provides ample opportunity for the incorporation of context-bound, personal geographies*" (participant 2).

Approaching climate change issues "holistically"

Participants 3 and 4 stressed how a place-based approach to climate change education can encourage students to acquire knowledge about climate change issues in a more "holistic" manner. As stated by participant 4, PBE "*supports a deeper learning methodology by putting the facts in context with an environmental, social and historical background analysis*". Building on this same idea, participant 3 highlighted how PBE strategies allow one to "*feel through their own senses how the historical, geographic, environmental and social components of a particular region touch, overlap and affect each other*". Participant 5 further argued that studying an issue through first-hand experience of a place, which is what PBE facilitates, has a more effective and long-lasting learning effect on students.

Fostering autonomy of learning

Some of the participants also particularly valued the ways in which a place-based approach to climate change education stimulates learners, both students and teachers, to take responsibility for their own learning process. Participant 3 tellingly outlined how this can positively affect learners' motivation and commitment: "*If the student himself/herself is an explorer and observes a place (in our case the observation is in relation to the impact of climate change), he/she is the one who decides what to pay attention to, and from this we can make deductions concerning his/her larger personal participation, enthusiasm or commitment*."

Stimulating learners' creativity

Moreover, a place-based approach to climate change education was also seen to stimulate learners' creativity, as it frequently involved "*choosing which way to take and which research strategy to use*" (participant 3). Participant 5 mentioned that PBE invites students to observe, evaluate and analyze their findings/results, which can "*lead to inquiry-based learning, as students ask relevant questions, make predictions and, if possible, find solutions*".

What is the value of working on and learning about teaching climate change in an international environment?

International collaboration as a 'source' of knowledge

Working in a group with university students from different countries and with different educational and professional experiences was considered by most participants as an opportunity to exchange thoughts, ideas, and best practices with fellow teachers.

Given their "*different educational backgrounds and specialisations*" (participant 2), the lecturers and students involved in the program featured as a "*source*" of knowledge about the causes, processes, and consequences of climate change in different countries and how to teach about these issues.

Participant 3 aptly summarized this aspect of internationalization: "*Collaboration in an international group offers a larger sample of people with different personal experiences and attitudes towards climate change and its mitigation. Students can share and discuss the adaptation measures taken in different countries.*" Building on that, participant 2 highlighted how "internationalization" in their view was therefore able to "*stimulate a richer and more diverse exploration of not only the local impact of climate change, but also the teaching strategies that could be employed to address these climate change issues.*"

Internationalization: making study into the impact of climate change more 'real'

Participant 4 stressed that "*having the chance to participate in an international educational exchange program, and see the reality each country faces, whilst meeting and sharing experiences with a group of international students and lecturers, made this issue more real*". For instance, various participants mentioned that the project made them aware of the fact that climate change-related issues regarding water can play out completely differently in the Czech Republic, Malta, the Netherlands, and Norway. An example of this insight was offered by participant 5, who stated that "*when the exchange occurred in Malta, students could see how vital water is on a small island where rainfall plays a huge role, while in Norway rainfall is not an issue*[5]*, but the rise in sea level is and it affects both countries.*"

Moreover, the participants also mentioned that the international nature of the group also made it possible "*to note that some issues are transcendent of location,*" such as the fact that the majority of teenage students do not consider themselves to be personally at risk from climate change issues (participant 4). Participant 1 added to this that, through the EduChange project, they realized that "*When you look at a specific process in a specific location, it is always important to realize that this process is also occurring elsewhere.*"

Extending professional networks

Working in an international group also meant that the participants could extend their personal networks, which could benefit their future teaching endeavors. As participant 4 outlined, "*the contacts made during such trips can be used for further projects, such as 'e-twinning', or for interviews through skype calls, to mention just a few.*" It is interesting to note that participants 4 and 5 emphasized how the international group and the EduChange program provided them with new insights into various technological applications, and how they can use them in their pedagogical strategies.

Developing personal skills

The participants also showed that being in contact with fellow teachers from other backgrounds was a form of (personal) inspiration. Participant 3 mentioned, for example: "*Personally, this collaboration has brought me contacts with like-minded people, some of whom have already enriched my future career opportunities.*" Additionally, an international group allowed participants to develop their communication, social, and intercultural skills. Communicating and processing information in English rather than their native language was a positive *"challenge for the brain"* (participant 3). Participant 5 highlighted that "*international groups can help in fostering intercultural skills*" as students explored other cultures through a range of activities.

[5] Note: This is not the whole truth about rainfall in Norway. Norway will be affected by increased rain due to climate change.

Reflections and conclusions

According to the participants in the EduChange program, place-based education (PBE) is a very useful approach to teaching and learning about the impact of climate change. Based on the participants' responses, taking part in the place-based educational EduChange program seems to have contributed to their learning in three particular ways, each of which corresponds to one of the three 'lamps' for exploring space and place, as defined by Freeman and Morgan (2014). These three lamps are discussed in the text box below.

Freeman and Morgan (2014) defined three main approaches within place-based education: a positivist, humanistic, and social science view. They refer to these approaches as "lamps" that can be used to "illuminate" places of students' attention in educational practice (figure 42).

Figure 42. The positivist, humanistic and social science approaches identified by Freeman and Morgan (2014), depicted as three distinct lamps shining their light on a particular place.

A positivist approach (the blue lamp) refers to the development of locational knowledge in the context of physical geography. Students can see spatial and objective aspects of a place such as location (latitude and longitude), distance, scale and identifiable features (settlements, mountains, etc.). This approach can bring students practical skills. *"There has been, and continues to be, a long tradition in schools of teaching students about the location of specific features and how to find them on a map"* (Freeman & Morgan, 2014, p. 95). This is an example of developing students' geographical skills and locational knowledge.

A humanistic approach (the green lamp) symbolizes the illumination of subjective interpretations rather than objective facts. It entails individual subjective aspects of place, such as emotional responses (e.g. fear, attraction, attachment etc.). The humanistic approach in place based education "places students at the centre of their learning and highlights the value of their personal, everyday geographies" (Freeman & Morgan, 2014, p. 97). In doing so, it offers students opportunities to explore their own personal feelings about places.

The third approach is focused on social science (the red lamp) and involves aspects of human-environment interactions at the collective level. It highlights socio-political and/or socio-economic processes on a variety of scales (from local neighborhoods to the international scale). This requires students' creativity for interpretation.

"Increasingly, students are encouraged to develop a 'sense of place' (Jarratt, Phelan, Wain and Dale, 2019) for both local and distant places. This tends to involve using a growing range of multimedia resources (photographs, music and moving images) to consider what it is like to be in a particular place" (Freeman and Morgan, 2014, p. 96).

