D2.1 LITERATURE REVIEW AND COMPENDIUM OF SUCCESSFUL PRACTICE

Project acronym: OTTER

Project title: Outdoor Science Education for a Sustainable Future

Call: H2020-SwafS-2018-2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 101006482

Project no.	**1010010082**
Project acronym:	**OTTER**
Project title:	**Outdoor Science Education for a Sustainable Future**
Call:	**H2020-SwafS-2018-2020**
Start date of project:	**01.09.2021**
Duration:	**30 months**
Deliverable title:	**D2.1 Literature Review and Compendium of Successful Practice**
Dissemination level:	**Public**
Due date of deliverable:	**28.02.2022**
Actual date of submission:	**28.02.2022**
Deliverable Lead Partner :	**University Of Limerick**
Work Package:	**WP2**
Keywords:	Education Outside the Classroom, Outdoor Learning, Outdoor Teaching, Museum Learning, Field Trips, Informal Science Learning, Science education, Sustainability & Plastics

Please cite as:
McCormack, O., O'Neill, D., Beal, E., Azevedo, N., González, H., Jarvinen-Taubert, J., Kajganovic, J., Kurucz, O., Marimon, O., Rusitoru, M. and. Valtonen, P (2022). D2.1 Literature Review and Compendium of Successful Practice the H2020 project OTTER (Outdoor Science Education for a Sustainable Future). Limerick, Ireland. 156 Pages.

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History			
Version	**Date**	**Reason**	**Revised by**
01	16.02.2022	Draft 1	Orla McCormack, Deirdre O’Neill & Erin Beal (UL)
02	21.02.2022	Draft 2	Nathália Helena Azevedo (RUG)
03	28.02.2022	Contributor comments addressed	Orla McCormack & Deirdre O’Neill (UL)

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List of Acronyms

EOC	Education Outside the Classroom
IBL	Inquiry-Based Learning
CML	Contextual Model of Learning

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OTTER project

Funded under the EU's Horizon 2020 research and innovation programme, the **OTTER project** aims to **enhance the understanding of Education Outside the Classroom** (EOC) **methods and pedagogies** and how they can help **improve the acquisition of scientific knowledge and transferable skills in students, specifically in the field of environmental sustainability and the reduction of plastic waste**. It aims to increase interest in scientific topics among young people, while also contributing to the range of innovative educational projects and the increase of scientific citizenship within the EU.

OTTER aims to strengthen educational outside-the-classroom (EOC) **networks within Europe**, connecting experts from four different regions within the continent (**Finland, Hungary, Ireland and Spain**). The strengthening of these networks will be utilised to carry out a programme of EOC pilot schemes and analysis of the effect they have on the performance of participating students, including their levels of sophisticated consumption and scientific citizenship, to increase understanding of the effects of education outside the classroom on EU citizens. The pilot schemes will share a common theme revolving around issues of plastic waste and recycling in order to build upon recent momentum in tackling related global educational, social, and environmental issues and due to the close relationship between reducing plastic waste and the need for more sophisticated consumers.

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Project Consortium

Geonardo Environmental Technologies **(GEO)**

European Science Foundation **(ESF)**

University of Groningen **(RUG)**

University of Limerick **(UL)**

Bridge Budapest **(BB)**

Learning Scoop - oppimisen osuuskunta **(LS)**

The Big Van Theory **(TBVT)**

Center for the Advancement of Research & Development in Educational Technology **(CARDET)**

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Executive Summary

This report presents findings from a systematic literature review exploring Education Outside of the Classroom (EOC). EOC is characterized by curriculum-based educational activities practiced outside the school buildings, in natural (e.g., a park or forest) or cultural (e.g., a museum or library) settings. The aim of this systematic review is to identify, organize, and synthesize empirical research into the impacts of EOC practices on students (aged 6-18 years) in terms of cognitive, affective, and psychomotor outcomes; gender and geographical differences in these impacts; methodologies for assessing impacts; and effective tools and practices used by EOC practitioners to achieve these positive impacts.

This systematic review draws on European literature, as well as international examples (USA, China and Taiwan). Partner Countries, including Finland, France, Hungary, the Netherlands, Ireland, and Spain, each completed a systematic review based on their individual country context. The inclusion criteria for the systematic review were that the studies were empirical based, published between 2012-2021, explored effective EOC practices, focused on and included students aged 6-18 years and was published in English (for European/International review) or in the native language (for partner country systematic review). Grey material related to unpublished or non-commercially published material such as government reports, policy statements, issues papers, project reports by organisations, with the same inclusion criteria applying to the selection of grey material.

The literature was searched in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021). For the European and International systematic literature review the search strategy was completed in the database Web of Science with the following search terms: “Models of Education Outside the Classroom”, “Models of Outdoor Learning”, “Models of Outdoor Teaching”, “Models of Museum Learning”, “Models of Field Trips”, “Models of Informal Science Learning” and “Models of Non-Formal Science Learning”.

Partner countries may have used differing databases and search terms, to reflect the specifics of each context. Due to the length and range of these search terms/databases, these aren’t presented within the abstract but are clearly outlined in the relevant sections in part three of the report.

In total, 109 research articles were reviewed, with 49 relating to the European/International review (25 from Europe; 16 from the United States of America and 8 from China and Taiwan). Across the six partner countries, 42 research articles and 28 pieces of ‘grey material’ were reviewed.

Part 1 of the report outlines the findings of the European/International review. A range of pedagogical models were found in part 1 to be employed across the research papers. Kolb’s Experiential Learning

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Cycle (1984) was the most used individual pedagogical model underpinning the international reviewed papers. Inquiry-based approaches, that scaffold students through the phases of inquiry, were also evident, albeit conceptualized in practice in differing ways i.e., 5E model of inquiry. Technology was often used as a supportive aid, to guide students learning while engaging in EOC. The concept of Contextualized Learning frequently underpinned museum learning, where learners are diverse, and learning is situated within a free-choice context. The country-based literature review, in part 2, highlighted interactive models of learning such as: learning-by-doing, collaborative learning, project-based learning, lifelong learning and creating a community of learners as effective EOC practices. A particularly interesting approach identified by two organisation involved a research-practice model in which educational tools were designed, tested and evaluated to inform practice.

While there was a diverse range of pedagogical models identified across the reviewed papers in part 1, the varied approaches shared some commonalities. Students did not just passively listen to talks while engaging in EOC, rather students engaged in activities that were student-centered, collaborative, fun and engaging. Effective EOC practices linked EOC learning with classroom and curriculum-based learning through pre and post learning. Bringing resources or data that was gathered in the field, back to the classroom, supported students to continue their learning after the EOC experience. Many of the EOC sites supported students to be outdoors and in nature, consisting of forests, parks, deserts, beaches or mountains.

In part 1 and part 2, the reviewed studies reported a positive impact on students learning and understanding within the specific subject area (cognitive outcomes), as well as a positive impact on students' attitudes, motivation, and enjoyment (affective outcomes). Psychomotor outcomes were not considered in any paper in part 1. However, there were some positive impacts of physical involvement in activities reported (psychomotor) in part 2. Some studies paid particular attention to supporting students with differing levels of ability through, for example, the development and provision of guided and scaffolded resources.

Part 1 and 2 found that there was a large range in the duration of the interventions, with some lasting one day, to others lasting a number of weeks.

In part 1, the majority of the research did not control or assess for effects of gender, or differences within genders in their samples. There were some gender differences reported in Part 2, however in most cases these results were as a consequence of the data collected and were not considered in the design phase. Future research should ensure to assess for gender differences and report them even when no difference is found. No study reviewed for geographical differences.

In part 1 and part 2, there was a range of assessment methods and instruments used to assess the impact of the education outside of the classroom interventions. Many used a pre and post-test when

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assessing learning outcomes or interest in a particular subject area. These included either close ended question, open ended questions or multiple-choice options. When assessing for affective learning outcomes qualitative methods were more readily employed to get a rich understanding of what it was that the participants enjoyed about the experience. The most common qualitative methods were semi-structured interviews and observations. The quantitative methods (although some used open ended questions) entailed the creation of a specific questionnaires with both Likert scale questions and open-ended questions and assessments or tests/exams on the knowledge acquired for the specific subject. Some studies did use validated scales, which are referenced in the report. Some of the studies in part 2, embedded data collection into the intervention to promote a dual nature of evaluating the intervention and enhancing the learner experience.

Part 1 and part 2 found that there are multiple barriers to consider when engaging in EOC. These range from failing technology, access to various sites and socioeconomic disadvantage. It appears also that without pre and post activities that link the EOC activities to in-class learning, much of the learning may either not occur in the first instance or be quickly lost. Teacher development, to support teachers to engage in pre and post activities, as well as EOC onsite practices, was deemed important.

Part 3 of the report identifies 12 areas for consideration based on the review. These considerations include issues relating to 1) Pedagogical approaches to EOC, 2) Sites of EOC, 3) Importance of pre and post Learning, 4) Importance of teacher development to support EOC practices, 5) The supportive use of technology, 6) Importance of relationships, 7) Effective use of resources, 8) Importance of differentiation, 9) Outcomes/impact, 10) Research paradigms and instruments, 11) the need for longitudinal data and 12) the need to consider gender or geographical differences.

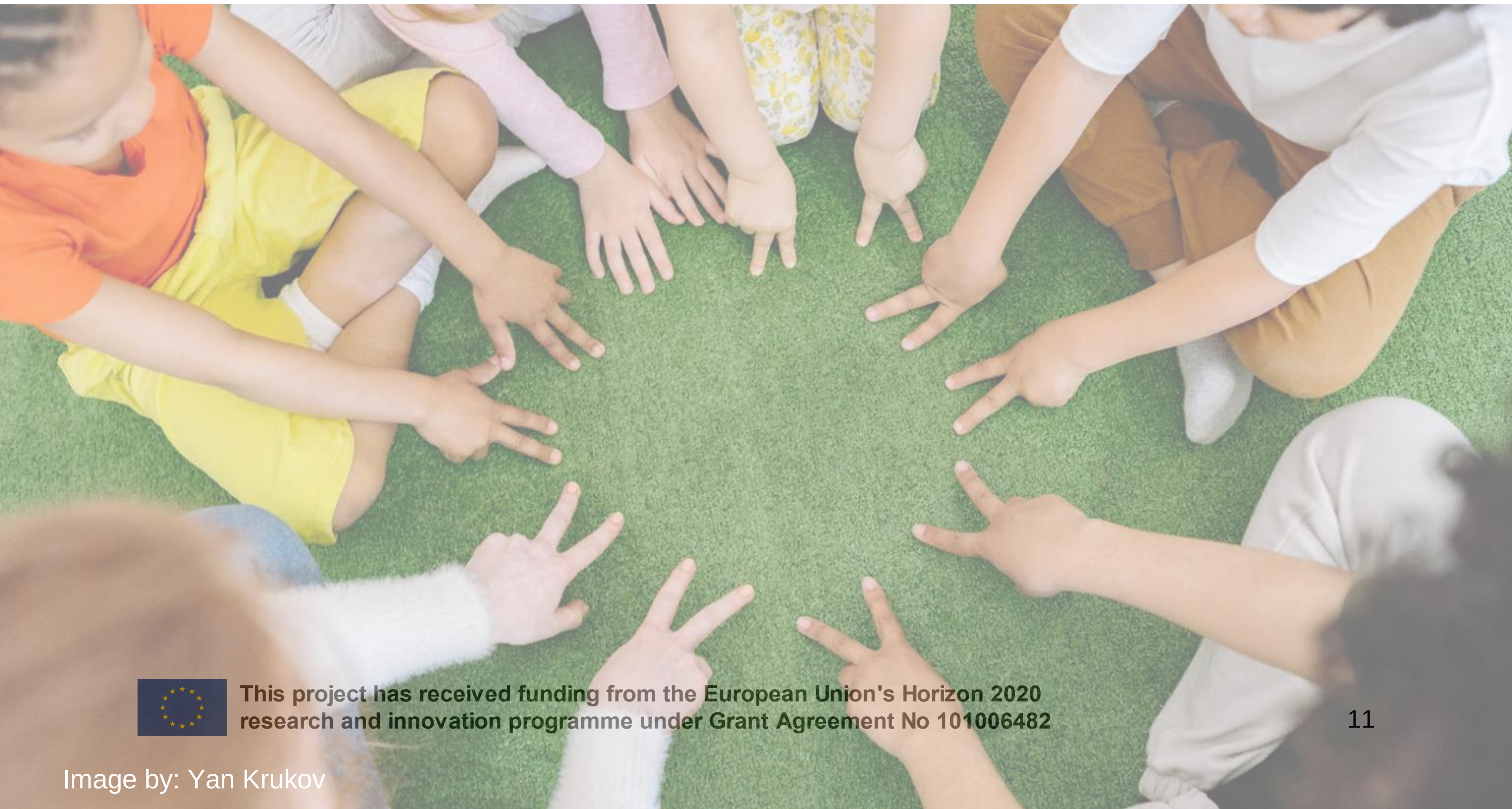

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Image by: Yan Krukov

Introduction

The aim of the literature review is to identify, organise, and synthesise previous empirical research into the impacts of EOC practices on students (aged 6-18 years) in terms of cognitive, affective, social/interpersonal, and physical/behavioural outcomes; gender and geographical differences in these impacts; methodologies for assessing impacts; and effective tools and practices used by EOC practitioners to achieve these positive impacts, with a particular interest in environmental education and sustainability. The search strategy targeted relevant electronic databases accessed via university libraries as well as grey literature (unpublished or non-commercially published material such as government reports, policy statements, issues papers).

The following systematic literature review is presented in three parts. Part One describes a systematic literature review of the empirical research on EOC practices in Europe and two international examples. Part Two describes systematic literature reviews for each partner country, including Finland, France, Hungary, the Netherlands, Ireland, and Spain. Part Three provides some areas for consideration based on the European, International and partner country systematic reviews. In total, 109 articles and reports were reviewed as part of this systematic review, consisting of European and International research articles (n=49) as well as research articles (n=37) and grey material (n=23) from the various partner countries. The grey material related to unpublished or non-commercially published material such as government reports, policy statements, issues papers, and project reports by organizations. The European and International systematic review is now outlined.

Report Layout

- Part 1: EU and Systematic Literature Review
- Part 2: Partner Country Literature Review
- Part 3: Key Areas for Consideration

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Part 1 – EU and International Systematic Literature Review

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Image by: Vardan Papikyan

Part one presents the findings of a systematic literature review on EOC related empirical research in Europe, the United States of America and China. The methods are presented, followed by the results and the section concludes by considering effective practices, challenges and difficulties, as well as gaps in the research literature.

Methodology

The following review of the literature sought to find research that has been conducted globally from 2012 – present day looking at 'Education Outside of the Classroom' (EOC). The aim of the systematic review is to identify, organise, and synthesise previous empirical research into the impacts of EOC practices on students (aged 6-18 years) in terms of cognitive, affective, and psychomotor outcomes; gender and geographical differences in these impacts; methodologies for assessing impacts; and effective tools and practices used by EOC practitioners to achieve these positive impacts.

A selection of search terms were identified based on the project proposal and piloted to determine suitability in terms of yielding a broad selection of research papers that were relevant. These included: Education outside the classroom, Models of education outside the classroom, Outdoor learning, Models of outdoor learning, Outdoor teaching, Models of outdoor teaching, Museum learning, Models of museum learning, Field trips, Models of field trips, Informal science learning, Models of informal science learning, Informal STEAM learning, Models of informal STEAM learning, STEM learning, Models of informal STEM learning, Non-formal science learning, Models of non-formal science learning, Non-formal STEAM learning, Models of non-formal STEAM learning, Non-formal STEM learning, Models of non-formal STEM learning. While the focus of OTTER is specifically on environmental sustainability and plastic use, the systematic review searched for EOC practices in all subject areas, as key learning can be taken from approaches to EOC irrespective of the subject area. Search terms that yielded non-relevant papers, were too broad in their results or did not relate to the parameters outlined in the proposal were excluded based on this preliminary pilot search. A systematic literature search strategy was then completed in the database Web of Science with the following search terms:

Search terms used for European and International Systematic Literature Review
"Models of Education Outside the Classroom" "Models of Outdoor Learning" "Models of Outdoor Teaching" "Models of Museum Learning" "Models of Field Trips" "Models of Informal Science Learning" "Models of Non-Formal Science Learning"

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Table 1:Search terms used for EU and International Systematic Literature Review.

The papers found were from European Countries, the United States of America, China and Taiwan. The literature was searched in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021). The review sought to identify all empirical papers that researched EOC practices in children aged 6-18 years. Research conducted from 2012 up to the search date (October-November 2021) were included for review.

The reference lists of the literature included were also checked for novel articles using citation chaining. The review included quantitative and qualitative studies.

Research eligible for inclusion was required to meet the following criteria:

- was an empirical based study,
- explores effective EOC practices[1] (as per the search terms),
- focuses on and includes students aged 6-18 years (may not include all of these age groups but should be within this age bracket)
- is published in English

The following research was excluded from the review:

- research looking at new models for teaching in the classroom only,
- research using a university student sample
- theoretical papers and review articles

The search yielded 5754 citations. The titles and abstracts were screened for eligibility and duplicates were manually removed. 303 full texts were obtained, read and considered for inclusion. The rationale for any exclusions at full text review was recorded. At this stage, the international (non-European countries) that had the most papers were identified as America and China and Taiwan. In total, 49 articles were included in the final review. This is reflected in the PRISMA flow diagram (Figure 1).

[1] While the focus of OTTER is specifically on environmental sustainability and plastic use, the systematic review searched for EOC practices in all subject areas, as key learning can be taken from approaches to EOC irrespective of the subject area.

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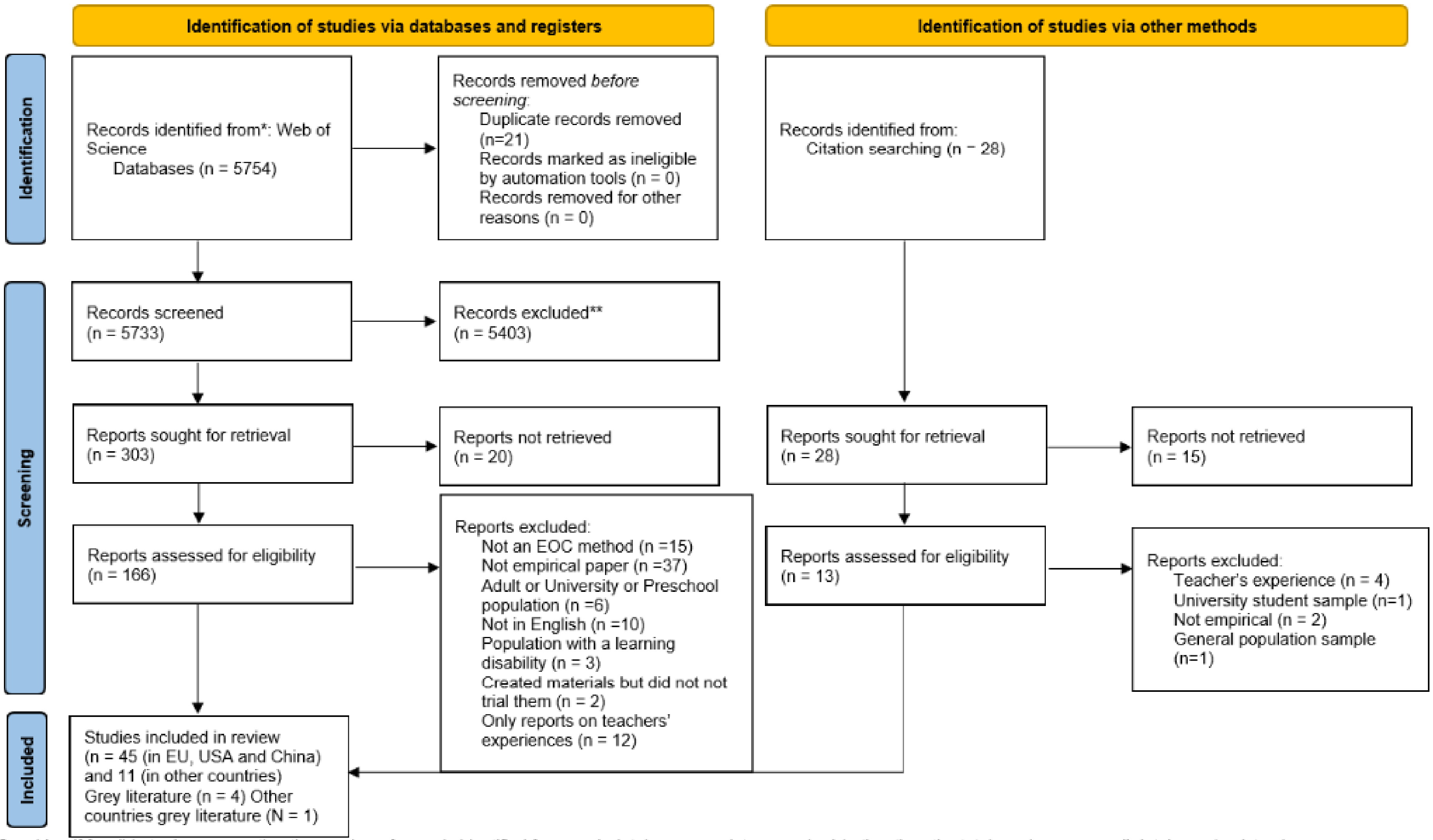
PRISMA 2020 flow diagram for new systematic reviews which included searches of databases, registers and other sources



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers).
**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://www.prisma-statement.org/

Figure 1: Prisma Flow Chart for European and International Systematic Literature Review

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Results

The results are presented under the following headings: Brief General Summary of Papers, Review of Pedagogical Models; Differences in Impact based on Gender and Geographical Differences; Research Instruments for Assessing Impact; Effective Practice, Challenges and Difficulties, and Gaps in Literature.

General Summary of Papers

This section provides a general overall of all papers included in the study in terms of approach and area of focus. A summary of each individual paper is provided in Appendix 1, while the pedagogical models and the research instruments employed in each paper are outlined later in this report.

The papers explored a variety of Education Outside the Classroom practices. Outside of Europe (n=25), the United States of America (n=16) and China & Taiwan (n=8) had the most and most relevant EOC papers. Within Europe, more papers came from Germany than other countries (n=6). However, papers from the UK, Finland, Denmark, Spain, Sweden, Turkey, Slovenia, Greece and Northern Ireland were also included in the study. Appendix 1 also includes additional papers (n=10) in other international contexts that, while beyond the remit of the current study, were considered worthy of inclusion in the appendix.

The reviewed papers focused on a wide range of subject areas and topics including, for example, science, geography, religion, mathematical understanding, music making and English language skills. STEAM related papers focused on a diverse range of topics including:

- Climate Change (for example, Petersen *et al.*, 2020; Puttick and Tucker-Raymond, 2018; Porter, Weaver and Raptis, 2012)
- Sustainability, Conservation and Sustainable Development Goals (Fisher-Maltese, Fisher and Ray, 2018; Affeldt *et al.*, 2015; Stöckert and Bogner, 2020; Roth and Reynolds, 2020).
- Space (Frappart and Frède, 2016; Salmi, Thuneberg and Bogner, 2020).
- The Freshwater Cycle (for example, Schneiderhan-Opel and Bogner, 2021),
- Rock Formation (Çelik and Tekbıyık, 2016)
- Identification of Sea Creatures (Cotič *et al.*, 2020)
- Dinosaurs (Salmi, Thuneberg and Vainikainen, 2017)
- Botany, Geology and Anthropology (Hsu and Liang, 2017)
- Evolution (Horn *et al.*, 2016)
- Developing a School Garden (Fisher-Maltese, Fisher and Ray, 2018)
- Motion, Force and Energy (Margolin *et al.*, 2021)

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Four papers placed specific emphasis on using EOC practices to promote and support positive attitudes towards STEM careers and subjects (see for example: Levine *et al.*, 2015; Shah *et al.*, 2021; Ghadiri Khanaposhtani *et al.*, 2018; Affeldt *et al.*, 2015).

The reviewed papers focused mainly on field trips (n=25), and museum learning (n=14). Papers focusing on museum trips included trips to, for example, science centres (see for example Kanlı and Yavaş, 2021; Eren-Sisman and Koseoglu, 2019) and planetariums (Salmi, Thuneberg and Bogner, 2020). Field trips were used in many countries to enhance and facilitate learning across primary and second level school groups. The most common country to utilise field trips in Europe was Germany. Field trips frequently focused on outdoor learning to forests (Meyerhöffer and Dreesmann, 2021) or national parks (Schneiderhan-Opel and Bogner, 2021) or visits to sites i.e. water treatment plant (Stöckert and Bogner, 2020).

Augmented reality was often used to either support or replace EOC practices through the development and/or provision of computer programmes and Apps (n=10). In such instances, students were provided with supportive technology to guide their learning during a museum visit (for example, Chen and Chen, 2018). China and Taiwan appear to use more augmented reality and technology to provide students with an opportunity to engage in some form of field trips and museums (n=8). Other studies specifically focused on summer camp experiences for 1- or 2-weeks (n=4; see for example Levine *et al.*, 2015; Ghadiri Khanaposhtani *et al.*, 2018).

As is outlined in more detail in the following section, the approaches to EOC adopted in the reviewed papers placed a strong emphasis on learner centred experiences (see for example, Schneiderhan-Opel and Bogner, 2021), collaborative learning activities (Alonso *et al.*, 2019), Play Based Learning (Beyer *et al.*, 2015; (Margolin *et al.*, 2021), games (Puttick and Tucker-Raymond, 2018), and hands on learning and peer mentoring (Todd and Zvoch, 2019).

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Review of Pedagogical Models and Related Outcomes

The following section reports on papers that were completed in Europe, the USA and China and Taiwan and provides an overview of the pedagogical model employed in each study. Some papers were vague about the pedagogical model that they were using, and some did not report a model. Reviews on outdoor education have suggested that the lack of identifying a specific pedagogical model is a common difficulty when reviewing research in this area (Hawxwell *et al.*, 2019). Those that did explicitly state a pedagogical model will be outlined here and any paper that includes a diagram or figure of the pedagogical model implemented is included in Appendix 2.

Eight main pedagogical models/approaches were identified across the reviewed papers. As can be seen below, some of these had a strong focus on the use of computing and software to support learning. The reported cognitive and affective outcomes of each study, where relevant, are also outlined. No study reported on the psychomotor outcomes of any intervention.

Outdoor pedagogy – Experiential Learning

A number of the papers (n=18) focused on providing students with experiential learning experiences within outdoor settings.

Ten European based studies focused on experiential outdoor pedagogy, five of which were in Germany.

German researchers examined students' motivation at a residential outdoor learning course. The courses combined social learning, personal development, and ecological knowledge in order to achieve global learning. Students learn about plant phenology, meteorology, micro climatology, glaciology, and paedology, which are all a part of the regular curriculum in school. Students use research techniques to collect data in an outdoor setting, to later analyse in a lab. The findings showed how those that engaged in these outdoor activities had much higher self-determination than those who just learned these concepts inside the classroom. The students reported that the outdoor activities are more fun and a more accessible way of learning (Dettweiler *et al.*, 2017).

In Germany researchers showed how field trips supported students learning a foreign language. The study used a content-based video exchange model as a way of introducing lower secondary English learners to English as the language of science. During a field trip to a forest and a desert, students created videos on what they learned. The German students made videos in English and shared these with a school in the USA. This content-based video exchange model using an outdoor learning pedagogy was found to be successful with students' knowledge scores increasing after the

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experience. The students also reported high levels of motivation for the field trip and would like to repeat it in the future (Meyerhöffer and Dreesmann, 2021, see Appendix 2O).

Again in Germany, researchers assessed how useful a field trip to a church was for learning about religious education. They found that experiential learning did increase students' knowledge on this subject, however the biggest predictor was the religiosity of the family from which the student came from (Riegel and Kindermann, 2016, see Appendix 2R).

German researchers used a weeklong field trip to a national park to support students understanding of the water supply. This authentic out of school learning environment also used inquiry based learning and cooperative learning techniques. The study found that students' knowledge on the topic of the water supply chain was increased in both the short and the long term (Schneiderhan-Opel and Bogner, 2021).

Researchers in Germany assessed students learning of waste management by teaching them firstly in class about the process and them bring them to a waste incineration plant on a field trip. The study is underpinned by collaborative learning, which includes 'supporting each other's learning progress by working together in small groups' and 'students working in groups and communicating with each other'. The study found these students showed higher interest scores for the topic and they increased the knowledge base on the topic at the post test (Stöckert and Bogner, 2020). The researchers define field trips as 'powerful instructional instruments; that 'provide first-hand experience, stimulate interest and motivation in the teaching subject, attach meaning to the content taught, strengthen perception, and promote personal and social skills'. On field trips students, leave the classroom to explore objects, concepts, or practices in their natural local and social setting. Such authentic encounters may contribute to specific content learning and ascribing meaning to it. Overall, field trips are not just about enhancing knowledge on subject matter, but for fostering further competencies.

In Slovenia, researchers assessed students learning of natural science using a Kolb's Experiential Learning Cycle at the beach. The researchers highlight the importance of experiential learning about the environment through practical activities. The study highlights how such approaches are motivating, stimulates learning and has a positive effect on the understanding of natural sciences. In comparison to the control group, the experimental group that went to the beach and engaged with the environment showed higher scores in content knowledge in all three tested cognitive domains, factual knowledge, conceptional knowledge and reasoning and analysis skills (Cotič *et al.*, 2020; see Appendix 2F).

A study in Turkey also assessed experiential learning at a science centre. They found that in comparison to a control group, the experimental group had better learning outcomes. The study

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advocated for pre and post learning in order to help prepare students for learning at the centre and to consolidate learning after the trip (Kanlı and Yavaş, 2021).

Research in Finland has also used outdoor locations to support students learning. A study assessing learning after a trip to a local Nature Park showed how students using inquiry-based learning were able to understand how the landscape is continually changing. The approach used also ensured that students learned how humans are changing the landscape (Kärkkäinen *et al.*, 2017) (see Appendix 2M for pedagogical model).

A residential programme in the UK showed how outdoor learning was beneficial to the participants acquisition of knowledge about history. The study was underpinned by the Kolbs Experiential Cycle of Learning. The two-day programme focused on information about Vikings which is a topic on the school curriculum. The results showed how students' knowledge on the topic improved and they began to think more positively about history. The study also found that students' knowledge was sustained at a six week follow up assessment showing that they did not forget what they had learned in their outdoor education trip (Harris and Bilton, 2019) (see Appendix 2J for pedagogical model).

In a UK based study, students were brought to an outdoor location to support learning about music making and to increase autonomy. The study was underpinned by a model of music making outdoors and was underpinned by concepts of agency and freedom. Students were asked to create music for a ceremonial performance to celebrate aspects of the environment. Music was the main focus of the ceremony, and the outdoor locations reportedly triggered the students' imaginations, allowing them to imagine people and cultures beyond their everyday experience. The students reported feeling freer, they felt emotionally connected to the experience, they engaged their sense more and they felt that they had a new sense of agency over the music making (Adams and Beauchamp, 2018) (see Appendix 2A for pedagogy model).

Six studies in the USA were deemed relevant within this section. One of these studies focused on an earth education programme called 'Earth Keepers', which attempted to engage students in meaningful outdoor learning while emphasising humans' dependence on nature. Framed as a "magical learning adventure", the programme aimed to support deeper understanding of the natural environment and to support the development of environmental behaviours through outdoor activities. The programme was organised around the concept of KEYS: Knowledge, Experience, Yourself, and Sharing. The programme consisted of a three-day outdoor experience at an environmental learning centre and further learning once students returned to the classroom. Throughout the programme: 'Students are invited to participate through a letter they receive from a mysterious character known only by the initials E.M. Each time a student earns one of the keys, they are able to open a locked box to reveal one of the secret meanings of E.M.'s name.' While on the programme, students earn the K and E. The Y and S are achieved later, if students change their behaviours (Y) and share their learning with

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others (S). The use of outdoor experiential learning increased the participants attitudes towards being environmentally friendly and their values around preservation increased (Baierl, Johnson and Bogner, 2021).

Another study in the USA assessed the influence of an urban environmental education programme on children's attitudes towards outdoor play in nature using an education outside the classroom pedagogy. Their goal in connecting children with natural areas through environmental education was to support the development of environmental literacy. The research found that children were less fearful of playing outdoors after the intervention and they reported that they played more often outside (Beyer *et al.*, 2015).

A US based study assessed an immersive soundscape outdoor ecology camp. The camp used hands on learning, direct experience with nature, authentic technology and exercises that promote collaborative teamwork. This experience allowed the students to increase their knowledge base and to become more aware of the sounds around them, create identities as ecologists and understand the importance of the different stages of scientific research (Ghadiri Khanaposhtani *et al.*, 2018).

Students in the USA were brought on a field trip to the local Delta preserve and participated in experiential learning activities led by the preserve staff and volunteers. The approach was underpinned by Kolb's Experiential Learning Cycle, which 'describes learning as a cycle that includes participants experiencing an abstract concept (Concrete Experiences), investigating the concept (Active Experimentation), reflecting on the experience (Reflective Observation), and generalizing how the concept works and relates to a previously established concept (Abstract Conceptualization). The learners must become immersed in the total experience to complete Kolb's suggested experiential learning cycle.' Teachers in the study were given materials that matched the student's science curriculum to teach them before and after the field trip to assist with learning. The research data indicated that the students had a much richer understanding of the Delta region after the trip and had increased their knowledge about rivers and the wetlands (Jose, Patrick and Moseley, 2017) (see Appendix 2L for overview of exhibits).

USA researchers assessed the socio-emotional learning of students that attended a programme called 'Outward Bound'. The study is underpinned by social-cultural theory, which recognizes the importance of transactions between peers. The programme encouraged peer-to-peer learning through challenges and problem solving in outdoor tasks and aims to build character and leadership skills. The learning model for these programs emphasizes challenges, especially physical challenges, as a central driver of learning. Young people are taken to unfamiliar wilderness environments and engage in novel and demanding activities including backpacking, canoeing, and rock climbing. The interpersonal challenges students faced in working together provided opportunities for social-emotional learning. The qualitative results showed how students felt that they increased their distress tolerance and they had engaged in collaborative learning with peers. All reported how invested they were in the tasks and how the culture of compassion and teamwork had assisted their learning throughout (Orson, McGovern and Larson, 2020).

A residential camp in the USA attempted to engage female students in learning about Chemistry. This was designed to increase the girl's engagement with science due to the lack of females progressing into STEM careers. The residential camp consisted of hands-on experiments, field trips and significant interactions with female scientists. They found that after engaging in the week long outdoor chemistry camp, students' interest in STEM careers increased and they also displayed more positive attitudes towards (Levine *et al.*, 2015).

A study in Taiwan sought to improve students understanding of plants using a mobile device to support learning while in the outdoors. Mobile learning, also known as M-learning, refers to the acquisition of knowledge through the use of mobile devices. Such a learning approach not only extends the learning space beyond the classroom, creating a meaningful learning experience, but also allows for appropriate adjustments according to the level of students, greatly enhancing learners' motivation. Ubiquitous learning, also known as U-learning, overcomes its shortcomings by using environmental awareness technology to guide students through the real world and help learners finish their learning activities. Students were taught in the classroom prior to the field trip to give them a base level of knowledge on the topic. While on the field trip, students could use a mobile device that had an e-compass and GPS system that would mark virtual objects on the screen so that students could click this and learn about specific plants and trees. The study did not assess for cognitive outcomes, however, the study found that there was a negative correlation with age and perceived usefulness of the app, where only younger children reported that the app was useful (Lo, Lai and Hsu, 2021).

Realistic learning environments

A number of studies (n=11) aimed to engage students in EOC practices which provided them with first-hand, realistic learning on a particular topic. Six of these studies were based in Europe.

In France, researchers found that when students were brought on a field trip to a museum to learn about space and gravity, they learned more about the topic than a control group that only learned about the concepts in the classroom (Frappart and Frède, 2016). These researchers defined 'formal teaching' as 'traditional teaching (i.e., by a teacher in a classroom with a textbook), which consists mainly in memorizing new information and learning answers, rather than exploring questions. Whereas 'informal teaching' was defined as 'any form of teaching that takes place outside the school building in an informal setting and promotes a constructivist view of learning, by taking account of prior knowledge and actively involving learners in the knowledge construction process'. Therefore, using this definition, informal teaching can take a variety of forms (stories, games, museum visits, etc.).

Researchers in Finland assessed the experience of experiential learning in a museum context. The study particularly focused on mathematics within STEAM and integrated mathematics learning and art and was underpinned by 'hands on learning'. The exhibition consisted of 11 interactive hands on scientific objects that the students could engage with. After the exhibit the students were asked to build their own structures and creatures by using and applying Lego and pieces of plastic. Interestingly, when compared to a control, there was no difference in the groups attitude towards maths. However, students with the lowest grade appeared to enjoy the hands-on learning more (Thuneberg, Salmi and Fenyvesi, 2017).

A study in Turkey used an activity called 'The Magic Flask' to teach students about the nature of science in formal and informal settings. The approach was designed around an 'explicit reflective' and engineering design approach. Students worked in teams to create their own model, test and evaluate their model with others formed by their peers. Students completed this activity in a science centre where the students are allowed to run the system to recognize the working principle of the device. Students followed a seven-step process of engineering design: (1) identify problem and constraints (2) research (3) ideate (4) analyse ideas (5) build (6) test and refine and (7) communicate and reflect. The data showed learning across various domains for the students, with students showing a lot of interest in the activity. Following engagement in the task, students then started showing greater interest in other exhibits in the museum (Eren-Sisman and Koseoglu, 2019).