Most importantly, the participants noted that studying the specific characteristics of places in their local contexts, which is an integral part of PBE, was a particularly well-suited strategy for them to better understand the different local consequences of global climate change issues. This learning outcome shows how the EduChange project taught the participants about the specifics of different locations (Malta, Norway, the Netherlands, and Czech Republic), and in particular about the physical geography of the fieldwork locations in Malta and Norway. In this way, the EduChange program's PBE approach contributed to extending the participants' geographical skills and locational knowledge, thereby 'illuminating' what Freeman and Morgan (2014) describe as the 'positivist, blue lamp' for exploring space and place.

Secondly, the participants described how the EduChange program had provided them with the opportunity to learn about and apply various educational strategies that are intended to more readily address students' personal interests and frames of reference. The participants recognized that the inquiry-based approach to education about climate change, as practiced in the EduChange project, "places students at the center of their learning and highlights the value of their personal, everyday geographies" (Freeman & Morgan, 2014, p. 97). In doing so, it offers students opportunities to explore their own personal feelings about places, which corresponds to the 'humanistic, green lamp' that Freeman and Morgan (2014) describe in their three-lamp PBE model.

Thirdly, the participants stated that the EduChange project helped them compare and contrast different geographical locations. Moreover, their responses reveal that the project encouraged them to consider climate change issues on various scales (local, regional, national, European, global), and in relation to the socio-political and socio-economic contexts of the places where they studied. Using various technological applications in education also helped the participants gain a better 'sense' of the places they visited during the fieldwork activities in Malta and Norway. This relates to the 'red lamp', which Freeman and Morgan describe as being concerned with a social science approach to studying space and place.

As deduced from the participants' responses, the 'internationalized' character of the EduChange project enabled a richer and more diverse exploration of not only the local impact of climate change, but also the teaching strategies that could be employed to address climate change issues. Because the students and teachers participating in EduChange came from multiple national and local contexts in Europe, and from a range of educational backgrounds and specializations, each of the participants could be seen as a 'source' of context-specific knowledge about climate change issues and education.

Exchanging thoughts, ideas, and best practices regarding teaching about climate change-related issues with their fellow participants and teachers was insightful for the participants. On top of that, the program encouraged its participants to use and develop their communication, social, and intercultural skills, as well as to extend their professional networks. In the future, these skills and contacts could be utilized by the participants in their teaching.

Therefore, the EduChange program could be seen as a means of 'pooling together' and activating the participants' personal experiences and skills, while creating an extensive 'reservoir' of didactic and pedagogical knowledge from different educational contexts (Bernstein, 1999, 2000; Wolff, 2013). During the project activities, participants were able to draw from this collective reservoir to enrich their own 'teaching repertoire' (Bernstein, 1999; 2000). Therefore, internationalization could lead to more competent and effective teaching about climate change issues.

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CHAPTER 12: MAKING SENSE OF INTERNATIONAL EXPERIENCES – THE VALUE OF REFLECTION

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Abstract

One of the main principles of the EduChange method is that the participants have an international experience. This is the core of the programme in two distinct ways. First, it is similar to the Erasmus exchange system in general – the programme brings students together from different countries and various educational systems. It provides them with opportunities to practise their language skills, work on their intercultural skills and gain new perspectives. As such it prepares students for life and work in a globalized world.

Second, we argue that climate change is a global phenomenon but it impacts places differently. Students need to be able to connect the global and the local. We assume that by seeing the impact in other places, students will get a deeper understanding of the range of impacts and the magnitude of the phenomenon of climate change. Moreover, they can discuss the current state of affairs in their respective countries and see what is already being done in terms of adaptation, for example. The programme which was carried out thus contained local fieldtrips during Field Week and ScienceJam, and lectures by staff using local case studies.

However, we noticed that although the students enjoyed the fieldtrips, they had trouble transferring the knowledge from the international fieldwork to the home context in which they are or will be teaching. For example one student from the first cohort stated in the evaluation, "*Why do I need to know about water education in the Netherlands?*" Similar voices were heard when the next cohort was on the fieldtrip to Malta – for some of the visiting students the water issues Malta experiences are so different from what is happening at home that they did not see how they could transfer these experiences to their own lives as both citizens and teachers.

Therefore we realized that although we had aimed for deep approaches to learning, where students would be able to transfer the knowledge gained during fieldwork to their own environments, we were not yet so effective. So in the second year we designed two interventions to ease the transfer of knowledge – on the one hand by using more explicit comparisons and on the other hand by clearly providing time and space for reflection. Both interventions aimed to create a stronger purpose by making students more aware of their learning processes.

This chapter will first discuss the benefits of international fieldwork in Higher Education from the perspective of the learner, and explain how international fieldwork can add to students' understanding of the impacts of climate change. It will subsequently discuss the challenges of international exchange and the difficulty of transferring knowledge gained during fieldwork. It will then describe both interventions and mainly focus on the importance of creating time and space for reflection. The chapter will use insights gained from research into international fieldtrips and from deep approaches to learning through fieldwork and intercultural competences. This will be combined with course evaluations and the observations made during the programme.

Climate change: global impact but with varying local effects

The rationale behind the EduChange programme is a reflection of the global – local nexus: Climate change affects the whole world. However, different places face different impacts. Even within Europe, which from a global perspective is a rather small region, the consequences of climate change vary.

During the international fieldtrips students will be confronted with several water (management) issues related to climate change: interventions designed to prevent rivers from flooding (Olomouc, Utrecht), the quick clay hazard in built up areas of Trondheim, the lack of (fresh) water in Malta, the issue of subsidence in the west of the Netherlands and the potential effects of sea level rise in Trondheim.

The EduChange proposal assumes that participating students will transfer the experiences and knowledge they gain through taking part in the programme to their practice in teaching secondary school students. The format of the EduChange project relies heavily on (geographical) thinking skills related to the comparison of places, and on seeing global – local interconnectedness. This allows students to transfer the experiences gained through fieldwork in places such as Olomouc and Malta to their classrooms in Utrecht and Trondheim.

EduChange also assumes that the participating students understand the value of international fieldwork for their own development as teachers. The project attempts to stimulate the transfer of their experiences to increased pedagogical content knowledge (PCK see chapter 1), which would result in greater awareness and self-efficacy in their teaching about water issues related to climate change. The EduChange project thus relies on transfer and the ability of students to translate experiences gained in one location into a general knowledge of (teaching about) climate change and related water issues. They can apply this general knowledge in such a way that, when teaching adolescents in other locations, the young people will understand climate change and related water issues and want to take some action. Although the benefits of international experiences are widely recognized, making sense of those experiences is not easy for students. The next two sections will focus on the benefits and pitfalls of international experiences in the form of short-term exchange programmes or fieldtrips.