Another study in Turkey, researchers utilised a realistic learning environment to support students learning of geoscience. The study was underpinned by GEMS (Great Exploration in Math and Science). GEM activities are underpinned by scientific inquiry, discovery learning, independent learning and critical thinking, through the use of 'amusing activities', and real-life practices. Students were brought on a field trip where they observed the structures of rocks, collected rock sample and wrote notes in the field about them. Thereafter students brought the rocks back to class to continue their learning. The learning approach was called 'great exploration in maths and science' and the data showed that the students found this way of learning fun, interesting and accessible. The study also found that the students' knowledge and conceptual understanding of the topic improved after the activity (Çelik and Tekbıyık, 2016).

In Greece, researchers assessed a mobile based assessment tool while allowing students to explore a local botanical garden. Students used their mobiles to scan QR codes placed under certain plants to get more information about them. They also were given questions to answer about the plants they were learning about. The students reported that they enjoyed this addition to the field trip (Nikou and Economides, 2015).

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Again, in Greece, students were given access to an interactive 3D model where they could engage in 'Finger Trips'. This was to promote interaction with tangible environments to promote the learning of history. This approach to learning engaged the students with historical events, made them feel like they were active participants in the event and they felt immersed in the experience. The participants reported that the environment they explored was motivating and effective for learning and they would like to use this way of learning more often for a variety of school subjects (Triantafyllidou *et al.*, 2018).

Six US based studies focused on realistic learning environ. One such a study looked at creating a school garden and how this assisted in experiential realistic environment learning for school children. Learning in these informal contexts are characterised as learner-motivated, interest-based, voluntary, open-ended, non-evaluative and collaborative. The students showed increased knowledge on where their food came from and how it grows. It also increased their environmental awareness. The researchers highlight that this would also be beneficial to urban areas to increase their sustainability and green outdoor spaces (Fisher-Maltese, Fisher and Ray, 2018).

Researchers found that science immersion trips for second level students in the USA was beneficial and well received. The paper assessed different residential trips that students engaged in where they spent time in the wilderness learning about the ecology of the areas. These included the Everglades in Florida, ski trips and trips to the desert. The study was underpinned by the concept of contextualisation. Contextualisation was described as a process of 'drawing specific connections between content knowledge being taught and an authentic environment in which the content can be relevantly applied or illustrated'. This environment includes the cultural backdrop, other actors, the physical environment, and a scenario in which the concept is inherently related and applicable. Situated cognition, which highlights the relationships between the learner and the environment and between context and knowledge, and authentic learning environments were also explored. Within the study, students learned about the environments before they went and engaged in impromptu teachable moments while in the wilderness. Students were also encouraged to build on the knowledge they learned in class. The field trips encouraged conceptualisation where students began to draw connections between content knowledge and the authentic environment they are in (Giamellaro, 2014).

A museum in the USA used a tabletop exhibit to teach students about evolution. The exhibit was designed around principles of *active prolonged engagement* (APE). APE supports 'open-ended exploration, self-driven discovery, and collaborative engagement'. Social interaction and collaboration are core concepts underpinning APE. Within the study, participants were able to engage with the exhibit to enhance their learning and the results showed that students who engaged in the experiential learning tool scored higher on knowledge than the control condition (Horn *et al.*, 2016).

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US based researchers brought live sea urchins into an afterschool's club and allowed the students to engage in an inquiry-based learning model with a realistic hands-on activity. The 5E Model of Inquiry (Engagement, Exploration, Explanation, Elaboration and Evaluation) underpinned the approach. The researchers used this approach to support learning about ecosystems and humans' impact on them. They found that the students really enjoyed the activity and their factual knowledge increased after the experience (Roth and Reynolds, 2020).

A study assessed an outreach programme in the US that aimed to increase girls' interest in science, through exploring the concepts of identify formation and self-efficacy theory. This programme, called *The Science Program to Inspire Creativity and Excellence* used peer mentors, positive reinforcement, hands on learning, student centred activities and the overall emphasis was on experience rather than achievement. The study found that the experimental group had higher levels of interest and affinity towards science related subjects in comparison to the control group (Todd and Zvoch, 2019).

Again, in the USA, a study utilised projective reflection as a framework to facilitate learning within a virtual learning environment. The study created an augmented virtual learning environment called Virtual City Planning and implemented this in a science museum to help students explore different roles in STEM. Virtual learning environments can be designed to emphasize both learning subject content as well as developing a student's personal and interpersonal competencies. The study was underpinned by Projective Reflection (PR), which refers to the process whereby a person engages in 'intentional exploration of role-possible selves' by engaging in play-based learning on potential future roles. The study found that the participants increased the factual knowledge of city planning, although personal interest in the topic was an important factor (Shah *et al.*, 2021).

One study in Taiwan utilised a situated learning pedagogy. They define situated learning as 'the process of obtaining knowledge which cannot be separated from its context and emphasizes that learning should be carried out in real situation so that learners can learn knowledge and skills through practical activities in real situation and form a rationalized interpretation of knowledge'. The study was based in a museum where the students were given interactive tablets connected to each exhibition. When students passed different exhibits, they had the opportunity to use their table to get more information about it and engage with it. The teachers were also able to follow students' progress through the museum and also view their scores on an interactive quiz. The approach enabled teachers to step in if the students were struggling. The results showed that learning with the interactive tablet was more effective than traditional navigation-based learning. The study found that in comparison to the control group, the experimental group had more motivation for learning and engaging with the exhibits as students can engage more and generate more connections and their attention is drawn to different exhibits (Chen and Chen, 2018).

Realistic learning environments through virtual reality

In some contexts, students were either unable to access actual sites and virtual reality was used to provide students with a 'realistic' learning environment in an online forum (n=4) or virtual reality was used to supplement onsite learning (n=7). Four of these studies were based in Europe.

In the UK, a museum-based study also utilized technology to engage students in the exhibitions on display. The study was underpinned by Kolb's Experiential Cycle of Learning, based on 1) concrete experience, 2) reflective observation, 3) abstract conceptualisation and 4) active experimentation. Using augmented reality students were able to explore the museum for 30 minutes and identify several points of interest. All the students had been to this museum previously and the results showed that the students reportedly learned more when they used the augmented reality technology to visit the museum in contrast to their previous visits without any technology. The participants reported that they wanted to go back and use the technology again and some said they would download the app on their phone to use outside of the museum. A highlight for some was the interact quiz that the technology afforded (Moorhouse, tom Dieck and Jung, 2019, see Appendix 2P).

In Finland researchers used a mobile interactive maths exhibition, underpinning by inquiry-based learning, called 'Mars and Space' which consisted of 30 interactive, hands on, concrete and digital objects that all related to basic physics, astronomy, biology and psychology. This interactive learning in a realistic environment increased the participants knowledge base, which was shown to be stable at six months post exposure (Salmi, Thuneberg and Bogner, 2020).

Another study utilising 'edutainment' in Finland brought students to a museum to engage with a dinosaur exhibit. The study used robotic dinosaurs that students could see and learn about. The exhibit was based on the seeing, feeling and being close to the robots to enhance learning as well as having written information. The students were found to have an increased knowledge base on the topic (Salmi, Thuneberg and Vainikainen, 2017).

Virtual reality technology was also used by researchers in Denmark to create virtual field trips. Researchers found that when they used technology to support an inquiry-based learning model to 'bring' students on a virtual trip to Greenland to learn about the effects of global warming, students' knowledge on the topic increased. The approach to IBL, as outlined in the paper, consisted of:

> '(1) *Orientation*, which introduces the learning topic (often including the introduction of a problem statement and main variables);
>
> (2) *Conceptualization*, which focuses on understanding concepts connected to the problem including generation of research questions and/or hypotheses to be investigated;

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(3) *Investigation*, where students carry out an investigation of the variables that make up the problem area including exploration, experimentation, experiment design and data interpretation;

(4) *Conclusion*, which involves addressing the original research questions and/or hypotheses; and

(5) *Discussion*, where students communicate their findings and receive feedback as well as reflect on the entire process'

The study found that when students were scaffolded through these phases, in addition to the supportive use of technology, their learning outcomes were increased further (Petersen *et al.*, 2020, see Appendix 2Q).

Researchers, in Taiwan, assessed a visit to a Botanical Garden where students were given pre session information on a range of topics such as Chinese medicine and plants. Thereafter students were guided around the botanical garden by the museum staff and given a tour. After the tour students engaged in a game where they had 'missions' which acted as reflection tools as they made their way around the exhibits to answer questions. This realistic learning environment (also considered a curriculum based virtual and physical mobile learning model) positively effects knowledge acquisition and students' problem-solving skills. The students also feedback that they enjoyed and appreciated the experience (Hsu and Liang, 2017, See Appendix 2G).

Similar to other studies conducted in Taiwan, researchers assessed a blended mobile learning game called CoboChild mobile exploration service which they hypothesised would aid children's learning and motivation. The contextual model of learning (CML) was adopted to explore the factors affecting museum learning and to support students continuous learning. CML is deemed important to museum learning, where learning is situated within a free-choice context and is viewed as both a process and product as a result of dialogue between the learner, and their physical and sociocultural environment. The CoboChild programme allows the children to interact with the museum exhibits and while they progress through the museum they can reflect on their learning and check their progress. They can also download their learning onto their mobile and share their learning with others. In this way, the programme provided a flexible learning environment for the child and can be matched to the individual child's abilities. Students could also engage with others through social networking, promoting collaborative working. The study reported that this created a meaningful museum experience for the children and promoted motivation for learning (Hsu *et al.*, 2018, see Appendix 2H).

Incorporating technology to museum visits is popular in Taiwan and China (n=5), with another study showing how a learning platform that allows students to continue learning after they leave the museum

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is very beneficial as the students report how much they enjoyed it (Hsu and Liang, 2017). The authors developed an 'online and on-site cyclical learning model (OOCLM)', that supported pre, on-site and post learning. The study was again underpinned by principles of contextual learning, which 'demonstrates that children's museum experiences are shaped by continuous interactions among the personal context, sociocultural context, blended virtual and physical context and the museum's virtuous learning cycle'. Through use of the online and onsite learning, students were provided with a personalized learning environment which offered them choice in interacting with social communities, virtual and physical resources within online and on-site spaces. The paper highlights the benefits of digital applications as they 'can provide online and on-site services before, during and after children's visits, thereby extending children's experiences to blend online and on-site museum learning in the pre-visit, on-site visit and post-visit stages' (see Appendix 2I).

This method of utilising technology to support EOC learning was trailed again as it was felt that using augmented reality was beneficial to students learning in a museum in Taiwan. Interestingly the control group, who engaged in the same tour, only using paper brochures for added information on the exhibits, showed an increase in their knowledge as well as the experimental group. Therefore, it can be seen that it appears that their learning is marginally improved through the addition of the augmented reality technology, however, both groups gained a significant increase in the pre to post-test knowledge just by being outside the classroom and engaging with the museum experience (Huang, Cen and Hsu, 2019) (see Appendix 2K for pedagogical model).

A study in Taiwan used immersive virtual reality to engage students in a realistic learning environment pedagogy. Virtual reality technology allowed students to have a 'virtual field trip' using image-based content to 'go'' and learn about a solar photovoltaic power plant located in the southern Atacama Desert in Chile in South America. The results showed that students who were already confident in the scientific knowledge based were less attentive to the virtual reality, whereas students that were less confident engaged more. Overall, the more immersive the virtual reality experience, the more students enjoyed it. The researchers also used a low cost option and the students still enjoyed it. This could be beneficial for students in urban areas, where they cannot access outdoor spaces for learning for distance, accessibility or cost reasons (Cheng and Tsai, 2020).

Another study in Taiwan used a Lilliput Multimedia system to bring the museum into the classroom. The study employed an interactive mat and remote-controlled cars so that students could navigate the museum virtually through interactive play. They chose the topic of famous buildings and allowed the students to drive their cars around the building, stopping at and engaging with the exhibits. In the study, a real map is deployed on the floor, and the students manipulate a remote-controlled toy car with a computer and navigate toy models of world-famous building along the tracks on the map. As the toy car approaches and stops near a toy model of the buildings, the radio frequency identification

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and wireless network transfer the location information of the model to the computer. Multimedia teaching programmes on the computer will then automatically display relevant exhibition knowledge about that famous building for the students. The students reported that they learned more about the topic of study and that they found it amusing and fun to use (Chou *et al.*, 2015; see Appenfix 2E).

A study in China assessed the difference between a virtual museum and real in person trip to the museum. Interestingly the students reported that they were more satisfied with the digital museum in comparison to the real museum environment. The students said that it was easy to use, and they enjoyed the immersive experiences. However, the number of students who preferred the digital museum was only slightly higher than those that reported they enjoyed the traditional museum learning experience (Ying *et al.*, 2019).

Community of Inquiry Pedagogical Model

The Community of Inquiry studies (n=2) attempted to connect students with people with particular experience and knowledge to support the development of a community of inquiry.

A study in Northern Ireland allowed students freedom and choice in learning by pairing them with university educators to learn about cutting edge science in a free learning environment. The study is underpinned by the concept of free-choice learning, which focuses on learning that takes place when learners can choose what, how and when they learn. Free-choice learning is individualised, depends on prior knowledge/experiences and involves interaction with others. As with previous studies, this study draws on Contextual Model of Learning, to 'organise the personal, sociocultural and physical contextual factors that contribute to young people's engagement with science'. The majority of students in the sample reported that they gained knowledge about a science topic and that the session helped them to understand science more. The sessions also taught students to ask questions and helped them to investigate ideas that they generated and think about how these questions could be answered using scientific techniques. Students also reportedly enjoyed the sessions, found them interesting and continued to discuss them after class ended (Dunlop, Clarke and McKelvey-Martin, 2019).

A study in the USA used the community of inquiry model by bringing experts into the classroom. The project Weatherblur invited fishermen into primary schools to teach students about the coastal community and climate change and was underpinned by a 'sociocultural learning approach that integrated communities of practice, knowledge building, funds of knowledge, and place-based education theory'. The study also used technology to support student learning on data analysis studying precipitation and air temperature. This sociocultural collaborative learning environments increased the student knowledge base as shown by a pre and post assessment (Kermish-Allen, Peterman and Bevc, 2019).

Play Based Pedagogical Models

While games and play were central to many studies, one study, based the USA, assessed a play based embodied active learning and engagement experience. The approach taken draws on the concept of embodied learning, which acknowledges that 'body movement through interactions with the physical environment contribute deeply to cognitive processes and understanding of complex and abstract science concepts.' This pedagogy aims to support students' engagement with and motivation to learn about complex and abstract physics concepts through play. In comparison to the control group, those that were exposed to the 'Playground Physics' model had a greater understanding of physics principals of motion, force and energy (Margolin *et al.*, 2021).

Differentiation Models

The differentiation model takes into account students' diversity in their personal interests, cognitive achievements, problem-solving skills, and linguistic capabilities and aims to develop learning experiences accessible to all children. A study conducted in Germany assessed a student laboratory or "Schülerlabor" that aimed to improve students' knowledge on sustainability concerns. The lab or visits take three hours, with the students working together in groups. The experimental instructions are given for all levels promoting open or guided inquiry learning. However graduated learning aids are implemented to allow low-achieving students to master a structured inquiry learning process. Different tools are available to support students at different performance levels. The learning aids are given at the phenomenological-descriptive, the verbal explanatory, and the sub-microscopic or formal-representational levels. Aside from this, learning aids focus on content and on the process of inquiry. Additional aids were also provided when dealing with linguistic heterogeneity among the students. Each set of laboratory instructions also contains a set of language-sensitive tools. Therefore, all student levels are accommodated, and all can successfully engage with the learning. Almost all the students surveyed reported that they felt that the topics of study were personally relevant to them, and they said that the instructions provoked their situation interest. Students also had fun and the activity increased their motivation to engage in chemistry learning. Their teachers also felt their students were more interested in their chemistry and science lessons (Affeldt *et al.*, 2015) (see Appendix 2B for pedagogy model).

Collaborative Learning through Social Computing

While a number of studies, as reflected above, emphasise the importance of peer-to-peer collaboration, two studies specifically looked at collaborative learning while engaging with computers. A study in Spain used a pedagogy of collaborative learning through social computing. In this study the researchers assess a framework that they created called Context-Aware Framework for Collaborative Learning Applications (CAFCLA). CAFCLA is a framework whose main objective is to

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provide teachers with an easy way to design collaborative learning activities using contextual awareness via social computing. One of the most important aims of the framework is to simplify the use of social interactions and contextual information, enabling teachers to block out tedious processes that are not related to education. The process of design and development of a collaborative learning activity through CAFCLA takes into consideration the objectives that the student should achieve, the learning content, the teaching resources available, the physical or virtual spaces that have been selected, the evaluation and monitoring of the activity, and pre-established social rules. The research showed that when using the software for learning in a museum the children worked together, and they completed the activities quicker than when working alone. They were able to engage with the exhibits on their mobile devices They also advocate that this form of software substantially increased the collaborative learning processes as they show the difference between the test group and the control (Alonso *et al.*, 2019; See Appendix 2D).

A study in the USA assessed how learning about climate change can be supported through the use of game design. The study employed a sociocultural constructionist pedagogy and found that students learning about the processes of climate change increased as they were asked to make games that would teach others about the processes, they were learning. This not only increased the knowledge based on climate change but also helped them to learn a new skill of game design. It also allowed them to think about the best ways in which to share their new learning with others (Puttick and Tucker-Raymond, 2018)

Model-based pedagogy

Two specific studies focused on students developing models, often with the support of technology. The MathCityMap-Project in Italy aimed to motivate students to solve real world tasks by using mathematical modelling ideas outside the classroom. The project was supported by the use of digital technology, where they follow a set trail through the city and find different shapes in real life. They are also asked to engage in such problem-solving activities such as ‘calculate the mass of a rock’. The app provides hints and gives direct feedback when a answer is input. The children reportedly really enjoyed the activity and the researchers reports that they had a better grasp of maths after the task (ARIOSTO *et al.*, 2021).

One study in the USA sought to explore students understanding of climate change and environmental science using a model-based pedagogy and a non-model-based pedagogy which utilizing evidence-based reasoning. The paper proposed a 3 stage Evidence-Based Reasoning Framework: Stage 1: Premise; Stage 2: Analysing the Data and Stage 3: Interpretation of Evidence. During both non-model and model-based investigation, students analyse climate data, including noise reduction and data

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smoothing techniques, across which teachers facilitate small- and whole-group discussions about the phenomenon in the context using a variety of questions and prompts. At the end of both activities, students review and revise their initial claims about the phenomenon of global increase in average surface temperatures. In the non-model-based activity, students use a NASA temperature data set (1881–2017) to explore the phenomenon of an increase in average global surface temperatures. In the model-based pedagogy, the students used a Global Climate Model (GCM) which is used by scientists to study past climate and predict future trends in climate. The climate modelling interface used in this study was developed by the researchers at Columbia University and NASA. The results showed how the model-based activity helped the students in developing more robust, accurate and explanatory accounts for the phenomenon of increasing global temperatures. This software helped them to use, manipulate and understand complex information by separating it into manageable chunks. The students showed more in-depth learning when using the pedagogy that included the model (Bhattacharya, Carroll Steward and Forbes, 2021) (see Appendix 2C for Evidence-Based Reasoning Framework applied to develop for non-model and model-based activity).

Differences in Impact/Outcome

Gender

Many studies did not control for gender, and if they did, they found no gender differences or did not report them. There were studies that had been completed exclusively with a female population. This, in many cases was due to the perception or 'stereotype' that girls do not 'like' science as much as their male peers and therefore do not progress into STEM and STEAM careers. Therefore, many papers sought to engage girls in science curriculum through summer camps or mentor schemes to allow them to engage with topics they may not have previously. Any study that assessed for the impact of gender, regardless of there being an effect or not is reported below.

Europe

A study in Germany sought to assess the impact of a residential outdoor camp that covered a range of topics included on the national curriculum (e.g., plant phenology, meteorology, glaciology, and micro climatology). The study found that the qualitative results were skewed as they included a sample group of all girls (not purposively), however in the quantitative data, they found that gender did not impact the results. They found that all students increased their self-determination when learning outdoors and all students reported that they enjoyed the trips and found the themes fun and beneficial to their learning (Dettweiler *et al.*, 2017).

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A study in Finland sought to bridge the gap between formal and informal learning though a museum exhibition about space. Boys in the sample had slightly higher scores than the girls in their science knowledge prior to the study. This difference was not evident in the post school, which implied that the girls in the sample learned more effectively. Furthermore, the exhibit appeared to be more attractive to the girls in the sample in comparison to the boys and the researchers reported that their results showed that the girls were more autonomous than the boys (Salmi, Thuneberg and Bogner, 2020).

Another study using museum learning in Finland also reported gender differences. This study sough to assess 'edutainment' where students are engaged in an entertaining way of learning. This exhibit was about dinosaurs and the students were allowed to engage with robot dinosaurs that were on display at the museum. Students were given information about the dinosaurs as they progressed through the exhibit. The overall results showed how the students enjoyed the experience and they also learned new information from it. As was seen in Salmi *et al.* (2020) the boys in this sample had higher knowledge scores than the girls in their pre-test scores on knowledge, however, they also scored higher in the post test after engagement with the exhibit and also at the delayed post-test. The girls in the sample had higher scores on autonomy as in the previous study. The researcher also assessed the biology scores from the school grades and although the boys and girls had equal scores on biology in school, they scored higher on biology knowledge during the study. Overall, the girl appeared to enjoy the experience more and were more motivated to learn, which the researchers hypothesised contributed to their learning. They also highlighted that this finding is in opposition to the commonly held belief that girls 'don't like science' (Salmi, Thuneberg and Vainikainen, 2017).

Another study from Finland, looking at a museum exhibit that engaged students in maths learning, controlled for the impact of gender. This exhibit consisted of eleven interactive hands on science objects that the students were allowed to use, test, and explore. Thereafter, they were asked to build different structures by using and applying maths knowledge with Legos and pipes. In this sample the results showed that the children reportedly enjoyed learning about maths regardless of the context (in the classroom vs the museum), however those with the lowest grades in school reportedly enjoyed the museum exhibition and the hands-on experiential learning more than their peers with higher grades. Boys were more likely to view the exhibition as useful and the girls in the group enhanced their experience more than the boys when their situational motivation was higher (Thuneberg, Salmi and Fenyvesi, 2017).

One meta study included previously reported studies (Salmi, Thuneberg and Vainikainen, 2017; Thuneberg, Salmi and Fenyvesi, 2017; Salmi, Thuneberg and Bogner, 2020) and looked at six science exhibits across four countries (Finland, Sweden, Latvia and Estonia).. The researchers gave the participants a series of questions prior to engagement with the exhibits, where they could give an answer or respond that they were unsure. In the pre-test being a girl directly predicted uncertainty of knowing in three out of six exhibition contexts (Dinosaurs and Evolution, Mars and Space and 4-D Math). This however changed in the post test and there was no difference found. In the post-test there was only one weak direct effect (4-D Math). In the case of Mars and Space, being a girl positively predicted situation motivation (Thuneberg and Salmi, 2018).

United States of America

Researchers in the USA assessed a full-time weeklong chemistry camp that was set up for girls in Rhode Island. This camp incorporated hands on experiences, field trips and significant interactions with female scientists with the aim of increasing the participants interests in and enthusiasm for science. They did achieve their goals of increasing interest in STEM careers with the sample population, however there was no male comparison group (Levine *et al.*, 2015).

Another study, using a sample of girls, assessed a summer workshop where students learned about climate science through a virtual programme where they were asked to create their own games. The girls all enjoyed the workshop, and they increased their knowledge of climate change as a system problem and learned how to create games. The authors highlight how their sample is limited as it is a single sex sample (Puttick and Tucker-Raymond, 2018).

Another study on an informal science outreach program for girls sought to explore identity formation and self-efficacy with middle school students' science affinity. The overall goal of the programme was to motivate young girls to pursue and persist in STEM education and careers after second level school. They found that the girls who participated did report a higher affinity for STEM careers immediately post intervention, however, without longitudinal data it is unknown if the programme increased the number of students who went on to pursue a career or further study in a STEM area (Todd and Zvoch, 2019).

China and Taiwan

Researchers assessing outdoor learning of plants using an app in Taiwan found no gender differences in their study. The study found that the younger students found the app to be more useful than the older students. The found that weaker students overall benefitted from the intervention more than the students with stronger digital literacy (Lo, Lai and Hsu, 2021, see Appendix 2N).

Geography

No study reviewed reported on the impact of geographical differences within the research paper.

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Research Instruments for Assessing Impact

There was a range of assessment methods and instruments used to assess the impact of the education outside of the classroom interventions. Many used a pre and post-test when assessing learning outcomes or interest in a particular subject area (cognitive outcomes). These included either close ended question, open ended questions or multiple-choice options. When assessing for affective learning outcomes qualitative methods were more readily employed to get a rich understanding of what it was that the participants enjoyed about the experience. No study focused on the psychomotor impacts of the interventions. The following section outlines the research methods used across the European, USA and Chinese studies. Any research instruments included in the papers are included in Appendix 3.

Qualitative Assessment Methods

The qualitative methods that were used included:

- **semi-structured interviews** with the participants (Chen and Cowie, 2013; Giamellaro, 2014; Chou *et al.*, 2015; Çelik and Tekbıyık, 2016; Horn *et al.*, 2016; Adams and Beauchamp, 2018; Puttick and Tucker-Raymond, 2018; Alonso *et al.*, 2019; Harris and Bilton, 2019; Aghaei *et al.*, 2020; Orson, McGovern and Larson, 2020; Kanlı and Yavaş, 2021; Lo, Lai and Hsu, 2021; Shah *et al.*, 2021; Bhattacharya, Carroll Steward and Forbes, 2021),

- **Observations** (Chen and Cowie, 2013; Chou *et al.*, 2015; Harris and Bilton, 2019; Aghaei *et al.*, 2020; ARIOSTO *et al.*, 2021; Lo, Lai and Hsu, 2021),

- **Focus groups** (Bamberger, 2014; Dettweiler *et al.*, 2017; Moorhouse, tom Dieck and Jung, 2019)

- **Filming the activities** (Chen and Cowie, 2013; Adams and Beauchamp, 2018),

- **Reflective diaries** (Dunlop, Clarke and McKelvey-Martin, 2019).

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Quantitative Assessment Methods

The quantitative methods that were employed (although some used open ended questions) were:

- the **design and creation of a specific questionnaires** with both Likert scale questions and open ended questions (Bamberger, 2014; Affeldt *et al.*, 2015; Beyer *et al.*, 2015; Chou *et al.*, 2015; Frappart and Frède, 2016; Hsu *et al.*, 2016, 2018; Hsu and Liang, 2017; Thuneberg, Salmi and Fenyvesi, 2017; Dettweiler *et al.*, 2017; Huang, Cen and Hsu, 2019; Todd and Zvoch, 2019; Chiovitti *et al.*, 2019; Dunlop, Clarke and McKelvey-Martin, 2019; Eren-Sisman and Koseoglu, 2019; Stöckert and Bogner, 2020; ARIOSTO *et al.*, 2021; Lo, Lai and Hsu, 2021; Baierl, Johnson and Bogner, 2021),
- **Assessments or tests/exams** on the knowledge acquired for the specific subject (Chen and Cowie, 2013; Giamellaro, 2014; Levine *et al.*, 2015; Riegel and Kindermann, 2016; Chen and Chen, 2018; Puttick and Tucker-Raymond, 2018; Todd and Zvoch, 2019; Kermish-Allen, Peterman and Bevc, 2019; Roth and Reynolds, 2020; Stöckert and Bogner, 2020; Petersen *et al.*, 2020; Bhattacharya, Carroll Steward and Forbes, 2021; Schneiderhan-Opel and Bogner, 2021; Kanlı and Yavaş, 2021; Margolin *et al.*, 2021; Meyerhöffer and Dreesmann, 2021),
- **Quantitative ethnography** (Shah *et al.*, 2021),
- **A word association method task** (write down three words that spontaneously came to mind – they could then elaborate on these) (Dettweiler *et al.*, 2017),
- **Interactive Quizzes** (Ying *et al.*, 2019)
- **Tracking different frequencies of online interactions** (Kermish-Allen, Peterman and Bevc, 2019).

Some studies did use validated scales (reference are for the papers that used these scales, not the scale reference). Those that were included were:

- **The Environment Questionnaire and the New Environmental Paradigm scale** (Baierl, Johnson and Bogner, 2021),
- **Scientific process skills test** (Çelik and Tekbıyık, 2016),
- **ARCS instructional materials motivational scale** (Chen and Chen, 2018),

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- **Intrinsic value and self-regulation in the Motivated Strategies for Learning Questionnaire (MSLQ) and the Immersive Experience Questionnaire (IEQ)** (Cheng and Tsai, 2020),

- **Trends in International Mathematics and Science Standards** (Cotič *et al.*, 2020),

- **Views of nature of science questionnaire** (Eren-Sisman and Koseoglu, 2019),

- **The Deci-Ryan Motivation test** (Salmi, Thuneberg and Vainikainen, 2017; Thuneberg, Salmi and Fenyvesi, 2017; Salmi, Thuneberg and Bogner, 2020)

- **The Raven test** (Salmi, Thuneberg and Vainikainen, 2017; Thuneberg, Salmi and Fenyvesi, 2017; Salmi, Thuneberg and Bogner, 2020).

These papers also reported the validity and reliability of the scales that they employed.

There were two novel assessment methods used also. One was a study that assessed the family food shopping receipt data to see if their food choices changed after the students were involved in the school garden curriculum (Fisher-Maltese, Fisher and Ray, 2018). Three other studies used drawing based assessments. In one study, students were asked to draw themselves learning. These were designed to see what the children felt about the subject they were learning (Harris and Bilton, 2019). Another used a 'draw an environment' test (Jose, Patrick and Moseley, 2017). Finally, one study used annotated drawings (Kärkkäinen *et al.*, 2017).

The various papers used a plethora of various assessment methods to understand the impact of the EOC interventions. The assessment methods were based on their aims. Many studies wanted to see if they could increase the knowledge gained using a variety of pedagogies approaches, therefore they utilised the assessment-based tests most frequently. In addition to the tests, many studies were interested not only in the academic outcomes, but also in participants enjoyment. Therefore, in many studies, the feedback questionnaires the researchers created were used in tandem with academic achievement tests. Furthermore, some studies assessed only if the students appreciated and enjoyed the experience and therefore these were assessed mostly using the qualitative methods of focus groups, observations, and interviews. The studies that utilised the validated measures were very specific in their aims and therefore were able to find and use the scales listed to assess for specific elements, such as motivation to engage with the science museum exhibits and values-based components.

Therefore, it is important for future research to be clear on what they are assessing when they are gathering data on EOC. If the focus is on formal learning outcomes, then assessment based pre and post tests would be most effective to assess these. The studies here used these as paper and pencil

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tests on content knowledge or as online tests. This gives a quantitative fixed value of factual learning that can be student centred. Each child can have a pre and post learning test score that shows whether the activity increased their understanding of the particular topic.

Studies that were more interested in increasing motivation or interested in a subject adopted research approaches that explored the experience of the individual – often times qualitative approaches as listed above. The difficulty with this method is the smaller sample size and the large volume of data qualitative methods produces. Therefore, the student feedback questionnaires that have been created in relation to the specific activity is a robust way to further the understanding of the experience for the students, without creating large volumes of interview transcript data.

Effective Practices, Challenges and Difficulties

All of the reviewed papers reported their specific intervention or pedagogy as a useful tool to be implemented into classrooms. Many highlighted how the techniques they implemented can be used with any subject (Chou *et al.*, 2015; Horn *et al.*, 2016; Hsu *et al.*, 2016, 2018; Chen and Chen, 2017; Cheng and Tsai, 2020; Cotič *et al.*, 2020). It is important to note that this may be a result of publication bias as the research that was reviewed showed mainly positive results of the interventions.

A particular piece of good practice that emerged from many of the papers reviewed was the use of in class learning prior to engagement in the outside of the classroom activity (for example, Salmi, Thuneberg and Vainikainen, 2017; Lo, Lai and Hsu, 2021). This appeared to prepare both teachers and students for the outdoor experience and allowed them to build on their learning. Many of the studies did not complete this and therefore the participants had to engage with novel information while engaging in EOC. Therefore, there should be a time prior to EOC that students are allowed to gain a basic understanding of the area, location, science exhibit, museum exhibit, so that they are familiar with the area of study. Providing teacher development, to enable teachers to effectively lead the pre and post learning was noted. Teachers could also be supported to lead the onsite visits, reducing the reliance on an external 'expert' and perhaps supporting the sustainability of EOC practices.

Some difficulties and challenges emerged across the reviewed articles. Some studies found that some of the lower academically achieving children struggled to engage and required extra support with their learning (Affeldt *et al.*, 2015). One study reported that it was raining on the day they brought the students to the outdoor activity, which was a challenge, however the students still enjoyed the activity (ARIOSTO *et al.*, 2021). EOC involving the use of technology are at the mercy of the hardware, internet network and the programme working as it should, which does not always happen (Chen and Chen, 2018). As is mentioned elsewhere, one study highlights how the outdoor activity was limited as there was no link to the formal education. Studies reported the importance of having both pre planning

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and post visits/reflections to solidify learning. Without this, some students may not value the experience as a learning activity and the knowledge gained may fade quickly. Some authors reported that there needs to be cooperation with informal educators to develop pre and post activities that relate directly to the classroom learning to enhance the field experiences (Jose, Patrick and Moseley, 2017). This is echoed by researchers in Turkey (Kanlı and Yavaş, 2021).

A study reported that they did not have enough tablet computers for the students which limited their learning (Cotič *et al.*, 2020). While another study highlighted how the researchers could not complete follow up surveys to assess longer term learning due to the school holidays, which indicates that the timing of interventions and data collection is an important point to consider (Dettweiler *et al.*, 2017). One study highlighted that some educational materials were too difficult for the age group (theory of gravity). Therefore, it is important to ensure that the age group and the material being taught are congruent (Frappart and Frède, 2016). An interesting reflection on the use of technology in museums reported that the activities may make learning more complex, which increases the cognitive load. This may impact on the level of learning, especially for novice learners (Hsu *et al.*, 2016). Younger learners may struggle with system problems when using technology and may require a lot of support from the teacher. This can take valuable time away from the learning experience and also decrease the student's enjoyment and motivation (Hsu *et al.*, 2018). Student's level of digital literacy was a further challenge. This needs to be assessed and supported when utilising technology as a learning tool (Lo, Lai and Hsu, 2021).

The academic gains reported in one particular study was limited due to the lack of opportunities for guided learning. This study engaged the students in hands on learning, however, without guidance from a 'more experienced other', the learning opportunities may be lost (Harris and Bilton, 2019). One study supported teachers and provided specific training to teachers to support them to guide students learning during EOC activities. The study viewed this as integral to the students experience and their learning outcomes (Kermish-Allen, Peterman and Bevc, 2019). An overall limitation reported by many studies was the lack of generalizability of the results due to the small sample sizes and lack of replication.

A limitation of this systematic review could be the lack of open access papers that could guide teachers to implement these reported practices in their classroom. In addition, it appeared that the language used for 'Education Outside of the Classroom' was vast, and many studies did not include this specific language in their studies. Additionally, many researchers do not operationally define their pedagogies or describe their methods in detail which makes it difficult to fully understand the EOC practices and approaches taken by some researchers.

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Duration of Intervention

There was a broad range in the duration of the interventions. These ranged from a one-hour trip to a museum (Salmi, Thuneberg and Vainikainen, 2017), to a day trip (Kärkkäinen *et al.*, 2017; Cotič *et al.*, 2020), to a multi-day trip (Harris and Bilton, 2019; Baierl, Johnson and Bogner, 2021) to a week long summer camp (Dettweiler *et al.*, 2017). The results and outcomes cannot be compared as the different studies assessed different outcomes using different measures. All reported positive outcomes on the dependant variables they measured, and it appears that students enjoyed education outside of the classroom regardless of duration. There are many considerations when assessing duration of intervention such as the socio-economic burden for families and cost implications for longer interventions.

Gaps in the Literature

The lack of reporting on the sociodemographic information was an interesting gap in the literature. Some papers did report this, however they reported that either all the students came from a disadvantaged background and received extra funding to engage with the intervention (such as the summer camps, residential camps, and programmes to support girls' engagement with science) or they reported that all the students came from affluent backgrounds. The papers using virtual reality from China do report that these interventions are useful when schools cannot afford to take classes outside of the classroom and reported how students can access this learning in school. It would be interesting for future research to explore how accessible outdoor education is for a variety of groups and schools. Location of the school would be an important factor as many urban areas may have access to museums, but not outdoor spaces. While the inverse can be said for rural schools who may have access to parks and coastal regions but access to museum in a city may be more difficult. Furthermore, class size may have an impact on the accessibility of taking students out of school to engage in EOC, which may also intersect with socioeconomic demographics. No study reported on how these trips were funded, which would be an interesting factor to consider. Many classes may have a student population with mixed access to extra funds for such activities. Therefore, it would be interesting to know if funding is available for disadvantaged students or if the excursions are self-funded. This information could then be linked with 'take up' of these activities to see if students with the economic capital are accessing these experiences more often than their peers with less available funds.