The Erasmus experience

The EduChange project was made possible by funds from the Erasmus+ programme. Erasmus was launched by the EU in the late 1980s to stimulate student mobility in Europe. The current Erasmus+ programme contains all the efforts by the EU to support student and staff mobility and collaboration in Higher Education in Europe. The objectives of the Erasmus initiative do more than simply promote the movement of students between Institutes of Higher Education. Student mobility is expected to be beneficial for their employability and it will improve their job opportunities, and as such contribute to the economic development of the EU. Furthermore, the acquired language skills and cultural awareness will prepare students for living and working in an increasingly globalized and diverse world. Authors such as Deakin (2013); Jacobone & Moro (2015); Llurda et al (2016); Cairns (2017) and Blankvoort et al. (2019) mention economic, professional and personal arguments in favour of student mobility. However, the objectives of the Erasmus+ programme also contain an element of European integration. Student mobility could help students develop a European awareness and create a feeling of belonging to Europe.

With the increasing popularity of student exchange and the growing number of students taking part in some form of mobility, researchers have attempted to measure the actual impact of student mobility. Jacobone and Moro (2015; 325) noted an "*increase in human capital in individuals but also in their cosmopolitan orientation*". However, it also became apparent that for students an important motive for having an exchange period is to have fun. Their survey also pointed to an increased awareness of Europe and of a European identity. In contrast, while the study by Llurda et al. (2016) did note increased confidence in using a foreign language, it did not see a greater identification with Europe.

Some authors warn that a focus on the increasing number of students involved in the Erasmus exchange programmes masks the huge amount of students who do not take part. In particular, studies have found that many students experience barriers to joining long-term exchange programmes (Deakin 2013; Cairns 2017; Blankvoort et al. 2019). The presence of potential barriers is reflected in the apparent over-representation of students from well-to-do backgrounds, implying that a lack of finance or financial support by family is a barrier.

Other factors that potentially inhibit students from taking part are perceived language barriers, organizational issues, lack of institutional support and encouragement, and even the application process. These barriers can
be partly overcome when students have the opportunity to embark on short duration exchange projects, such as EduChange.

However, some studies into such effects suggest that the length of the stay is an important aspect of student mobility. Short-term exchange programmes may have a more limited impact (Lemmons 2016; Blankvoort et al 2019). The shorter the stay, the less likely students are to truly interact with the culture of the host and therefore cultural understanding is less likely to develop.

The benefits and pitfalls of international fieldwork

Concerns about the extent of cultural interaction and understanding are similarly voiced in research into international fieldwork (Hope 2009; Simm & Marvell 2015; Glass 2014). Fieldwork offers opportunities for engagement and active learning that are not easily achieved in the confinement of the classroom (Glass 2014). Notwithstanding the many acknowledged benefits of fieldwork, such as the development of content knowledge, training of skills, and increase in motivation (see for example Kent et al 1997; Fuller et al 2006; Scott et al 2006; Boyle et al 2007; Oost et al. 2011; Stokes et al. 2011), there are also pitfalls. There are concerns over the extent to which fieldwork actually leads to an understanding of 'the field' as a functioning place - as a place where people live and make a livelihood (Simm & Marvell 2015). International fieldwork might not move beyond a superficial experience, which is little different from a voyeuristic *tourist gaze (Simm & Marvell 2015; 595). Therefore it may fail to take the opportunity to really challenge students to see beyond their preconceptions and stereotypes of others (Hope 2009).* Lemmons (2015) observed the tendency of students on a four-week international field course to take the path of least resistance, which meant they would stick together as a group (they were all from the same department) and thus they mainly interacted with people culturally similar to themselves. The group provided a degree of familiarity in strange surroundings, but eventually the group also prevented the students from venturing out independently, as this may have been interpreted negatively by others in the group. It is not wholly unexpected that students would initially prefer the familiarity of the group, as international fieldwork can be demanding, both academically, physically and emotionally, and students may experience culture shock while in the field (Glass 2014; Simm & Marvell 2015; Marvell and Simm 2018).

Other factors that influence the opportunity fieldwork provides for raising cultural awareness include the character of the fieldtrip (look-see tours offer mostly superficial experiences) and the emphasis given to reflection in the programme (Nairn in Hope 2009; Simm & Marvell 2015). While Nairn (in Hope 2009) may be rather pessimistic about the transformational power of international fieldwork with regard to the values, viewpoints and prejudices of students, Hope (2009) is more optimistic and sees signs of tranformation when students start to care about a place and its people: *"It seems that the depth of our understanding of others goes hand in hand with whether we feel they are worth the time and effort needed to get to know them"* (Hope 2009; 180). Marvell & Simm (2018) likewise emphasise the emotional geography involved in international fieldwork and the importance of these emotions in developing a sense of place, as well as the production of knowledge through these field experiences.

The EduChange programme and intercultural experiences

From day one of the programme the atmosphere in each of the groups was open, engaged and lively. The day started with a brief name-game. Students were subsequently divided into mixed (international) groups for several of the Field Week activities. On the opening morning they took part in an outdoor activity aimed at getting to know their teammates in the mixed teams and they began to familiarize themselves with the host city and with a variety of ways of carrying out fieldwork.

The mixture of course activities and (planned) social activities in the evenings led to a great deal of interaction. While perhaps breakfast was predominantly enjoyed in national groups, as soon as the whole group got together there was much cross cultural interaction. However, as the programme was rather full, both during Field Week and ScienceJam, students felt that they did not have much leisure time to get to know each other. A number of students in the third cohort (the largest of the three) suggested changing the mixed international groups, either during Field Week or prior to the ScienceJam event, so they could get to know more people.

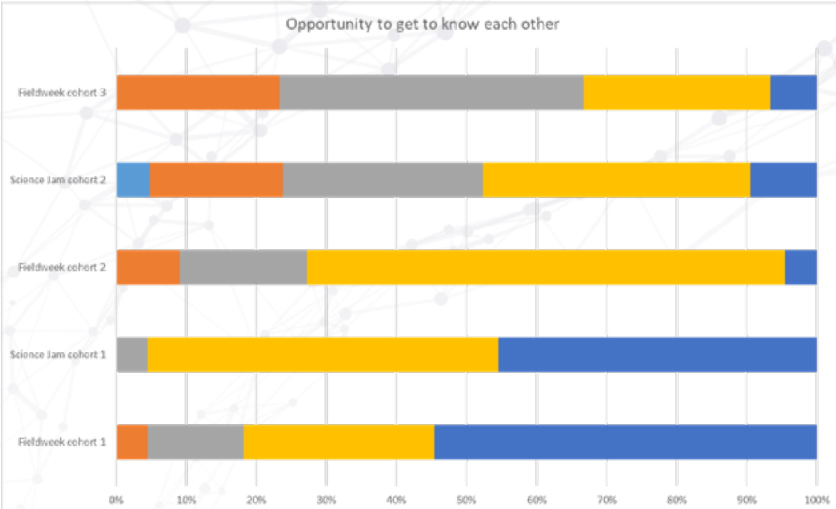

Figure 43: Student responses to the statement "There was enough opportunity to get to know each other". Cohorts 1 and 2 was comprised of 22 students, all of whom completed the questionnaire. Cohort 3 yielded 30 responses.