Many of the studies also note that one limitation is the lack of longitudinal data. Some studies did assess the participants at a six month follow up, however there was a lack of long-term longitudinal data to see if the longer-term implications of EOC practices. Therefore, future research could further this area of study by completing longitudinal studies to follow the participants and see if EOC impacts on student's educational choices and achievement further down their educational path. This was particularly evident in the camps and programmes for girls whose aim was to increase their interest in science subjects and hopefully lead them towards a STEM career.

It appears that although EOC is an experience that participants across age groups reportedly enjoy and benefit from, teachers should also be educated on the topics that the students are learning to ensure that they can support with student learning and integrate this back into the curriculum. One study reported that some teachers struggle to teach students about climate change as they did not receive training on this topic. They understand the importance of it but lack confidence to support students learning in this regard. As this study was the only one to report this, it may be that the sample of teachers in the study felt this way, but this cannot be generalised further (Porter, Weaver and Raptis, 2012). However, assessing the teacher's knowledge of the educational experience should also be considered when engaging in education outside of the classroom for future studies.

Conclusions from European and International Systematic Review

A range of pedagogical models were employed across the research papers. Kolb's Experiential Learning Cycle (1984) was the most used individual pedagogical model underpinning the reviewed papers. Given the emphasis on pre and post learning in EOC practices, this is understandable. Inquiry-Based Learning, that scaffold students through the phases of inquiry, were also evident, albeit conceptualized in practice in differing ways. Technology was often used as a supportive aid, to guide students learning while engaging in EOC. Contextualized Learning was commonly recognized within museum learning, where learners are diverse, and learning is situated within a free-choice context.

While there were a diverse range of pedagogical models identified across the reviewed papers, the varied approaches shared some commonalities. Students did not just passively listen to talks while engaging in EOC, rather students engaged in activities that were student-centred, collaborative, fun and engaging. EOC learning was linked to classroom and curriculum-based learning through pre and post classroom learning. Bringing resources or data that was gathered in the field, back to the classroom, supported students to continue their learning after the EOC experience. Many of the EOC sites supported students to be outdoors and in nature, consisting of forests, parks, deserts, beaches or mountains.

In general, the reviewed studies reported a positive impact on students learning and understanding within the specific subject area (cognitive outcomes), as well as a positive impact on students' attitudes, motivation, and enjoyment (affective outcomes). Psychomotor outcomes were not considered in any paper. Some studies paid particular attention to supporting students with differing levels of ability through, for example, the development and provision of guided and scaffolded resources.

The majority of the research did not control or assess for effects of gender, or differences within genders in their samples. This is an oversight as it can be seen from the research that there are stereotypes regarding girls and boys and the subjects they prefer and gravitate towards. Future research should ensure to assess for gender differences and report them even when there is no difference found. Interestingly, studies from the USA appear to focus more on giving girls opportunities to explore STEM subjects to ensure girls are aware of the options career paths available to them. Europe had the most studies that assessed for and reported on gender differences, with only one study from China reportedly checking for this within their reported results.

There was a large range in the duration of the interventions, with some lasting one day, to others lasting a number of weeks.

There was a range of assessment methods and instruments used to assess the impact of the EOC interventions. Many used a pre and post-test when assessing learning outcomes or interest in a particular subject area. These included either close ended question, open ended questions or multiple-choice options. When assessing for affective learning outcomes qualitative methods were more readily employed to get a rich understanding of what it was that the participants enjoyed about the experience. No study focused on the psychomotor impacts of the interventions. The most common qualitative methods were semi-structured interviews with the participants and observations. The quantitative methods that were employed (although some used open ended questions) were the creation of a specific questionnaires with both Likert scale questions and open-ended questions and assessments or tests/exams on the knowledge acquired for the specific subject. Some studies did use validated scales, which are referenced above.

There are a multitude of barriers to consider that range from failing technology, access to locations and socioeconomic disadvantage. It appears also that without pre and post activities that link the EOC activities to in-class learning, much of the learning may either not occur in the first instance or be quickly lost. Teacher development, that supports teachers to engage in pre and post activities, as well as EOC onsite practices, was deemed important.

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Part 2 – Partner Country Literature Review

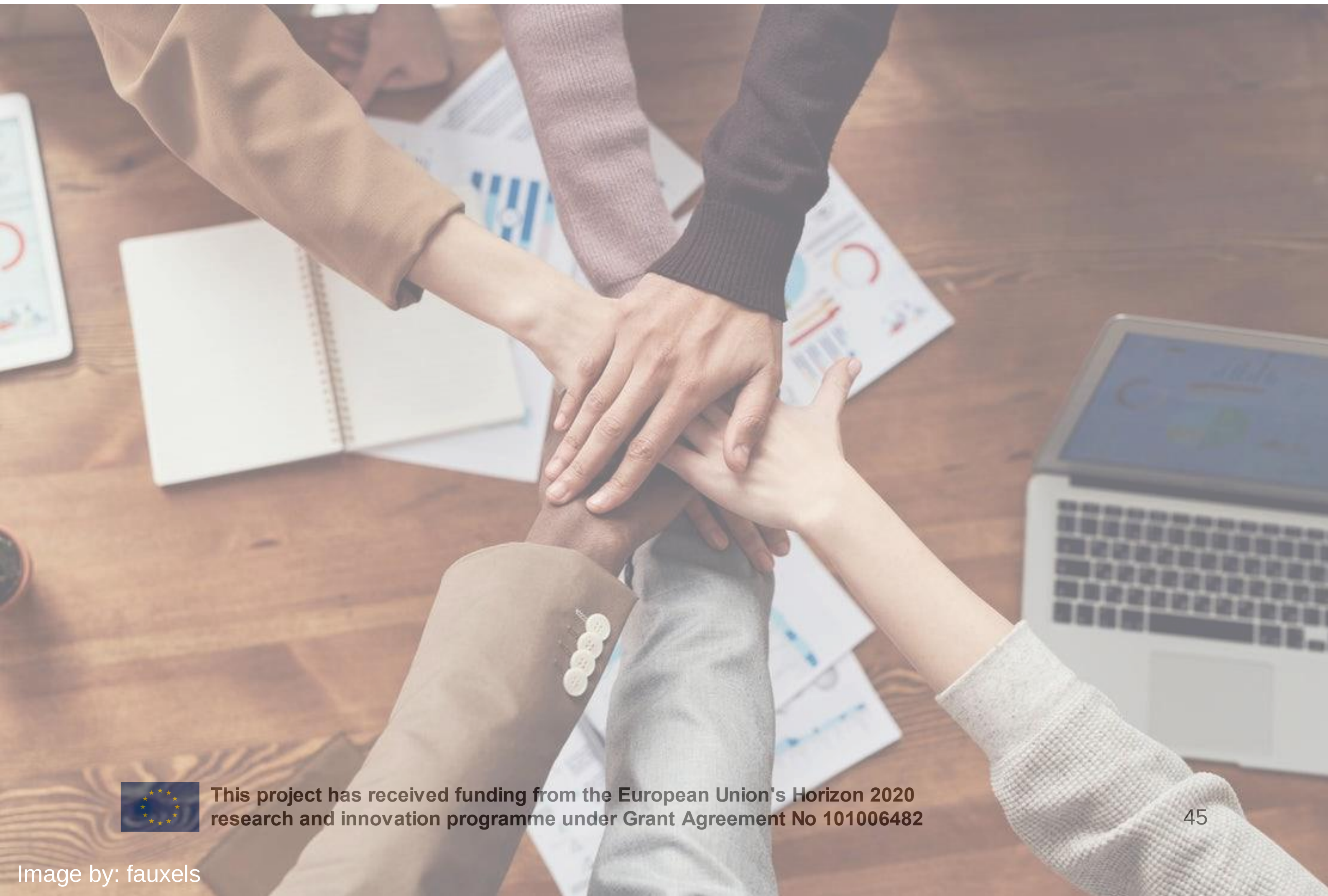

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Image by: fauxels

Introduction

It was noted the context of partner countries was necessary to consider when reviewing the literature in order to capture a particular nuances that could inform practices within the OTTER design phase. With this in mind, a country-specific literature review was conducted in contributing countries. This part of the report outlines key findings from the seven participating countries in the OTTER project consortium: Finland, France, Hungary, Ireland, Spain & The Netherlands.

Each country was guided to collect relevant documents and literature under two main categories: research articles and grey literature. The inclusion criteria set out for the research articles requested: peer-reviewed articles (where possible), educational research & science education research focus within the last 10 years (01-01-2012- date of search), empirical, explores education outside the classroom practices (as per relevant search terms suitable to the country's context), focused on students aged 6-18yrs, is predominantly based in the partner country, may be in the native country's language. The inclusion criteria set out for grey literature included: unpublished or non-commercially published material such as government reports, policy statements, issues papers, project reports by organisations, within the last 10 years (01-01-2012- date of search), educational & science education focus, explores education outside the classroom practices (as per relevant search terms suitable to the country's context), focused on students aged 6-18yrs, is predominantly based in the partner country, may be in the native country's language.

Each partner country reviewed papers and analysed their final papers according to relevant fields of analysis and reported on their findings according to the following headings,

- Some General Findings
- Pedagogical Models/Approaches
- Research Instruments
- Impacts/Outcomes
- Differences in Impact/Outcome
- Effective Practices, Challenges and Difficulties

Part two of this report highlights the result of each partner country's review.

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Finland

Methodology

Search Terms

Finnish search terms, such as 'luonto-opetus' (nature education), 'ulkoilmaopetus' (outdoor education), 'ulkona oppiminen' (learning outdoors), 'tiedekasvatus' (science education), 'projektioppiminen' (project-based learning), 'kestävä kehitys' and 'kasvatus' (sustainable development and education) and 'informaali oppiminen' (informal learning) were used to find prominent peer reviewed articles and grey material. This appeared to be efficient search strategy for grey material since grey material was found using these Finnish search terms.

On the contrary, it was difficult to discover relevant peer reviewed articles in Finnish using Finnish search terms. The material found were research articles that were not published in peer reviewed publications or were doctoral dissertations, master thesis etc. English search terms like experiential learning, outdoor education, outdoor learning and science education were applied to find significant articles published by Finnish researchers in English.

Finland has two official languages: Finnish and Swedish. The Swedish speaking population is about 5% and thus there is much less research published in Swedish than in Finnish. We also used Swedish search terms to find relevant peer reviewed articles and grey material in Swedish. For some reason, it was not possible to find prominent material for our purpose. The research articles we found in Swedish were a little bit out of the scope (e.g., studying teachers' perceptions about out of school science education) and the grey material was rather ambiguous and not well organized. They were not included in the final material.

Search Engines

The search engines used in the search for relevant peer reviewed articles: ERIC (Institute of Education Sciences) https://eric.ed.gov/, Tampere University Library, Andor search service https://www.tuni.fi/en/library, Finna (Finnish cultural and science resources) https://www.finna.fi and ResearchGate https://www.researchgate.net/. In addition, we also used Google to find relevant peer reviewed material.

For grey material the most used search engine was Google. Furthermore, we found useful links from the webpages of several environmental organizations: for example, FEE Suomi https://feesuomi.fi/, LYKE verkosto https://www.luontokoulut.fi/?lang=en, and LUMA Centre Finland https://www.luma.fi/en/.

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Results

At first, there were a bigger pool of articles that met some of the inclusion criteria. Articles that didn't meet the age limit (e.g., children under school age), time frame (e.g., there were older research available that were excluded from this review), and the focus was not on pedagogical models (e.g., articles studying teachers' conceptions of EOC) were excluded.

Initially, under ten peer reviewed documents and about twenty grey materials that met all inclusion criteria were identified. Articles that seemed to provide most relevant material for the OTTER project, were explained in more detail, and also had different pedagogical models were selected. Articles with somehow clear pedagogical model were included, whereas articles concentrating on general EOC description were excluded. In addition, articles with as many different pedagogical models as possible: for example, there were several articles dealing with science camps, and the ones with the most detailed description of the pedagogical model were included.

The grey material found was mostly a collection of different pedagogical models and practices created and implemented by Finnish teachers. However, different type of publications: a government report, a guide for teachers and educators, a report of a teaching experiment, and a manual for EOC workshops were selected as the most appropriate. When there were several very similar types of grey material documents found, the most comprehensive and / or detailed was selected.

There are five peer reviewed articles and five grey materials included in final review.

Key findings

Some General Findings

The main conclusion across all material was that EOC practices and outdoor learning were considered to be both effective and enjoyable for the students. The EOC practices and learning outdoors increased motivation, resulted in deeper learning, and opened new perspectives for students. The possibility for actually doing things and exploring yourself was considered to be very meaningful for the students.

Some research highlighted the importance of careful prior planning. However, there is no "one model fits all" option. Every school and class need to be able to shape and modify the pedagogical model that serves them the best. For the OTTER project the pedagogical model used should be well planned and yet allow some modifications according to the needs of different groups.

One **challenge** encountered in the articles was using understandable language in the questionnaires. This is something to be considered in the OTTER project as well.

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Most common **subject area** mentioned in the peer reviewed articles was science in general (Halonen & Aksela, 2018; Nuora & Välisaari, 2018) or everyday science (Salmi & Thuneberg, 2019). Many articles didn't specify subject area they were focused on but were rather concentrated on the pedagogical model used to learning science. For grey material the subject areas mentioned were: multidisciplinary study on snow (Palviainen, Pesonen & Selenius, 2021), sustainable development (Mellanen, 2021), science education (Suomi, 2020), teaching outdoors (Laine, Elonheimo & Kettunen, 2018), and nature connection and outdoor activities (Hasanen & Vähäsarja, 2019).

For peer reviewed articles the most common **age cohort** was 10–13 years and for grey material the age cohort was wide: from 3 to 25 years.

Pedagogical Models/Approaches

Some research underlined the priority for students' own involvement and participation in designing the activities. Many traditional approaches needed to be discarded to allow true participation and co-creation, and to support young people as active agents. In the OTTER project the pedagogical model created needs to allow students involvement and co-creation.

The **main approach to EOC** was learning outdoors in nature (Nuora & Välisaari, 2018; Sjöblom & Svens, 2019). Other approaches mentioned were science camps, science exhibition, and maker culture. The main approach to EOC was outdoor learning ((Laine, Elonheimo & Kettunen, 2018; Hasanen & Vähäsarja, 2019; Palviainen, Pesonen & Selenius, 2021). In addition, workshop was main approach in one of the grey material (Mellanen, 2021).

The most common **pedagogical models** used or suggested in the material were project-based learning/inquiry-based learning (Laine, Elonheimo & Kettunen, 2018; Nuora & Välisaari, 2018; Salmi & Thuneberg, 2019; Suomi, 2020; Mellanen, 2021; Palviainen, Pesonen & Selenius, 2021), and learning by doing/experiential learning (Halonen & Aksela, 2018; Laine, Elonheimo & Kettunen, 2018; Salmi & Thuneberg, 2019; Sjöblom & Svens, 2019; Vuopala, et, al., 2020). There are two examples of pedagogical models in the appendices: Appendix 4a. An example of a pedagogical model: real-world learning model, and Appendix 4b. 20 steps to the Outdoor Classroom.

Research Instruments

The most common **research instruments** were questionnaires (Halonen & Aksela, 2018; Hasanen & Vähäsarja, 2019; Nuora & Välisaari, 2018) and interviews (Halonen & Aksela, 2018; Hasanen & Vähäsarja, 2019; Sjöblom & Svens, 2019). One study also used different type of tests (Salmi & Thuneberg, 2019). There were only two studied material that included the used research instrument as a resource. One was 'Moved by Nature – School-children's experiences of outdoor activities in nature' (Hasanen & Vähäsarja, 2019) that provided the used questionnaire. However, this survey concentrated on students' physical activity and relationship with nature. The other article that provided the used instrument was 'Implementing a maker culture in elementary school – students' perspectives' (Vuopala, et, al., 2020). The used questionnaire was rather simple using smiley faces and focusing on students' self-assessment about their learning and group processes. In this material there was no suitable research instrument presented for the OTTER project.

Because the articles were conducted in very different research settings, the comments about **reliability** vary. One research reported that the reliability may be weakened by the interviewee's tendency to provide socially desirable answers (Nuora & Välisaari, 2018). In some of the research the reliability was enhanced by using two researchers analyzing the data independently (Halonen & Aksela, 2018; Nuora & Välisaari, 2018). In one of the studies (Salmi & Thuneberg, 2019) the reliability was ensured by using different tests to measure the same variables or using the same test in two phases. On **validity** there was no unanimous approach in the material, but the comments differed. In one of the studies the internal validity of the research has been increased with triangulation of the methods. The material for this study was collected with both questionnaires in two years and with theme interviews (Halonen & Aksela, 2018). In another study the validity was enhanced by using acknowledged tests to examine the variables in question (Salmi & Thuneberg, 2019).

Outcomes/ Impacts

The **cognitive impacts** reported in the research were for example learning more about natural science (Salmi & Thuneberg, 2019; Palviainen, Pesonen & Selenius, 2021) and the topics under study (Nuora & Välisaari, 2018; Sjöblom & Svens, 2019), thinking skills (holistic and systems thinking) (Mellanen, 2021), understanding scientific research process (Palviainen, Pesonen & Selenius, 2021), and practical skills (e.g., programming, using the compass etc.) (Hasanen & Vähäsarja, 2019; Vuopala, et, al., 2020). The **affective impacts** included increased motivation towards science education (Halonen & Aksela, 2018; Palviainen, Pesonen & Selenius, 2021; Salmi & Thuneberg, 2019), willingness to make an impact through one's own actions (Mellanen, 2021), respectful attitude towards nature and sustainability (Sjöblom & Svens, 2019), feeling of togetherness and closer relationship with classmates (Hasanen & Vähäsarja, 2019; Nuora & Välisaari, 2018) etc. Very few materials reported any impact on **psycho-motor development** but learning new forms of physical activities were mentioned (Hasanen & Vähäsarja, 2019; Sjöblom & Svens, 2019).

Differences in Impact/Outcome

Only a couple of articles (Halonen & Aksela, 2018; Salmi & Thuneberg, 2019) mentioned any **differences between genders**, and the differences were not significant. None of the materials reported any **geographical differences**.

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Conclusions

The Finnish National Core Curriculum for Basic Education underlines the multi-disciplinary and holistic approach for studying real-life phenomena. The same approach was considered to be very fruitful also in the reviewed literature. In addition, the national core curriculum highlights learning by doing, collaborative learning, project-based learning and phenomenon-based learning, and all these ideas can be put into practice in the context of outdoor learning.

Furthermore, the true participation and involvement of students should be the ultimate goal in all education. This can be achieved by gradually strengthening the skills needed for self-directed and co-operative learning and increasing the student's role as active agents as they gain the needed skills.