The specific activities aimed at intercultural exchange, such as the international dinner and the celebrations of the Norwegian National Day (17 May), were valued highly in each of the Field Weeks and Science Jams. Some students explicitly expressed what they felt the added value of being in international team meant to them. One student explained, "*Mixed international groups were interesting to work in, this provided insightful comparison between countries and perspectives*".

After Field Week the students rated the value of being in an international group highly – a large majority strongly agreed with the statement (Figure 44). At the end of the ScienceJam the same groups were somewhat less positive about the added value of the international groups. Perhaps they had become partly used to the international setting or were less surprised by its effects on them.

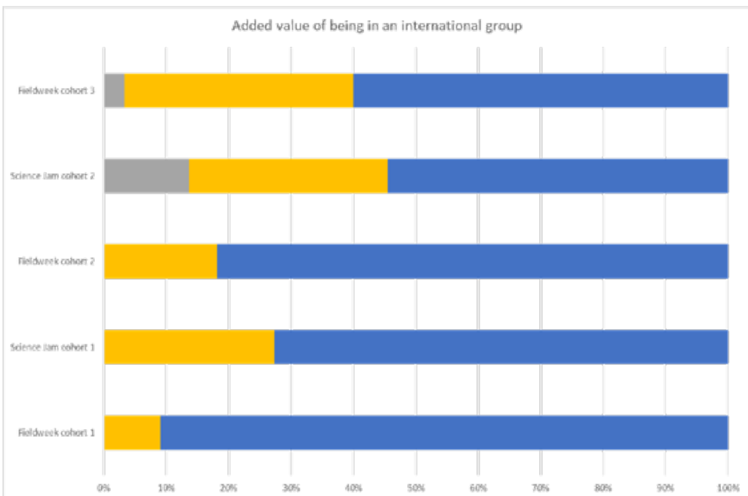

Figure 44: Student responses to the statement "Being in an international group was an added value". Both the first and the second cohorts comprised of 22 students who all completed the questionnaire. The third questionnaire was completed by 30 participants.

Making sense of a 'strange' environment

The various fieldtrips during the Field Weeks and Science Jams were mostly enjoyed by the students. They included several additional comments along with their responses to the evaluation questions, and in these they comment on the fun of being out in the field. Students claimed to have enjoyed the experience, stating that it was nice to be outdoors and not in the classroom.

However, practical issues can hinder the effect of fieldtrips and language issues (one speaker was perceived to be not fluent enough in English) did reduce the learning effect according to a number of students: "*it was a really interesting topic but I did not get all the information, due to the language barrier unfortunately*", was the response of one student in cohort 1 regarding one of the fieldtrips.

The engagement of students in the field activities was high. For example, they looked carefully for frogs and other aquatic life in an artificial lake and river in Malta. Students also asked several questions for clarification during the river walk in Olomouc (to understand the interventions in the river and how they would prevent flooding in the future) and the mountain walk in Trondheim (to understand the formation of the landscape). They worked on numerous assignments together during fieldtrips in the vicinity of Utrecht and scavenged the beach of Tautra in small teams – frequently discussing their finds with other students they crossed paths with.

Students also demonstrated more embodied engagement with the places they visited. They drilled a bore hole in peat near Gouda, some went for a dip in the fjord on the Tautra excursion, they made snow angels in one of the last patches of snow, and they challenged each other to an uphill run. Dutch students built small dams in a stream at the end of the river walk in Trondheim. And many of the students took pictures – either with their smartphones or with more professional cameras.

Experiencing other places and the water issues that affect those places was an important part of the project. We explicitly included the question in the evaluation which asked whether the students had learned how climate change impacts various places differently. The majority of the students agreed that they had. Interestingly, in 2019 the effect of the Field Week to Malta appears to have been stronger than that of the ScienceJam in Trondheim, while there appeared no marked difference between the effect of the two events in 2018. The Field Week in the Netherlands seemed to have the strongest impact in this respect. Students enjoyed the fieldtrips to the river Lek and to the peatland areas near Gouda, both of which pose different challenges in terms of water management.

Still, the evaluations showed that some students struggled with seeing the relevance of what they heard and experienced during the many fieldtrips. "*I did not really understand the aim of the trip*" and "*Interesting with a hike, but also a bit random since we did not use it*", were some of the more critical comments. It is important that the purpose of the field trip was clear to the students and that they could relate it to the programme and to their personal or professional lives beyond this EduChange project.

Students especially felt the need to see the value in being confronted in the field with water issues that were so different from those in the locations where they taught. Although they enjoyed the lectures, the field visits and hearing stakeholders talk about local water issues, they still struggled to see how all this was relevant to them. After a lecture on how to teach about water issues (based on experiences from the Netherlands) some students missed the connection with their personal context or with the location where the group met. Comments such as: "*Only relevant to the Dutch" or „It was informative but we are in Norway and since this is place-based education, it should have been about Norway, not the Netherlands" illustrate the perceived lack of connection and thus of purpose.*

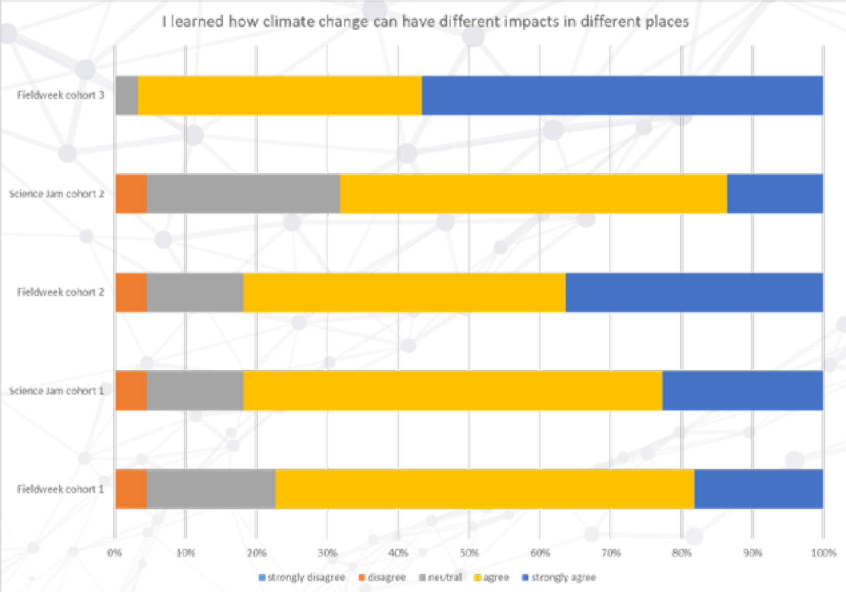

Figure 45: Student responses to the statement "I learned how climate change can have different impacts in different places". The first and the second cohorts comprised of 22 students and they all completed the questionnaire. The third questionnaire was completed by 30 participants.