In the OTTER project the pedagogical model created should allow collaborative learning and learning by doing. In addition, it should provide opportunity to study real-life phenomena, and be based on multidisciplinary approach. Moreover, it should be founded on students' involvement and co-creation.

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France

The final report provided by the European Science Foundation concerning good practices in science education in France includes mainly the findings of 5 peer-reviewed articles and 5 papers from grey material.

Methodology

According to Otter methodological design, it was decided to use significant terms related to science education. To facilitate the literature search, several concepts were used in French language, such as:

- éducation scientifique (science education)
- éducation en dehors de la classe (education outside the classroom)
- pédagogie par la nature (nature-based pedagogy)
- éducation à l'environement (environmental education)
- éducation au dévelopement durable (education for sustainable development)
- école-fôret (forest-school)
- activités tri des déchets (waste removal activities)
- pédagogies alternatives (alternative pedagogies)
- éducation à la biodiversité (biodiversity education)
- pédagogie muséale (museum pedagogy), etc.

These terms were included related to science education and to different aspects of this type of activity (activities outside, creative, and innovative activities, museum activities, forest activities, Fab Lab initiatives, environmental actions). For the purposes of this research, several search engines well-known in France were used, for instance: Open Archive Hal https://hal.archives-ouvertes.fr/, Cairn Reviews and Books in Humanities and Social Sciences https://www.cairn.info/, Persée Scientific publications https://www.persee.fr/, Research Gate https://www.researchgate.net/, Google Scholar https://scholar.google.com/.

The search was efficient and useful, giving access to relevant papers with available open access. All in all, almost 40 papers from both scientific reviews and grey material were identified. It was noted that, on the one hand, scientific articles are predominantly theoretical and focused mainly on the debate concerning the science education and the alternative pedagogies. On the other hand, grey material is mostly organised as brochures, leaflets, and less structured as articles. In this regard, articles that were less well organised or articles out of the scope (for instance articles with a too high theoretical-orientated approach) were excluded. The same criteria were used for the academic papers and the grey material. Thus, in the final review were selected articles which present innovative aspects on activities outside the classroom and good practices in science education in France.

Key findings

Some General Findings

When analysing the findings of the papers selected, it was revealed that the most common subject areas were environmental education and education for sustainable development. Briefly, this debate-based approach focusses on the historical approach of education in France. Thus, issues related to environmental education, science education and alternative pedagogies remain still very theoretical and linked to the political measures aiming to educate a “good citizen” able to act according to the own freedoms and the values of French Republic.

However, the main approach to education outside the classroom is related to field trips, activities in the forest, nature pedagogy and teachers training. As for the age cohort, most activities were oriented towards kindergarten and primary school, but also secondary and high schools. As already mentioned, most of the academic research in the field of science education also pays significant attention to the training of teachers for preparing them properly on how to organize and realize an educational activity outside the classroom.

Pedagogical Models/Approaches

A variety of pedagogical approaches based on qualitative and quantitative methods and ground experience seems to be used when organising science education activities with students and future teachers in France. The most applicable were:

Evidence-based intervention related to a police investigation when students are involved in waste removal on the French beaches. The approach increases the motivation and engagement of students, emphasising the playful, enjoyable, and ludic nature of this “laboratory activity”. The impact on students is not only cognitive (they acquire new knowledge on macro-waste from the coastline) but also affective and psychomotor (respect for the environment, attachment, and actions to preserve the nature) (e.g., Surfrider Foundation Europe, 2021).

Research-driven pedagogy aiming at improving the results on science education and increasing the attractiveness of research careers. Students are familiarized with the scientific investigation,

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formulation of research problem and hypothesis, elaboration of research protocol and experimentation. The impact on students is three-fold: development of language skills, self-esteem, capacity of collaboration and listening skills, problem-solving, motivation, curiosity for science careers (Franc, Reynaud & Hasni, 2013).

Collaborative experimental design helping students to acquire new scientific, affective, and social skills and to get familiarized with innovative methods. This approach supports them to better understand and choose scientific disciplines by writing research protocol, creating scientific mapping, drawing and disseminating conclusions, identifying and controlling emotions, collaborating with peers, or developing imagination and critical thinking (Lange, 2011).

Learning by doing correlated with learning by moving and learning by manipulating which increase the well-being of the students thanks to the benefits of the outside activities. The lack of activities in the nature could be associated with depression, obesity, fear of nature and sedentarism, or other physical and mental illnesses, developing the nature-deficit syndrome. Outside activities become a matter of public health, helping children to develop positive emotions or teamworking, and to avoid screen-dependance, impulsivity, aggressivity, attention and sleep troubles (e.g., Nicolas, 2021).

Inquiry-oriented learning and learning by games for supporting students in their educational activities, offering them a strong opportunity to explore and become autonomous. Though games in nature, students develop imagination, creativity, freedom, risk-taking, etc. Forest bathing also supports the learning by games and through own discovery. Thus, a better learning is associated to discovering and moving in the nature (Simonneaux et al., 2017).

Collective acting and empowerment, by which students learn to act together when it comes to science education issues. It means that they develop the sense of empowerment and engagement, the agency, as an ability of acting depending on values, reflexivity, and responsibility, and the self-efficacy belief according to their physiological and emotional state. The personal empowerment is thus linked to the collective sense of acting when students are sharing the same freedoms to act for sustainable development (Morin, Therriault & Bader, 2019).

Investigation and exploration highlight that nature education has huge benefits for students, in the sense of the pedagogy of astonishment. Students can thus discover educational activities using “natural tools”: birds, insects, sheets, woods. When students are astonished by the learning content and the educational methods helping to present the content, they are likely to be more motivated and ready to get involved and to grow up safely. (e.g. Rochebois, 2018).

Participatory lifelong learning emphasizes that contents and knowledge are better understood and applied in daily life when they are taught in the nature. Students learn easier and deeper when the

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activity is organized outside, and they have the freedom to choose activities or to propose their own activities. Outside activities prevent major risks of isolation and develop solidarity, and provide some huge benefits in terms of resilience, wellbeing, intergenerational solidarity, confidence throughout life and the holistic approach in science education (e.g. Réseau École et Nature, 2013 ; Constitutional Council, 2005).

All approaches and models are pertinent, but the learning by doing and the inquiry-orientated learning seems potentially more effective given that students are directly engaged in practical activities. No further details on implementing EOC activities were available.

Research Instruments

Assessing impacts of science education remains a topic to be explored by the scientific community, the biggest challenge being how to assess affective dimension. Despite this difficulty, some assessment instruments, both qualitative and quantitative, were decrypted:

- **Questionnaire and survey** to familiarize students with research approach on education (e.g., Rochebois, 2018; Franc, Reynaud, & Hasni, 2013).
- **Interviews and scientific portfolio** to help students for synthesizing and restitution of the findings (e.g., Lange, ,2011).
- **Content analysis, essays and scientific writings** supporting to learn some major intellectual skills: questioning, doing research on a topic, formulating and testing hypothesis (Meirieu & Wagnon, 2011).
- **Participatory exchange** promoting reflection and increasing the knowledge related to issues addressed by science education (e.g., Nicolas, 2021).
- **Self-assessing or peer-assessing** over different steps of activities, for example distribution of the waste, quantity of garbage and types of waste collected (e.g., Surfrider Foundation Europe, 2021).

All research instruments presented are valid and reliable, helping to assess the impact of learning activities in science education. To assess properly the learning outcomes, it is highly recommended to use predominantly qualitative methods, completed by quantitative methods. Taking the example of affective dimension in science education, its impact is minimalized for ensuring scientific objectivity. But survey responses and experimental protocol can shed light on the correlations between emotional maturity and knowledge and on the impact of emotions and personal convictions when learning biodiversity education. Maybe the most relevant research instrument is the participatory exchange within the learning community in a holistic and inclusive approach (as included in the appendices).

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Differences in Impact/Outcome

Within the papers selected, girls and boys were represented in the final sampling, but deep analysis in this regard is lacking. Geographical differences were not presented at all. The only remarkable difference affects both students and teachers when they are using a scientific-based approach in science education. Consequently, it will be challenging to do future research comparing the learning outcome both for students and teachers when a traditional method or an innovative method are used in science education.

Effective Practices, Challenges and Difficulties

All examples provided in this report may be considered as good practices used in France. As mentioned, benefits are tremendous for students, but also for teachers who are exploring criteria for observing and assessing students, stepping out of their comfort zone, or working together on a common project. In science education, teachers act mainly as mediator between the children on the one hand and the forest, the nature, the experiences, and the knowledge, on the other hand. Some good practices showed that research-based approach in science education implies a practical dimension, where children are directly involved. This method helps students to experiment either emotional attachment, affective distancing, or affective matching according to their knowledge on the topic taught.

Through the investigative pedagogy, students can coordinate projects for promoting unloved insects, for instance, passing from scientific citizenship into scientific and political citizenship. The most used methods to promote the involvement in science education remain the scientific investigations, debates and critical discussions, role playing, participative research projects, prospective workshops, and field surveys. When it comes to arts, museal pedagogy and the constructivism approach improve the direct contact with the works of art.

However, despite the novelty of the pedagogical approach adopted when teaching contents linked to education for sustainable development, students could experience a sense of powerfulness concerning the issues revealed. Thus, a huge challenge remains how to cope with this nature-deficit syndrome. Briefly, the concept of nature-deficit disorder was introduced in 2005 by Richard Louv as defining psychological and behavioral troubles caused by living in urban areas. In this regard, it is important to keep the balance between empowerment to act and powerfulness.

Conclusions

Based on participatory approaches, these activities supplement majestically the traditional learning. Oriented towards lifelong learning, activities outside contribute to the amelioration of the auto-discipline, emotional development, respect for natural environment, to diminish aggressions, to

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conquer the fear of nature – biophobia and to avoid solastalgia, the emotional nostalgia and distress due to the climate issues. Maybe the most important lesson from the papers is to consider science education in a lifelong learning approach.

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Hungary

Methodology

For the literature review, the following keywords were used:

- ‘környezeti nevelés’ (environmental education)
- ‘iskolán kívüli tanulás’ (out of school learning, outdoor education),
- ‘természettudományos nevelés’ (science education)
- ‘élménypedagógia’ (experiential education)
- ‘informális/nem-fomrális tanulás’ (informal/non-formal learning)
- ‘erdei iskola’ (forest pedagogy)

The following search engines were used to extract suitable material: ERIC (Institute of Education Sciences) https://eric.ed.gov/, ResearchGate https://www.researchgate.net/, Academia.edu https://www.academia.edu, MATARKA (Hungarian Periodicals Table of Contents Database) https://matarka.hu/index.php?nyelv=hun, Google and Google Scholar search engines.

Grey materials were identified mainly through the google search engine, while the peer reviewed were identified primarily using the MATARKA and Academia.edu search systems.

The English-language search terms produced limited results, so Hungarian-language literature was mostly referred to. A further difficulty was that most of the journals found on international search sites listing scientific journals were only available to subscription users. Given that it was a requirement that the studies were freely available, these results were omitted from the analysis. Several pieces of literature relevant to the project were excluded as they were outside the timeframe specified in the guidelines. In addition to the above-mentioned keywords, a STEAM keyword search was used, but this did not bring any valuable result. We searched through nearly a hundred references and selected the 5(research)-5(grey literature) documents that best met the requirements and were relevant to the project. Finally, grey material was included in the analysis, which examined teachers' views on non-formal pedagogical methods as it might be interesting to find out what teachers think about the effectiveness of these methods.

The literature was further selected with the following in mind:

i. The selection of the study was also based on finding the most well-known out-of-school programme in Hungary (forest school) that focuses on sustainability education

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ii. Present good practice that does not require significant financial resources to implement (Urban Values Programme)

iii. An innovative good practice (The Maths Connect Foundation, 2022)

Key findings

Some General Findings

The majority of the literature included in the analysis examined the effectiveness of out-of-school environmental education, including forest schools. The literature generally focused on the primary school age group (6-13 years old), but there were also studies covering the older secondary school age group (14-18 years old) (Mokrainé Orosz, 2019, Horváth, 2016, Nárai, 2021).

Research showed that extracurricular activities most often cover (natural) science topics. Technical and IT programmes are relatively rare. During these activities, presentation and guidance is a common method, while the average number of extracurricular activities per young person is 2-4 per school year (Fűz, 2017).

The out-of-classroom activities presented focused mainly on environmental education, with the most common thematic areas being:

i. exploring the interrelationship between man and nature

ii. environmental awareness and lifestyle

iii. selective waste collection - ecological footprint

iv. sustainable consumption

Pedagogical Models/Approaches

The studies mainly focused on pedagogical methods that consider the learner as an active knowledge creator. When the learner is an active knowledge creator, the new knowledge or attitude is built into the learner' cognitive construct like a new brick into the house. If the new knowledge fits in properly, it will be preserved without difficulty, and the new experience will fit into this element in the future. We are not only talking about the acquisition of current knowledge and attitudes but also about the ability to incorporate future ones. It is the teachers' responsibility to construct new knowledge and attitudes in the pupils' personality structures in a way that they fit in properly. Environmental education should aim to develop students' relationships with their environment within this cognitive construct. Research in environmental psychology has shown that the individual's sense of comfort and personality development (also) depends on his or her knowledge of the environment. In simple terms, the "know-like" principle applies (Rigóczki, 2018).

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The most common pedagogical approaches were experiential learning, project-based learning and collaborative methods. An excellent example of project-based learning is the Forest Pedagogy project, developed in 1996, which revolutionised forest school education in Hungary, with theoretical and practical guidelines. The primary scene of the Forest Pedagogy project was nature, the forest. The Forest Pedagogy method has a practical side, as it provides a model for new cross-curricular content. On the other hand, it is research because efficiency and impact studies can demonstrate the effectiveness of the project in raising environmental awareness and it provides a practical platform for various ecological and pedagogical studies. And finally, it is a school development because learning takes place in a new environment that enriches the environmental activities of public education. The theoretical concept of the project is the "theory of harmony", which aims to develop environmentally responsible behaviour and lifestyles. The basic principle of the personal development programme is that the individual should develop a good relationship with himself and strive for physical and mental health. To become a productive member of society by cultivating a basic behavioural culture and maintaining harmonious relations with fellow human beings. The broader circle means to lead an environmentally responsible lifestyle that has the lowest negative impact on nature (see Appendix 4e). The first module focuses on the following subjects: nature, environment, geography, history, literature, physics, chemistry, art and information technology. The second module covers health, biology, physical education, technology and life skills. Finally, the third group of subjects is local history, ethics, art, folklore, dance and drama (see Appendix 4f). The process of knowledge acquisition is always based on experience, which the learner experiences independently or in groups. The process of cognition emphasises learner receptivity, reproductivity, exploration, heuristics and inquiry. (Leskó, 2017)

Another study also confirms that (environmental) education can only be truly effective if it uses action-oriented methods outside school, which involve a real-life investigation. The methods that promote self-regulated learning are all activity-based. Learners must have the opportunity to present the product they have created, which can be evaluated together to allow for correction and thus motivate them to continue to produce quality work. The methods are grouped into three categories by the author, based on the process of project implementation (Horváth, 2016):

i. Methods to enhance learners' existing knowledge and personal goals. Most commonly used in project teaching: thinking aloud, supported recall, concept map, discussion, debate, pupil presentation, role play, narration, explanation, illustration.

ii. Methods to promote creativity, exploration and autonomy in the design and implementation of the project. These methods develop students in the process of knowledge acquisition, displaying many competencies: research, investigation, observation, experiment, analysis, exploration, field research, case study, homework, impact assessment.

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iii. Lastly, assessment methods, which display the synthesis of knowledge acquired through self-regulated learning, are methods that lead to the presentation of results that can even be corrected and that requires cooperation. The common feature of these methods is that they can be carried out in pairs or groups: project method, cooperative methods, games, field trips, excursions, guided tours, organisation of events.

The Urban Values Programme (UVP) is also an out-of-school activity based on experiential learning, which combines gamification and M-learning outdoor method. During the activity, the participants walk along the path in a playful, even competitive way (experiential pedagogy), and in the process, they spontaneously construct new knowledge and attitudes. The UVP does not, of course, aim to create new interpretative frameworks (reframing) but merely at enriching and complementing existing interpretations. Participation cannot be rewarded with school marks, because the very essence of the activity is to leave the school learning environment. The programme uses gamification's components (e.g. points can be scored, ranking can be achieved). However, the competition must be considered in a differentiated way. If the game becomes too challenging, the participants will take the programme too seriously and the attitude of the players will shift from light-hearted fun to wanting to win (Rigóczki, 2018) (see Appendix 4G for detailed description).

A truly innovative and successful initiative is the Bear Maths programme of the Maths Connect Foundation (A Matematika Összeköt Egyesület). The Maths Connect Foundation organises outdoor maths competitions and camps for 10-18-year-olds and interested adults. Their aim is to promote the love of maths, and their principle is that anyone can get closer to the world of maths through exciting and enjoyable intellectual challenges - regardless of age. They aim to promote an environmentally aware lifestyle. Their events focus on promoting an active lifestyle by making use of the opportunities offered by modern technology. Attention is also paid to promoting cooperative thinking, community building and promoting the teaching profession. The Foundation is unique in that it brings together professionals who have demonstrated outstanding mathematical talent from secondary school onwards. It is also important to involve young people in the organisation. In addition to its members, the Foundation also involves hundreds of volunteers in the organisation of its events. The worksheets can be freely downloaded and used for educational purposes, thus helping teachers.

Research Instruments

The most commonly used research method was the questionnaire, in some cases combined with interviews (Leskó, 2017, Rigóczki, 2018). In three cases a control group study was used (Horváth, 2016, Leskó, 2017, Szákovicsné Bérczy – Lakotár, 2015). Information on validity and reliability was not found for all studies, which could be explained by the low number of samples. However, the researchers have attempted to use internationally validated tests adapted to Hungarian conditions

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and have tried to verify the validity of the data with various statistical tests. In two cases, the researchers reported that they conducted a pilot survey and corrected the developed research instrument on this basis (Kövecsesné, Mokrainé Orosz, 2019).

Kövecsesné used mixed methods (qualitative and quantitative methods) in her research to provide the internal validity of the research. Accordingly, questionnaires, attitude measurement, concept maps - and children's artwork - were used. In addition, the instruments developed were pre-tested by the researcher on a small sample. The Forest Education Project's effectiveness was explored through a three-part series of studies. In each of the three parts, students first created a concept map related to the forest. They then answered questions about their habits, thinking and knowledge about the environment, nature and the forest, and concluded with an attitude test.

Adrienne Réka Kopasz also used a questionnaire method. She sought to find out whether the forest school has an impact on the development of environmentally conscious behaviour - the attitude of students who recognise environmental problems and actively participate in solving them. To assess environmental attitudes, she used an international 15-item Likert scale (NEP - New Ecological Paradigm).

In her study, Nóra Fűz investigated the pedagogical use of out-of-school settings. The online questionnaire was filled in by thousands of pupils and hundreds of teachers/head teachers nationwide. It was part of a complex research project consisting of several measurement periods. The research explored students' attitudes towards school and out-of-school activities. She used an internationally published Likert scale with 23 items for the attitude measurement, the Hungarian version of which was adapted and validated by the author in a pilot study in 2014.

Impacts/Outcomes

The reviewed literature has focused on the effectiveness of extracurricular educational methods from a cognitive and affective perspective.

Reported impact concerning cognitive development: Experience has shown that extra-curricular activities have been effective in transferring knowledge. The results of the control group studies showed that the use of extra-curricular methods is more effective than the traditional classroom method. They knew the answers to more questions because they had experience-based information. They even performed better on questions for which the control group could have found the answers in the textbook (Nárai, 2021). Experiences in the field broaden and deepen what is learned in school (Szákovicsné Bérczy – Lakotár, 2015). The out of school education programmes make learning more interesting, allow for stress-free, enjoyable learning. They create situations in which children learn without being seen (Nárai, 2021). Students learned several concepts they had not previously known

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(e.g. sustainable development, ecological footprint) (Kövecsesné). In addition, the activities develop young people's vocabulary, reading comprehension skills and encourage them to think logically (Rigóczki, 2018).

Reported impact concerning affective development: The developmental impact of extracurricular education programmes is most evident in the affective area of education. The programmes have made young people more aware of their relationship with the environment (Horváth, 2016). Outdoor education has a positive impact on the students' attitudes towards nature and their behaviour towards their environment, it has made students more sensitive to nature and empowered them to act on these experiences (Kövecsesné). The following behavioural improvements can be observed in the students as a result of their participation in the forest school programme: active, participatory environmental awareness, an attitude of recognising and being sensitive to environmental problems (Kopasz, 2019). Experiential methods used in extracurricular activities also develop learners' social and interpersonal skills, making them more successful, confident, cooperative and accepting. The curriculum should highlight the residence's culture, history and other values. When it happens, it transforms learners' identities and they become more attached to their local environment (Nárai, 2021).

Not least of all, students prefer to learn outside school rather than in the classroom. This also applies if the programme is not merely for entertainment (Kopasz, 2019).

Differences in Impact/Outcome

Two studies have examined the gender difference, but we cannot draw any firm conclusions. One study found that there was no significant difference in attitude (Leskó, 2017), while the other found that girls' attitudes towards both in-school and out-of-school programmes are significantly higher than boys' attitudes (Fűz, 2017). One material reported geographical differences (Fűz, 2017). Classes from schools in cities with county status were the most likely to have an extracurricular activity, followed by classes from schools in the county's capital. Classes from city and township schools were the least likely to attend. There is a significant difference between municipal and large municipality schools and between metropolitan and large municipality schools, with large municipality classes attending extracurricular activities more often in both cases. Any material reported impact on students' psychomotor development.

Due to the low number of samples, the results are not generalisable, but we believe that the literature presented provides valuable insights into the experience of out-of-school learning methods. With one single exception, the studies described in the literature review were small, non-representative studies. In the research conducted by Nóra Fűz, the sample is representative by type of settlement, and among the regions, it is representative of schools in North Great Plain, Central Transdanubia and Western Transdanubia (based on the results of homogeneity tests).

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Effective Practices, Challenges and Difficulties

Out-of-school activities can be very diverse in terms of the educational value they add. The countries which benefit most from this teaching method are those which, recognise its potential, implement systemic school-based programmes, are supported centrally by research teams or NGOs, integrated into teaching practice and based on research findings. This awareness is still lacking in many cases in Hungary, although there is a growing number of consciously structured programmes.

Most of the literature reviewed addressed the difficulties. In many cases, extra-curricular activities are not organised because they are difficult to implement within a rigorous curriculum and because they generate costs that the school cannot finance (Fűz, 2017, Leskó, 2017). Forest schools are an excellent setting for interactive, experiential environmental education, but even if a school or class cannot go to a forest school due to lack of (financial) resources, it can and should plan effective learning activities for its students in nature, whether in a city park, in the schoolyard or on the banks of a stream near the school (Kövecses).

The proportion of traditional, face-to-face teaching is still high. Three-quarters of respondents often use frontal teaching (forcing the pupil into a passive role), despite the fact that this is considered the least effective method (Nárai, 2021). Another difficulty identified is that it is more time-consuming for teachers to use non-formal and informal methods, more difficult to supervise children, more difficult to maintain order, and more difficult to measure and monitor the knowledge acquired (Horváth, 2016).

Conclusions

The Hungarian National Core Curriculum explicitly recommends organising classroom activities other than traditional classroom-based ways, such as project teaching, forest school, museum activities. However, it requires that the delivery of the required curriculum is ensured, that the sessions are free of charge and that the regulations limiting the workload of pupils, which set the maximum number of hours per day, are respected. The new draft National Curriculum, published on 31 August 2018, devotes a specific chapter to the commitment to a sustainable present and future. The literature analysis shows that extra-curricular education has a positive impact on the development of pupils in all aspects, as well as providing a community experience for young people.

Unfortunately, even though these benefits are recognised by educators, it is still not the case that teaching outside the classroom is a widespread practice. Such programmes only take place sporadically (Fűz, 2017). The obstacles are, on the one hand, the strict curriculum (there is no specific time frame for it), the financial situation of schools (funding difficulties), and the lack of teacher motivation (it is more time-consuming for teachers to use non-formal and informal methods, and extra-curricular activities are not valued) (Fűz, 2017). Fortunately, there are a growing number of initiatives

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to change this situation. There are several methodological collections available free of charge to teachers, which can help them to implement extra-curricular education in a (cost-)effective way.

Despite its decades-long history, forest school is still a popular method of out of school education. Based on the literature reviewed, it is still a very effective method. Of course, there are innovative methods that, following digital trends, rely heavily on ICT tools. For example, the Urban Values Programme, where a virtual avatar guides students on a walk through the city or the Bear Maths' playful logic competitions, where students can compete with each other not only outdoors but also online.

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The Netherlands

This report includes a brief synthesis and some highlights of the 12 peer-reviewed articles and five grey literature materials. In addition, nine previous reviews are listed that can contribute to the OTTER tasks and deliverables (See Appendix 4K). Finally, considerations regarding the searches conducted with Dutch, English and Portuguese terms are presented.

Methodology

The systematic review was initially conducted using Dutch keywords and search terms. For this, after consulting Dutch academics at Rijksuniversiteit Groningen (RUG) and aligned with the goals of the systematic review in the OTTER context, a list of ten Dutch terms were defined:

- *Onderwijsmodellen buiten de klas*
- *Modellen voor buiten leren*
- *Modellen voor buitenonderwijs*
- *Modellen voor museum leren*
- *Modellen van excursies*
- *Modellen voor informeel leren*
- *Modellen van niet-formeel leren*
- *Lesgeven buiten de klas*
- *Milieu educatie praktijken*
- *Effecten van milieueducatie op studenten*

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The terms were used in quotation marks on the search platforms, and in the absence of results, broader searches without the use of quotation marks were proceeded with. Databases to return articles and texts of interest in the grey literature category were defined. The databases consulted are summarized in the following table.

Database name	**Considerations**
ERIC	Institute of Education Sciences. https://eric.ed.gov/
HBO Kennisbank	HBO Knowledge Bank provides access to the research publications and graduation projects of the participating universities of applied sciences and makes them available for reuse. https://www.hbo-kennisbank.nl/index
NARCIS	This database provides access to scientific information, including publications from the repositories of all the Dutch universities, KNAW, NWO and several research institutes, datasets from some data archives, and descriptions of research projects, researchers and research institutes. https://www.narcis.nl/
Pedagogische Studiën	Peer-reviewed Dutch Journal for the educational sciences with open access. https://pedagogischestudien.nl/home
Ministerie van Onderwijs, Cultuur en Wetenschap	The website where all the reports from the ministry of education are published. https://www.rijksoverheid.nl/onderwerpen/rijksoverheid/auditbeleid/rapport en-auditdienst-rijk-adr/onderwijs-cultuur-en-wetenschap
SLO	The website with materials and general information about the Dutch curriculum https://www.slo.nl/

Table 2: Databased consulted as part of partner country review (The Netherlands)

Since it is widespread for Dutch academic and technical works to be published in English, English terms were used (Dutch scientific community publishes in English since there are no national research journals on education, the few that exist are for practitioners). For this, the works were searched on ERIC and Google Scholar, primarily for providing open access studies.

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The English search terms (used within quotation marks) were: *Models of Education outside the classroom, Models of outdoor learning, Models of outdoor teaching, Models of museum learning, Models of field trips, Models of informal science learning, Models of non-formal science learning*. However, we noted that many papers were theoretical rather than empirical and did not meet all the established criteria. So, to increase the chances of finding more relevant papers, the terms *teaching outside the classroom*, *environmental education practices*, *environmental education impacts on students* were also used. Searches were also conducted in Portuguese as an attempt to cover possible publications from Portugal, Brazil, and Portuguese-speaking African countries. Since the searches also returned literature reviews, the were included in this report as well.

Key findings

Some General Findings

Few papers were found with the Dutch search terms, but all were discarded in the screening stage for different reasons. In general, the papers addressed higher education, were theoretical, or out of the OTTER context (e.g., did not cover STEM subjects or environmental education). A similar effect was observed concerning the searches conducted in Portuguese.

Considering the search criteria and using the terms in English, no papers conducted in the context of the Netherlands were found. Despite this, included here were some of the findings intending to extend the OTTER literature review. Various papers with a predominance of **US-based research** (Stern et al., 2021; Largo-Wight et al., 2018; Bergman, 2016; Tran, 2011; Ernst & Monroe, 2006; Volk & Cheak, 2003) were identified. Two papers from **Denmark** (Otte et al., 2019; Bølling et al., 2018) (but found other very similar papers from the same research group – not included in our table of results but listed in this report, e.g., Otte et al., 2019; Jørrin et al., 2020) were found. Regarding the age range studied, **10 to 12 years** was the most common, but there are papers covering students of various ages. In general, the interventions reported in the studies were short (below one year), with only one paper being conducted for five years.

Research Instruments

In general, the papers used (partially or fully) **research instruments** previously validated by another research. Among the instruments reported were the following: *Hogrefe's MG/FG test* (Otte et al., 2019)*, Academic Self-Regulation Questionnaire (SRQ-A)* (Dettweiler et al., 2015)*, EE21'* (Stern et al.,

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2021), *Attitudes towards Living Organisms Scale (ATLOS)* (Genc et al., 2018), *Environmentally Oriented Affective Trends Scale (EOATS)* (Genc et al., 2018), *Environmental Attitude Scale (EAS)* (Genc et al., 2018), *Critical Thinking Test of Environmental Education (CTTEE)* (Volk & Cheak, 2003), *Middle School Environmental Literacy Instrument (MSELI)* (Volk & Cheak, 2003), *Children's Environmental Perception Scale* (Bergman, 2016), *Cornell Critical Thinking Test* (Ernst & Monroe, 2006), and *California Measure of Mental Motivation* (Ernst & Monroe, 2006). However, the **validity** and **reliability** of the instruments were not always included or discussed, which brings additional questions to the results reported in the studies.

Impacts/Outcomes

One study in Dutch (from grey material) was of particular interest. In the *Natuurbetrokkenheid bij Jongeren in het Secundair Onderwijs – Wetenschappelijk rapport* (Heyman et al., 2021), the authors reinforce the importance of the English language for publications on the topic in Dutch since part of the work was precisely to conduct a literature review - including English terms - based on the PRISMA principles. Broadly summarised, the report sought to answer what can be learned from international best practices on improving 12-18-year-olds' engagement with nature. Among the report's findings were: (i) there is little or no mention of nature engagement as an objective in curricula; (ii) the implementation of environmental education at school depends heavily on the motivation of individual teachers or school leadership, but teachers often do not feel prepared to conduct outdoor activities; (iii) young people do not get sufficiently in contact with nature, and the effect of these interventions is temporary on young people's engagement with nature; (iv) programmes that focus on the experience and perception of nature have a more substantial impact on pupils than excursions that aim to improve their knowledge of a topic; and (v) the literature points out that girls tend to feel more connected than boys, that interest in nature tends to decline between the ages of 13 and 15 and that family economic status and living environment are factors that impact engagement with nature.

The materials in the **grey literature** category presented quite different formats, making it difficult to compare them. However, we also see some possibilities for contribution in the four works we report – two from England (Kendall et al., 2008; National Foundation for Educational Research in England and Wales, Dillon, 2005), one from the USA (Wheeler et al., 2007), and one from New Zealand (Hill et al., 2020). Despite having teachers as its target audience, the first of them (Kendall et al., 2008) may provide some interesting highlights for discussion about models (or the lack of them) as it focuses on teacher education. Moreover, since we will also collect data from teachers, the report can contribute to discussions of OTTER future results.

The material *Engaging and learning with the outdoors: The final report of the outdoor classroom in a rural context action research project* (National Foundation for Educational Research in England and Wales Dillon, 2005) brings some **theoretical models** that we highlight as an appendix (See Appendix 4I & 4J) at the end of this report. In this work, the authors use the framework to discuss models they have found in their data analysis.

Differences in Impact/Outcome

Few papers have a **gender** perspective (e.g., Otte et al., 2019; Bølling, 2018; Genc et al., 2018), and none have made **geographic comparisons** outside the boundaries of the same country. We have not found papers as comprehensive as OTTER.

Literature reviews

By using the English search terms, we also found nine literature reviews focusing on EOC. These reviews had relatively different questions from each other, and different goals than the OTTER literature review but are still worth considering given their contributions to the topic (See Appendix 4K). Some evaluated programs rather than research articles, but they bring a well-grounded discussion with potential contributions to OTTER discussions.

Conclusions

Considering that terms were searched in three different languages and several databases (some more context-dependent, such as the Dutch ones), there are still fundamental theoretical and empirical gaps regarding learning outside the classroom. In particular, there is relatively little work that dialogues with the goals of OTTER in a more holistic way. Despite this, we have found empirical work (reported in our results table) essential to discussions of the data obtained in the OTTER context. In addition, several literature reviews, including at least one in Dutch (Heyman et al., 2021), address the various facets of OTTER. Although these reviews have different purposes compared to each other and are somewhat more or less inclusive concerning the aims of the systematic review conducted as part of OTTER, they bring distinctive evidence on the role of education outside the classroom and therefore should critically compose our systematic review.

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Ireland

Methodology

The following research papers were found through searing the database Web of Science with the following key words “Models of Education Outside the Classroom” or “Models of Outdoor Learning” or “Models of Outdoor Teaching” or “Models of Museum Learning” or “Models of Field Trips” or “Models of Informal Science Learning” or “Models of Non-Formal Science Learning” and “Ireland” or “Republic of Ireland’ or “Irish”. The papers were also found through data changing and searching within specific Journals. All empirical papers that research EOC practices in children aged 6-18 years and research conducted from 2012 up to the search date (October-November 2021) were included for review. Grey literature was extracted from a google search using the same key word search while also including the search terms “Outreach Science Learning in Ireland” and “Education Outside the Classroom in Ireland”. All grey literature that was recent (in the last 10 years) or current (but began more than ten years ago) were included in the review. Ten research papers and nine grey literature documents were identified from the search terms and inclusion criteria. A final five research papers and four grey literature documents were identified for the final report as they provided the most information related to the fields of analysis.

Key findings

Some General Findings

The overall key findings focus on hands-on student learning that enhances the student experience of learning. Pedagogical approaches identified from this review to support this type of learning include inquiry-based labs that build on student interest, integrating everyday experience in nature with learning and embedding a research practice model to refine practices to suit the learners needs. There is some evidence to suggest that creating links to role models and career paths can strengthen student perceptions of science and relevance of science to everyday life. Gender differences and geographical differences are sparsely reported in the findings which suggest a gap in these studies to be addressed in the future. There were a wide variety of research instruments utilised throughout this review with some of the most novel findings arising from those that were embedded into the initiative design e.g., learning portfolios, participant self-reflections, video recorded observations. Challenges were poorly reported and suggest a gap in the literature to inform future studies.

The most common age groups found were in the primary school range. The youngest in the samples were five and the oldest in the primary school sample was twelve (Murphy, 2018; Collins et al., 2020; Gilleran Stephens, Short and Linnane, 2021; Gilligan and Downes, 2021). One paper found used a sample from a secondary school population using a sample of senior cycle students aged 16-18 years

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(Donnelly, O'Reilly and McGarr, 2013). The grey literature focussed mostly on "all young learners" (Forest School Ireland, 2021; NUIG, 2021; SySTEM 2020, 2021) with the exception of the Science Gallery which was open to 15-25 yr olds only (Trinity College Dublin, 2021).

Pedagogical Models/Approaches

Collins et, al., 2020, assessed a treatment group and a control during a school visit to the zoo. In the treatment group the students engaged in an hour long, **hands on educational intervention** designed to enhance the students learning. This took place in the student's classroom before the visits. It focused on knowledge about the study species, children's attitudes towards zoo housed animals and it aimed to reduce negative behaviour such as feeding, touching, shouting and banging on the glass at the exhibits. Murphy (2018), investigate the concept **of forest schools that can be added to a traditional educational setting** that is backed up by extensive research. This research is built upon long-standing theories that children engage with nature naturally and that learning becomes more relevant to the student when they can relate it to real life scenarios. This particular study sought to use an action research methodology to assess the Irish Primary School Visual Arts Curriculum through Forest School for children aged six to eight years old.

Another study assessed an environmental education program called H2O Heroes that they piloted with a group of primary school children aged seven to ten years old. This intervention used a **catchment-based framework** to explore the links between human activity, water quality and water, not just in an individual water body, but in the wider catchment. The aim was not only to foster environmental understanding but to connect the students with their catchments to achieve long term changes in attitudes and behaviours. The intervention consisted of a fun three house classroom-based tour of a water catchment, focusing on the link between human activity and water quality. The goal of H2O Heroes is to inspire, inform and engage so that children become environmental ambassadors for water protection and conservation. Donnelly, O'Reilly and McGarr (2013) describe **a virtual chemistry laboratory** to support students learning. The teachers used the program to engage students in an **explicitly guided inquiry**. The program is a java app that contains a virtual stock room of chemicals that students can bring on to a work bench on the computer. They can add solutions to each other as they see fit. They can then interpret what is happening in the 'solution info' that is provided on screen. One novel study sought to investigate the socioemotional benefits for children when they were allowed to keep and care for hens at school. This **care-farm initiative** was completed in a school that was situated in an urban area that had a high context of socio-economic exclusion with children aged five to nine years old (Gilligan and Downes, 2021).