Moreover, the various local environmental concerns were, at times, so different from the concerns they were familair with in their daily lives that it actually estranged students. Even though the course took place in Europe and not in remote locations, the differences in environments, landscapes and therefore in water issues related to climate change may have come as a surprise to the students. The concerns relating to the increasing forestation in mountains surrounding Trondheim led to very surprised responses from the non-Norwegian students who were only familair with concerns about deforestation. This otherness even led them initially to think it could only be a non-issue. Similarly, in their conversations after the river walk in Trondheim some students felt that Norway could have no water issues related to climate change at all, especially after seeing the limited impact of a projected 7 metre sea level rise on a 3D model of the city. This suggests that students initially focused on differences and struggled to form a deeper understanding of the place. Similar disbelief or lack of understanding of a complex local situation was heard from students wondering why people in the Netherlands would build houses in a polder 7 metres below sea level, or why the roofs of the houses in Malta lacked a system to collect rainwater.

The students' responses in the evaluation shed light on how the students felt about their experiences on the international fieldtrips. Their responses show how they compare or connect places and the impacts of climate change. We discerned four different standpoints: Home, Distance, International differences and Global issue. Home refers to students of the „host" university and how they rank the information. Distance means students do not make a connection; they look at a new place and understand it to be just that – a distant place. International difference means that students make comparisons between what they saw or heard and other places. Other remarks by students highlighted climate change as a global issue – they described how this particular part of the programme reflected a gobal phenomeon or process.

	Positions
Home	Eventhough I am from the Netherlands I learned a lot Didn't realise the situation in X was that bad. Good sites to use in my own lessons.
Distance	Nice to see in real life how the Czechs did it It was nice to see how the Netherlands are prepared for flooding Good to get an overview of the Maltese context Nice to enjoy a typical landscape of the area
International difference	I think it would be more interesting if it was about comparing water issues all over the world. It was to related to the Netherlands. Interesting to hear about challenges in different countries
Global issue	Good connection to international context Good reminder of temporal and psychological distancing trends as global problems

With the programme we aimed for deeper understanding, and for students to move beyond superficial gazes at otherness. The issues at hand are much more complex. When guided well, international comparisons can move beyond a focus on otherness to an understanding of the global – local interconnections and what can be learned from other places. One way of making the international comparison more visible to students was by programming twin lectures on the attitudes of young people to environmental issues and climate issues for the second cohort during Fieldweek. This made the students aware of commonalities and of the importance of context, while it also prepared them to be climate change educators, aware of their audience and its perceptions.

The value of reflection

Several authors (i.e. Glass 2014; Simm & Marvell 2015) have emphasized the importance of reflection in the context of international fieldwork. Reflective exercises provide students with the opportunity to clearly face the unfamiliar, unexpected and uncomfortable moments that happen during international field trips. Opportunities for learning are created when students reflect on disruptive experiences or feelings of anxiety, as this leads them to consider their views as regards the place and people during the course of their fieldtrip. Furthermore, through critically reflecting on their prior knowledge and presumptions in connection with their new experiences in the field, students can transform these experiences into new knowledge. This is the core of Kolb's experiential learning cycle (Dummer et al. 2008).

However, reflection and reflexivity do not occur naturally – not even when students are confronted with unfamiliar places. Nor does this automatically lead to deeper insights. Glass (2014; 2015) therefore states that reflective exercises need to be intentional. They need to be designed as part of the course and they need to be scaffolded. Moreover, teachers should not rely on just one type of assignment or tool but should include a combination of such activities as field dairies, blogs, reflective essays and group reflections, as each of these leads to different kinds of reflection (Marvell & Simm 2018).

EduChange students reflecting on their experiences

Even though, after Field Weeks in Olomouc (2018) and Malta (2019) and ScienceJam in Trondheim (2018), the majority of students reported that they were stimulated to reflect on what they had learned, there was obviously a need for more intentional or structured reflection in order to enable students to make more sense of their international experience.

The reflection built into the second cohort's ScienceJam programme consisted of a field diary in which students could make notes, as well as two short reflective essays; on day one and day four, both of which were followed by a focus group discussion. The individual essays and the focus group were structured by a number of questions that revolved around the international experience, international comparisons and the learning effect of the course as a whole.

All the teachers present during the exercise on day 1 noted that the response to the first reflective assignment was that the students immediately began writing in their journals, and for the assigned 10 minutes there was absolute silence. This was followed by very lively focus group conversations in which all students were involved and shared their personal views and experiences. The open atmosphere was probably enabled by the fact that during the intensive field week 2.5 months earlier the students had created a community, and that sense of community had been rekindled the evening before when everyone had arrived and eaten an informal pizza dinner together.

Students mentioned several aspects that reflected their views on the international experience offered by EduChange and their ability to transfer local experiences. Two students from one of the focus groups reported a sense of connection to the place where they had attended Field Week. They stated that, for example, they were now more interested in news items about Malta, which they would otherwise not have noticed. This is an example of how students have come to care about the location where their field trips took place (see Hope 2009). Another student felt the connection to the other participants and that this was empowering: although they all came from different places and disciplines, there was one issue on which they bonded: trying to make a difference for the planet. Residential fieldwork has been found to be a strong instrument for creating a community (see for example Kent et al. 1997)

While students agreed on the importance of seeing global and local issues and their interconnectedness, they did not all feel that the local experiences in Malta and Trondheim could be used in their lessons. One student felt that the fieldtrip would provide interesting examples to discuss with children, while another student felt more tied to the national curriculum and thus expected there to be no room to use examples from Trondheim or Malta in class. A third student wondered whether children would be able to see the connections between places in the same way as the teachers.

Not all students immediately saw the value of the reflective exercises added to the programme. In response to the reflection held on day one, one student commented that it was valuable to share experiences, whereas another student felt it did not add much. Moreover, the latter student had been hesitant to use the field diary, feeling that written notes would be vulnerable and also not wanting to offend anyone. A third student noted that the reflection on the experience of Field Week should have taken place at the end of the week itself, not 2.5 months later – while in one of the focus groups two students explicitly mentioned the importance of looking back after this time. With regard to the reflective exercise on the fourth day, one student felt there had been too much reflection and another felt the group talk was hard, as no one wanted to talk. This was recognized by the teachers that were present: it seemed that a week of fieldtrips, workshops and lectures had taken its toll and students were tired.

Conclusion

This chapter has demonstrated the importance of what Glass has termed intentional reflection. Reflective exercises need to be part of the design of international fieldtrips in order to make these trips more than pleasant breaks from daily routines and normal classrooms. Although fieldwork may be inherent to teaching and learning in geography and environmental sciences, making sense of the experiences does not come naturally – it requires effort. Being confronted with something different does not immediately lead to reflection or a deeper understanding of a place. To benefit from the international experience of being in an international group and doing residential fieldwork abroad, scaffolding of the experience is needed. This starts with the design of the programme. The international and comparative perspectives need to be emphasized and built into the whole programme. Moreover, reflection needs to be stimulated, albeit with careful attention paid to timing.

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CHAPTER 13: THE EFFECTIVENESS OF THE EDUCHANGE PROJECT IN DEVELOPING KNOWLEDGE, VALUES AND ATTITUDES ABOUT CLIMATE CHANGE.

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Abstract

The EduChange project was led by a consortium of four universities and its main focus was to develop teaching and learning experiences about Climate Change through water related issues, utilising innovative place-based education and blended learning. Through EduChange, pre-service teachers were encouraged to develop creative learning environments in which students could work together to create knowledge and learning experiences.

Research on projects that aim to influence awareness and behaviour towards climate change have been published globally, but studies on the effectiveness of inter-university led projects that focus on pedagogy are rather limited. This study aims to shed light on the knowledge, values and attitudes of student teachers towards climate change, and the extent to which the EduChange project can be a vehicle for change. The student cohort selected for this study was composed of students from the Czech Republic, Malta, the Netherlands and Norway.

A mixed method approach was adopted entailing the collection of data using both qualitative and quantitative methods. The data was collected after fieldwork sessions carried out during the project. The study shows that EduChange had a positive effect on the knowledge and awareness of student teachers concerning climate change issues. Moreover, results show that the various activities had varying rates of success in different contexts. In response to these findings, a number of recommendations and a list of possible activities are drawn up to further enhance the effectiveness of the project and to infuse ESD principles into Climate Change Education.

Climate Change and Education for Sustainable Development

The goals, objectives and principles for an educational system that was action-oriented and prepared individuals and social groups to face environmental issues and their associated problems was tabled at the UNESCO-UNEP Intergovernmental Conference on Environmental Education in Tbilisi (1977). Work on achieving this aim officially commenced as a follow up to the UNESCO Conference on Human Environment held in Stockholm (1972). Environmental education had to be contextually relevant, interdisciplinary, inclusive, participatory, transformative and emancipatory.

Although hopes were high, the outcomes soon showed that this intended revolution was not successful to the degree originally anticipated. Quite naively, blame was attributed to issues related to semantics rather than to the inability of educational institutions to be flexible and adapt to emergent needs. Consequently, a myriad of forms of education flourished, with Education for Sustainable Development (ESD) becoming the most popular to date, probably because of the interest generated by the UN Decade of Education for Sustainable Development (2005-2014) (Pace, 2010).

The Decade served to highlight the importance of a proactive stance and a supportive infrastructure in its list of Priority Action Areas that ESD should address in the coming years (UNESCO, 2014):

- Mainstreaming ESD into both education and sustainable development policies;
- Integrating sustainability principles into education and training settings;
- Increasing the capacities of educators and trainers to deliver ESD more effectively;
- Empowering and mobilizing youth; and
- Accelerating sustainable solutions at community level.

If one had to gauge the success of ESD, one would have to look into whether we have succeeded in developing learners who are open to change, i.e. not just thinking, but functioning outside the proverbial box. This is particularly relevant to education about Climate Change.

Although experts over the years have studied, highlighted the complexities and foretold the impacts of Climate Change, we are still learning and discovering new aspects of its multifaceted nature. Like other issues concerning sustainability, Climate Change is a wicked problem as dealing with it requires a deep understanding of the complex interactions between environmental, social, cultural and economic systems. While ESD holds the promise of preparing students to anticipate, face and address wicked problems, higher education institutions – seen as central contributors to ESD – have been repeatedly criticized for not providing students with the required skills, attitudes and values to do so (e.g. Orr, 1994; Pace, 2010; Leal Filho et al. 2019). Perhaps the inability of higher education institutions to adapt to ESD is in itself a wicked problem, as there are complex issues involving monodisciplinary structures; traditional approaches to learning; lack of clear commitment to ESD; lack of resources; territoriality issues and competition between students, faculties, departments and universities (Moore, 2005).

Climate Change Education (CCE) falls within the domain of ESD. It may therefore be appropriate to present it through an ESD framework such as the Delors Report to UNESCO in 1996 (Mochizuki and Bryan, 2015). The Delors report conceptualises four pillars of education (Delors, 1996), two of which are especially significant in the CCE context:

Learning to know: Students need to understand the causes and consequences of Climate Change as well as Climate Change mitigation and adaptation tools.

Learning to do: Students need to develop cross-cutting skills such as coping with one's emotion such as fear, being able to adapt fast to different situations and learning contexts, understanding systems and envisioning different solutions and future scenarios.

Nonetheless, it is important to point out that CCE is seen to be complex and institutions who provide it within an ESD framework may consider it as having a number of challenges, including:

- while requiring immediate action, the consequences of Climate Change cannot be seen easily nor understood and measured;
- climate is a public good and affects every person in the world, but the vested self-interests of certain actors hinder the debate;
- action (decarbonisation) needs to happen on an unprecedented timescale;
- cognitive dissonance is common with individuals believing that climate mitigation needs to happen;
- in line with cognitive dissonance, many individuals feel that they do not need to act as it is someone else's job to do so; and
- integrating Climate Change mitigation is not seen as the social norm.

The above challenges can be more successfully addressed through being better embedded into existing teaching episodes, further highlighting the need to incorporate CCE within an ESD framework utilising different teaching and learning approaches.

The EduChange project

The project *EduChange – Making knowledge together* was a co-funded project supported by the Erasmus + Program involving a consortium of four universities: Norwegian University of Science and Technology – Norway; Palacký University – Czech Republic; University of Malta – Malta; and Utrecht University – the Netherlands. The project's overarching aim was to promote Climate Change Education – focusing particularly on water issues - through innovative place-based education and blended learning (http://educhange.net/).

EduChange was developed to address the inadequacy of traditional teaching and learning modalities by providing learners with practical first-hand experiences through which they could relate their acquired knowledge about climate change to real-life challenges. This was achieved by exposing university students to different methods and techniques that facilitated knowledge acquisition, development of skills and internalization of attitudes. Although the project allowed and encouraged personal reflection, most of the activities involved tasks carried out in collaborative groups of international peers to facilitate the sharing of different perspectives and the realities of different university students from a variety of educational backgrounds.

This current study was carried out mid-way through the project with the aim of reviewing and evaluating the project's methods and possibly improving its approach for the remaining year. The research questions thus focused on:

- Did students develop new and deeper perspectives about climate change?
- Did students develop new pedagogical and communication skills?
- Did experiences in place-based learning motivate students to learn?
- Did students develop a sense of commitment towards environmental action?
- Was the international dimension conducive to a deeper educational experience?

Methodology

Survey design

A questionnaire was undertaken to address the research questions on the effectiveness of EduChange and to fill the research gap of specific information on the programme. In a nutshell, the aim of the survey was to understand whether and how EduChange has an effect on student behaviour.

The survey aimed to portray the opinions and realities of students from different institutions regarding their opinions of EduChange, in addition to associated attitudes, practices and beliefs. The first list of items was reviewed by the authors to minimize redundancies and similar items, and to ensure that all important questions were included. The questionnaire was pre-tested (and subsequently revised) by a small panel of academics from the areas of education and sustainability. Survey Monkey was used for the final version of the online survey.

Sampling

The survey was disseminated via a web link through email to the participants of the 2019 EduChange fieldtrip that took place in Malta. There were 22 responses in all, which constitute all members of the cohort present at that time in Malta (Table 19).

Table 19: Distribution of sample based on country of origin

Country	No. of students	% of sample
Czech Republic	7	31.8
Malta	4	18.2
The Netherlands	5	22.7
Norway	6	27.3

The sample was predominantly female (Table 20) and within the 22-25 age bracket (Table 21).

Table 20: Distribution of sample based on gender

Gender	No. of students	% of sample
Female	16	72.7
Male	6	27.3

Table 21: Distribution of sample based on age

Age bracket	No. of students	% of sample
18 - 21	3	13.6
22 - 25	13	59.1
26 - 29	4	18.19
30 - 33	0	0.0
34 +	2	9.1

More than half of the sample was comprised of students studying a 2nd cycle degree at their respective university (Table 22).

Table 22: Distribution of sample based on their current degree level

Qualification	No. of students	% of sample
1st cycle degree	6	27.3
2nd cycle degree	15	68.2
Other	1	4.6

The main limitation of the study is that, although the sample represents all the students engaged in the second year of the project, the results cannot be generalised, and should be seen as trend indicators and insights for the design of similar future projects.

Results

Perspectives about the EduChange project

The students' responses summarised in Table 23 show that the primary target of the EduChange project, i.e. the promotion of innovative place-based learning, was achieved. The students overwhelmingly agreed that, due to their relevance, these teaching and learning techniques were much more effective than traditional lecture-based sessions. While acknowledging that adopting these techniques in class could be challenging, the majority of students agreed that it would be possible. In fact, all the students expressed their intention of using these techniques when they start their teaching careers.

The international dimension of the EduChange project had a very positive impact on the educational experience of the participating students. Although some of the students (36.4%) preferred working and learning within their national groups, all of them admitted that working as part of an international group widened their experience.

Table 23: Perspectives about EduChange

	Strongly agree	Agree	Don't know	Dis-agree	Strongly disagree	Weighted average
EduChange exposed me to teaching methods that I was not aware of.	22.7%	59.1%	4.6%	13.6%	0.0%	2.1
Place-based teaching methods make learning more relevant to students.	63.6%	36.4%	0.0%	0.0%	0.0%	1.4
When learning about climate change I would prefer listen-ing to a good lecture rather than having a place-based session.	4.6%	0.0%	13.6%	59.1%	22.7%	4.0
The teaching methods pro-posed by EduChange are difficult to use in a normal lesson.	4.6%	9.1%	18.2%	63.6%	4.6%	3.6
The teaching methods pro-posed by EduChange are interesting, but not practical.	0.0%	9.1%	13.6%	54.6%	22.7%	3.9
I would like to use the teach-ing methods proposed by EduChange when (if) I start teaching.	63.6%	36.4%	0.0%	0.0%	0.0%	1.4
Visiting a foreign country helped me see aspects of climate change that I was not aware of.	31.8%	45.5%	18.2%	4.6%	0.0%	2.0
Working in international stu-dent groups helped me widen my experience.	63.6%	36.4%	0.0%	0.0%	0.0%	1.4
I prefer working and learning within national groups.	18.2%	27.3%	18.2%	31.8%	4.6%	2.8

Favourite EduChange activity

Students were asked to mark their most favourite EduChange activities. Table 24 summarises the results. It is quite evident that hands-on and experiential activities were the most popular. The Workshops introducing students to innovative educational methods topped the list (72.7%), with Lectures (with the exception of the lecture on Youth perspectives in the Netherlands) trailing behind.

Table 24: Favourite EduChange activity

Activity	No. of responses	% of respons-es (N=22)
Workshop on innovative educational methods	16	72.7
Field Visit: Chadwick Lakes	13	59.1
Group Activity: Designing Educational Sessions	12	54.6
Playing the Y-Floods Game	11	50.0
Playtesting of Educational Activities	11	50.0
Lecture: Youth perspectives in the Netherlands	10	45.5
Field Visit: Marsaxlokk fishing village	9	40.0
Visit to the Esplora Science Museum	7	31.8
Visit to the l-Ghajn Interactive Centre	7	31.8
Lecture: Malta and water – Irrigating a semi-arid landscape	4	18.2
Lecture: Youth perspectives in Malta	3	13.6
Lecture: Climate change and its impact on our life	1	4.6
Lecture: Water Education	1	4.6

Effectiveness of the EduChange project

The vast majority of the students (86.4%) rated the overall effectiveness of the project quite highly (Table 25).

Table 25: Effectiveness of EduChange

Rank	1 (lowest)	2	3	4	5 (highest)	Total	Weighted Average
No. of Responses	0	2	1	13	6	22	4.1
% Responses	0.0%	9.1%	4.6%	59.1%	27.3%		

Sustainable Development Goals

This question concerned the perceptions of students regarding the importance of the seventeen Sustainable Development Goals (SDGs). As shown in Table 8, students considered SDG13 - Climate Action to be the most important (59.1%) followed by SDG 11 - Sustainable Cities and Communities (50%) and SDG 12 - Responsible Consumption and Production (50%). This was to be expected as the main themes addressed during EduChange were in line with these SDGs and, to a lesser extent, with the next two SDGs listed in Table 26.

Table 26: Important Sustainable Development Goal

Sustainable Development Goal	No. of re-sponses	% of respons-es (N=22)
SDG 13: Climate Action	13	59.1
SDG 11: Sustainable Cities and Communities	11	50.0
SDG 12: Responsible Consumption and Pro-duction	11	50.0
SDG 4: Quality Education	10	45.5
SDG 6: Clean Water and Sanitation	7	31.8
SDG 1: No Poverty	6	27.3

SDG 7: Affordable and Clean Energy	5	22.7
SDG 10: Reduced Inequality	3	13.6
SDG 16: Peace and Justice Strong Institutions	3	13.6
SDG 2: Zero Hunger	2	9.1
SDG 9: Industry, Innovation and Infrastructure	2	9.1
SDG 15: Life on Land	2	9.1
SDG 5: Gender Equality	1	4.6
SDG 8: Decent Work and Economic Growth	1	4.6
SDG 17: Partnerships to achieve the Goal	1	4.6
SDG 3: Good Health and Well-being	0	0.0
SDG 14: Life Under Water	0	0.0

Attitudes about Climate Change

Students participating in the EduChange project showed an overall positive attitude towards action to combat Climate Change (Table 27). They believe that Climate Change is a real phenomenon that needs attention and it affects them. While acknowledging the importance of both environmental and economic considerations, they were overwhelmingly in favour of prioritising environmental concerns over economic ones. They also felt that effective solutions regarding Climate Change require commitment on a local and a global level, and that one solution is the promotion of Climate Change Education directed towards the whole population.

Table 27: Attitudes about Climate Change

	Strongly agree	Agree	Don't know	Disagree	Strongly disagree	Weighted average
Persons engaged in climate change work are making a big deal of nothing	0.0%	4.6%	4.6%	22.7%	68.2%	4.6
Climate change is not affecting us in our country	0.0%	0.0%	0.0%	13.6%	86.7%	4.9
The highest priority should be given to protecting the environment, even if it hurts the economy.	27.3%	59.1%	13.6%	0.0%	0.0%	1.9
Both the environment and the economy are important, but the environment should come first.	57.1%	33.3%	4.8%	4.8%	0.0%	1.6
Both the environment and the economy are important, but the economy should come first.	0.0%	0.0%	4.6%	63.6%	31.8%	4.3
The highest priority should be given to economic considerations such as jobs, even if it harms the environment.	0.0%	4.6%	13.6%	45.6%	36.3%	4.1
We, common citizens, cannot do anything about climate change	0.0%	4.6%	0.0%	13.6%	81.8%	4.7

Countries should work together to deal with climate change issues	86.4%	13.6%	0.0%	0.0%	0.0%	1.1
People need more information on climate change	72.7%	22.7%	4.6%	0.0%	0.0%	1.3
Children should be taught about climate change in schools	95.5%	4.6%	0.0%	0.0%	0.0%	1.1

Personal actions taken on Climate Change

Table 28 summarises the students' personal actions that help reduce Climate Change. As expected, the majority of self-reported actions target energy consumption, waste management and transport, which are the three major causes of Climate Change. However, students are also quite engaged in other 'less familiar' actions, i.e. the reduction of meat consumption and the purchase of climate-friendly products.

Table 28: Personal actions taken on Climate Change

	No. of responses	% of responses (N=22)
Turn off lights when not in use	21	95.5
Reduce, Re-use or recycle waste when possible	21	95.5
Reduce meat consumption	19	86.4
Use energy saving light bulbs	17	77.3
Use public transportation to save fuel	17	77.3
Switch off standby devices	14	63.6
Buy from companies that sell or produce environmentally friendly/climate friendly goods and services	14	63.6
Use energy saving appliances	10	45.5
Car pool (share)/travel with friends to save fuel	10	45.5
Defrost refrigerator/freezer often	7	31.8
Use a solar water heater	3	13.6

The Authorities' role regarding Climate Change

In this open question students were asked to state what they thought the authorities should do with regard to Climate Change. Overwhelmingly, the students felt that the authorities should assume more responsibility and take concrete actions to address Climate Change. Most of the respondents (42.9%, N=28) felt that authorities should be more forceful when implementing Climate Change measures:

"*I think that states may interfere more explicitly to influence people's environmental knowledge and behaviour.*"

"*They should take action against it* (Climate Change) *even if it is not a popular decision.*"

"*Authorities should implement realistic policies to ensure we work towards more sustainable practices sooner rather than later.*"

They also proposed that the authorities should "*take specific actions*", implement mitigation and adaptation measures such as: "*Invest more money in developing renewable energy*"; "*Stronger policy for pollution and higher taxes for big companies*"; and "*invest in urban planning with an ecological perspective*".

Other students felt that change can be fostered by incentivising citizens and businesses and supporting grassroots initiatives. Students acknowledged that education is key for any behavioural change and hence suggested that authorities "*invest in good* (Climate Change) *education*" directed at "*the public, not just kids,* (so that) *… people know what is being done*".

Some students felt that the root of the problem is that Climate Change has a low priority in the authorities' political agenda, either because they think the whole issue is a hoax or because they are not fully aware of the threat it poses. Students further suggested ways in which this can be addressed. The authorities need to "*educate themselves on the issue*" and get their facts right by "*collaborating with* (Climate Change) *experts*". Students also suggested that policy makers need to "*listen to the public and the environmental organizations*" to ensure that the common good is addressed through their decisions. Furthermore, considering that "*global climate change is hard to tackle*", the authorities need to "*cooperate with other states*" to create a global alliance. This is of particular importance for small states.

Discussion

The results indicate that the EduChange methodology was successful and had a considerable impact, not only on the knowledge base of the participants, but also on the development of their skills and attitudes towards Climate Change. They felt this to such a degree that all the students said they will include this approach in their own teaching methods. The international dimension of the project seems to have provided tangible and lived experiences of how Climate Change impacts the lives of people in different countries. This face-to-face encounter with the realities of Climate Change seems to have been more effective than the traditional teaching / learning methods.

The students' main preferences regarding learning activities was for those that provided first-hand experiences (preferably in the field) and opportunities for active learning. The level of popularity of an activity with the students was dependent on its level of student engagement and on how relevant it was to their needs (i.e. what they consider important for their teaching career), or a combination of the two. It is worth mentioning the importance students ascribed to the education of all age-groups – including policy makers – in an effort to bring about effective change towards sustainability.

Students participating in the project not only acknowledged that Climate Change is real, but they were quite knowledgeable concerning its far-reaching implications. This was evident in their consideration of 'important' SDGs and in the behaviour they chose to adopt in their day-to-day lives. Of particular interest was their concern for the need for a radical change in the predominant paradigm of development that puts economic interests above the needs of people and the planet. However, the students' low scoring on SDGs such as No Poverty, Reduced Inequality, Zero Hunger and Good Health and Well-being might be an inherent unconscious bias of the EduChange project that might have dealt with Climate Change predominantly from an environmental perspective and less from a development perspective. Students unambiguously advocated for policies that favour environmental health over economic growth. Nevertheless, students did not fall for the sustainability myth, that "*consumer choices and grassroots activism, not government intervention, offer the fastest, most efficient routes to sustainability*" (Lemonick, 2009). While acknowledging their role as consumers, they provided several scenarios through which the authorities could support grassroots initiatives towards actively combatting Climate Change.

Conclusions

This chapter analysed the EduChange project and its effectiveness as an education for sustainable development (ESD) initiative. The study showed that the careful choice of educational experiences relevant to the learners, as well as teaching and learning approaches that actively involve students in their learning, can lead to the development of skills and attitudes conducive to a sustainable lifestyle.

One limitation of the study is that it refers to the responses obtained from a set of 22 students and, as such, it cannot be regarded as comprehensive. However, bearing in mind that the sample encompassed all the EduChange cohort over one year, it enables a profile to be built concerning the extent to which EduChange affected the students.

One clear conclusion to be drawn is that the methodology adopted by EduChange is effective and should become more conspicuous by expanding its focus to other areas of the SDGs. This is particularly relevant during this particular period characterised by the covid-19 pandemic, which has been likened to "*watching the climate crisis with your finger jammed on the fast-forward button*" (The Economist, 2020, May).

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