Pedagogical methods or approaches used in the grey literature loosely centered **around interactive workshops** that fostered student centered learning (Forest School Ireland, 2021; NUIG, 2021;

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SySTEM 2020, 2021; Trinity College Dublin, 2021). Forest School Ireland focus on inspiring "*inclusive, playful, learning for all, in nature*" through a **community of learners** (Forest School Ireland, 2021). Engagement, motivation to learn and achievable tasks for all learners were highlighted as key elements in their design to contribute to students' development of intrinsic motivation and social and emotional skills (Forest School Ireland, 2021). Two of the initiatives focus on a **research-practice** model whereby pedagogical tools are designed, tested and evaluated to inform practice (NUIG, 2021; SySTEM 2020, 2021). Cell EXPLORERS aims to promote **hands-on discovery** of molecular and cellular biology through school visits and interactive workshops. They attribute small demonstrator to pupil ratios where every child does each activity to their success and growth. "Real science" with "real science role models" are the selling points of this initiatives where Cell EXPLORERS also involves the whole family through bringing materials from home or completing activities with parents to spread science self-efficacy (NUIG, 2021). SySTEM 2020 focusses on the use of **self-evaluation tools** to inform their toolkit for educators. The pedagogical approaches within this toolkit are described under three themes: design for everyone, design for experience and design for growth (See Appendix 4L). Within these themes there are 11 design principles; make it accessible, embrace diversity, be inclusive, make it matter, keep it engaging, inspire and motivate, build social learning environments, create pathways, support identity building, promote learner autonomy and assess your practice (SySTEM 2020, 2021). Pedagogical approaches in Science Gallery Dublin were less descriptive and mostly outlined their focus on a week-long programme for transition year students and home educated students to learn, play and explore through workshops, talks and activities with a focus on the intersection between art, science, technology and design (Trinity College Dublin, 2021).

Research Instruments

The papers found used a variety of methods to assess the outcomes and impact of their interventions. One study designed their own survey and designed three different sections. One to assess knowledge, one to assess attitudes and one to assess behaviours. These were completed pre and post a field trip to the zoo or an aquarium and were all quantitative Likert scale questions (Collins et al., 2020). Another paper used qualitative methods to assess the impact of a forest school and used observations, video footage, journals that the students wrote and informal interviews to assess impact (Murphy, 2018). Another study that assessed an intervention to each student about water used a pre and post assessment design. They used quantitative questionnaires that also included qualitative open-ended questions, however the teacher read aloud the questions and stressed that the questionnaire was not a test. Thy were also given a draw and write assessment, this was to avoid language barriers in a younger sample (Gilleran Stephens, Short and Linnane, 2021). Another study assessing a virtual chemistry program used video recording, observations and a talked aloud Inquiry Science Implementation Scale. They also used interviews and the Reformed Teaching Observations

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Protocol (Donnelly, O'Reilly and McGarr, 2013). A study assessing the impact of caring for hens on students' socioemotional development used focus groups to gather data from the students and assess the impact (Gilligan and Downes, 2021).

Within the grey literature a variety of questionnaires, surveys, semi-structured interviews, video recorded participant observations and focus groups were used to assess and evaluate both the quality of the programmes and impact the initiatives had on participants. It was common among these initiatives to embed data collection within practice. For example, SySTEM 2020 made use of zines (learning portfolios – See Appendix 4M) to assess students' reflections on STEAM learning during the workshops. They also utilised an Experience Sampling Method (ESM) which involved a series of questionnaires being sent out by text message to captures students feeling about science at a specific moment in time (e.g., before, during and after an event) (SySTEM 2020, 2021). The observation mapper was used as a hands-on tool in SySTEM 2020 to facilitate participation self-evaluation during activities. Finally, a Credentialisation Diagnostic Tool was designed by SySTEM 2020 based on a checklist of criteria. Cell EXPLORERS created their own validated questionnaire to measure the impact of their activities on students' science self-efficacy. They concluded that one of their modules (Fantastic DNA) improved student confidence to do skills and answer questions. The Science Gallery Dublin used a visitor survey to collect quantitative data on their visitor profile and the effectiveness of their exhibitions in enhancing knowledge and creating stimulating discussion with friends and family.

Impacts/Outcomes

One study assessed students learning before and after visiting a zoo or an aquarium. The results showed that those in the experimental group did have an increase in their knowledge about the species, and their behaviour was reduced. This hands-on experiential learning pedagogy appeared to have a positive impact on the students' knowledge and behaviour (Collins et al., 2020). A qualitative study that assessed a Forest School in Ireland showed how this experiential outdoor learning assisted in the development of a sense of responsibility, resilience, independence, and happiness in a sense of achievement. It also allowed to an awakened awareness of the child to their surroundings (Murphy, 2018). H2O Heroes reported that the majority of the students enjoyed the intervention and the students showed an increase in their knowledge, particularly around where their drinking water came from and water conservation (Gilleran Stephens, Short and Linnane, 2021). Another study assessed a virtual chemistry laboratory to support students learning. The findings suggested that this program was helpful to students, but that teachers lacked the time to properly integrate it into the curriculum. Teachers also reflected that it was perhaps too difficult for students as they are not used to engaging in self-directed problem-solving learning like this. Therefore, they see it more as an add on rather than an integral part of learning (Donnelly, O'Reilly and McGarr, 2013). In the study of caring for hens, the results showed how the students increased their sense of responsibility, they engaged in cooperation

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with other students, and they demonstrated relational empathy. In addition, the data shed that the students increased their trust and connection with the animals. The students also benefited as they reported that the activity was relaxing. They also reported that the intervention increased their empathy and respect for the natural world (Gilligan and Downes, 2021).

The grey literature exhibited a variety of outcomes related to students cognitive, affective and psychomotor skills. The Science Gallery reported a 90% increase of visitor's knowledge on the themes that were exhibited e.g., plastics, perfection and open labs. 85% of visitors said they would discuss what they learned with a family or friend (Trinity College Dublin, 2021). SySTEM 2020 found from their focus groups that students had an increased self-belief in their mastery of 21st century skills such as collaboration, critical thinking, creativity and communication. These students could also see how science and art related to one another and identified the science related topics that they were most interested in were: the human body and genetics, animals, computers and planets were named most frequently (SySTEM 2020, 2021). Forest School Ireland reported that their initiative enhanced numeracy and literacy skills and improved language and communication skills (Forest School Ireland, 2021). However, empirical evidence to support these claims are lacking. Students' affective skills was most commonly reported in the grey literature. Cell EXPLORERS reported an increased exposure to sources of self-efficacy by scientists (Verbal persuasion & Vicarious Experience), enhanced student perceptions of scientists and students felt that wearing a lab coat helped them feel like a real scientist (NUIG, 2021). They also reported that students enjoyed performing experimental work independently. SySTEM 2020 reported educational backgrounds of parents to be a factor that influenced students science attitude or consideration of a career or further study in STEM. They also reported findings related to increased confidence or self-worth and resilience with STEAM subjects (SySTEM 2020, 2021). Forest School Ireland reported an increase in motivation for learning and improved concentration, changes in self-esteem and confidence and improved relationship with and understanding of the outdoors (Forest School Ireland, 2021). Finally, psychomotor skills were reported in just some of the initiatives. Science Gallery Dublin reported that their non-profit gallery provided opportunities for visitors to connect and have conversations with artists and scientists (Trinity College Dublin, 2021). SySTEM 2020 reported 23% of learners regularly engaging in self-directed learning activities (e.g., experiments at home, videos and creating or building things). They highlighted that 25% of young learners got involved in arts activities such as playing musical instruments, singing, dancing or drama. Finally, SySTEM 2020 highlighted that 44% of 8-11yr olds regularly engaged in sports related activities. Forest School Ireland highlighted that their participants had improved their ability to co-operate as part of a team, be aware of others and improve physical skills (Forest School Ireland, 2021).

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Differences in Impact/Outcome

Papers and grey literature that did not report on gender included (Donnelly, O'Reilly and McGarr, 2013; Murphy, 2018; Forest School Ireland, 2021; Gilleran Stephens, Short and Linnane, 2021; Gilligan and Downes, 2021; Trinity College Dublin, 2021) or geographical differences (Donnelly, O'Reilly and McGarr, 2013; Murphy, 2018; Collins et al., 2020; Forest School Ireland, 2021; Gilleran Stephens, Short and Linnane, 2021; Gilligan and Downes, 2021; NUIG, 2021; SySTEM 2020, 2021; Trinity College Dublin, 2021).

The one study that assessed a trip to a zoo or an aquarium, found that the students from the girls only schools were the most likely to have an increase in knowledge and behaviour scores after their visit (Collins et al., 2020). SySTEM 2020 reported that male learners engaged in self-directed learning activities and team sports more than girls. In contrast, female learners were reported to engage in arts-based activities. However, they outlined that these gender differences were not significant outside of samples from highly educated backgrounds (SySTEM 2020, 2021). Group differences (between genders) were not affected by the enjoyment of science lessons but male learners (higher educational capital) had more positive science attitudes and could see the relevance of science to their lives (SySTEM 2020, 2021). Some gender differences were noted as part of a drawing activities that children participated in in Cell EXPLORERS. From the drawings collected, children tended to draw their own gender of scientist and older children drew more stereotypical scientist (NUIG, 2021). However, these findings were not part of an empirical study and would need to be verified by further studies.

Effective Practices, Challenges and Difficulties

A study using hens to develop students' socioeconomic development highlighted the benefits of this intervention. Hens gave rewards to the students when they were cared for properly in the form of eggs. The students were also able to handle the animals as they were small. Their size also allowed them to be kept on the grounds of an urban school in Dublin, which could be replicated in other areas (Gilligan and Downes, 2021). Another research study indicated that learning before a field trip to a zoo or aquarium in the classroom benefited the knowledge acquisition on the field trip (Collins et al., 2020). However, another study outlined how due to staffing issues, they were the class teacher, forest school leader and the researcher, which may have created bias in the results. They also highlighted how they had to attach their video camera to a tree and that they had their camera on them which at times interrupted the flow of the data collection and observation (Murphy, 2018).

Grey literature documents focussed on design principles as their effective practices for delivery. Forest School Ireland highlight six key principles; Regular Sessions, Woodland Setting, Community, Holistic development, Opportunity to take risks, Qualified Practitioners. The qualified practitioners receive training to become a Forest School Leader which can also be based within another organisation. However, they outline that the success of the school hinges on these leaders and is very much dependent on their skills or knowledge of curriculum in order to encompass the varied opportunities for learning that emerge from students' interaction with the setting (Forest School Ireland, 2021). Cell EXPLORERS outlines that the sustainability of their model attributes to its success. Staff and students from the university participate on a voluntary basis or as part of their degree. Sustainability is achieved through large team of volunteers, the integration of science outreach into the curriculum, and the development of fee-paying activities such as holiday and revision camps (NUIG, 2021). The Science Gallery Dublin effective practices centred around the content within their exhibitions. They aim to exhibit "creative ideas that interrogate and explore the boundaries of art and science". This focus on visitor interests concentrates on highlighting the interconnectedness of science, the arts, culture, design, business and innovation at key decision making times in people's lives such as choosing school subjects, college courses or future careers (Trinity College Dublin, 2021). Science Gallery Dublin were also the only initiative to outline the specific challenge of closures due to the COVID-19 pandemic which caused them to redesign their approach in order to reach their audience online. SySTEM 2020 effective practices focussed on combining approaches to gain deeper insight into the experiences of learners. Involvement of relevant stakeholders to gather a global assessment of science attitudes and engagement, identify the variability of the learning process, measure the change in learners' skills and promote self-reflection among learners were central ideas within their programme design (SySTEM 2020, 2021).

There were many gaps found when searching for articles that related to empirical investigations of education outside of the classroom in the Republic of Ireland. It appears that there are many school trips being offered by museums and places of interest across the country that promote learning outside of the classroom, however little research assessing the impact could be found. Therefore, there is a significant gap in the Irish research field in this area generally. This was surprising as Ireland has a wealth of historical sites to visit and also promotes access to the Gaeltacht region to promote the learning of the Irish language with residential camps on offer every summer for school age children to attend. Therefore, this should be seen as an area that should be prioritised for research so that evidence of the good practice that is being completed can be produced.

Conclusions

It appears that education outside of the classroom does occur in Ireland, however it is not being widely reported. From the studies reviewed here, it can be seen that there are novel contributions to students learning through care-farms in urban settings, forest schools, hands-on activities and gallery exhibitions. The use of qualitative and quantitative methods of data collection are utilised and recommendations for further research into this area has been highlighted.

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As with the larger systematic review, the majority of the studies coming from Ireland did not report on geographical or gender differences. This should be included in future research to further understanding of the impacts of education outside of the classroom interventions.

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Spain

Method

A mixture of terms in both Spanish and English has been made to find the greatest possible number of contents:

- modelos de educación fuera del aula
- educación ambiental fuera del aula
- educación ambiental no formal fuera del aula
- environmental citizenship
- non-formal nature-based activities
- aprendizaje en la naturaleza
- impacto pedagógico salidas escolares
- salidas de campo medio ambiente secundaria
- cómo hacer una buena excursión escolar educativa

Approximately 50 articles and materials were found, of which 11 were selected. The main reason for exclusion was that they were articles published more than 15 years ago, or that they were very specific on outdoor leisure activities and not on any educational subject.

The search engines used: Google Academics, Google Scholar, Google, Scientix, Web Page of Ministry for ecological transition in Spain, Research Gate, DialNet – Universidad de la Rioja (https://dialnet.unirioja.es/), DuGi-Doc (https://dugi-doc.udg.edu/)

Key Findings

Some General Findings

The most common subject was field trips in nature, eventually in museums. For peer reviewed articles the most common age cohort was primary years (8-12).

Pedagogical Models/Approaches

The most common pedagogical approaches were inquiry-based learning, learning by doing and experiential learning. Some papers use scientific portfolio to or essays and scientific writings, supporting to develop some cognitive skills: questioning, doing research on a topic, formulating and testing hypothesis, etc.

Research Instruments

The most common research instruments were questionnaires (quantitative using scales and qualitative using open questions) and interviews.

Impacts/Outcomes

The **cognitive impacts** are generally focused on natural science, concepts and values (specially focused on climate change). The **affective impacts** included less fear towards science education, more environmental empathy, change-maker attitude, respectful towards nature and sustainability. Some papers reported a good impact on **psycho-motor development** but no scientific analysis was found.

Differences in Impact/Outcome

There is a specific paper we found interesting for the OTTER outcomes, saying high school adjustment was related to higher environmental empathy (cognitive and emotional) and greater connectedness to nature. Moreover, females reported the highest levels of environmental emotional empathy and connectedness to nature (regardless of their school adjustment). Furthermore, only males with high school adjustment reported similar connectedness to nature to that of females (regardless of their school adjustment). Implications of these findings for research and psychosocial interventions in environmental education may be important to take into account.

None of the materials reported any geographical differences but as many of them report more environmental empathy when knowing their surroundings, maybe interesting to explore if rural students show more connectedness to nature and awareness of the environmental crisis.

Conclusions

The EOC activity constitutes an important form of teaching organization that can be used in the management of local knowledge, in order to contribute to education for local development. The application of this form of teaching organization demands teaching training.

Three stages must be considered when a EOC activity is designed: preparation, execution and conclusion. During the EOC students must be protagonists and play an active role. After the EOC, it is convenient to dedicate a session in the classroom to review what has been learned.

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Part 3 – Key Areas for Consideration

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Image by: Thirdman

Part three of this report attempts to synthesis the key areas for consideration based on the findings of the systematic literature review. For clarity purposes, the key areas for consideration are presented in bullet point form and draws on important lessons from across the European/International and partner country systematic literature reviews.

1. **Pedagogical Approaches to EOC**: firstly, the pedagogical models and approaches underpinning approaches to EOC were not always explicitly and clearly stated in some of the reviewed articles. Where approaches were stated, these tended to focus on student-centred pedagogy that employed, for example, play, games, and group work. Peer-to-peer collaboration was common across the reviewed papers. Kolb's Experiential Learning Cycle (see for example Cotič *et al.*, 2020; see Appendix 2F) and Inquiry-Based Learning ((Kärkkäinen *et al.*, 2017) see Appendix 2M) were the most common specific approaches explicitly referenced. Museum learning was frequently considered in terms of Contextual Models of Learning, which acknowledges the differing experiences learners may have within a museum, based on their personal and sociocultural context. This is particularly true within contexts where learners can make personalized choices (Hsu *et al.*, 2018).

2. **Sites of EOC**: field trips, museum learning and site visits (science centres) were the most common sites for EOC. A large number of the reviewed papers explored EOC practices within nature, engaging students in learning in, for example, forests, beaches and mountains. In fact, forest (nature-based) learning emerged across all aspects of the systematic review i.e., European, International and all partner countries (see for example Meyerhöffer and Dreesmann, 2021; Schneiderhan-Opel and Bogner, 2021).

3. **Importance of Pre and Post Learning:** the importance of situating learning from EOC within a classroom context, and within official curriculum, was noted within some reviewed articles (Jose, Patrick and Moseley, 2017);(Kanlı and Yavaş, 2021). These articles indicated that learning may not be consolidated without pre and post learning. The following principles could apply:

    a. The goals and learning outcomes of EOC need to be explicit and made clear to students, without losing the element of surprise

    b. EOC learning should be directly linked to the established curriculum

    c. As outlined in post 4 below, teachers need support and continuous professional development to enable them to effectively scaffold students pre and post learning

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4. **Importance of Teacher Development to support EOC practices:** Firstly, teachers need to be supported to effectively lead the pre and post learning to ensure students learning is effectively consolidated from the EOC experience. Secondly, teacher professional development could support teachers to lead the entire EOC experience i.e. pre, onsite, post learning. This would mean that teachers aren't relying on an 'expert' to lead the onsite learning. Such an apprtoach could support the sustainability of EOC practices in schools, beyond the life of the project (see for example Kermish-Allen, Peterman and Bevc, 2019).

5. **Supportive use of technology:** many studies, especially within China and Taiwan, used technology and virtual reality as a replacement for EOC onsite visits. Others however, used technology in a supplementary way to support and guide students learning during EOC. This may consist of, for example, a mobile app that students can use while visiting a site (see for example (Petersen *et al.*, 2020)

6. **Importance of Relationships:** the importance of relationships was stressed in several differing ways. Firstly, many of the EOC practices, as outlined in point 1 above, stressed the importance of peer-to-peer collaboration (see for example, Orson, McGovern and Larson, 2020). Secondly, the importance of effective collaboration between formal and informal learning providers to develop pre/post activities was noted. Finally, mentoring, through connecting students with a 'more knowledgeable other' during EOC was used in a small number of papers (Dunlop, Clarke and McKelvey-Martin, 2019).

7. **Effective use of resources:** providing students with opportunities to collect resoures or data during the EOC experience, which they can bring back into the classroom to continue their learning was noted (see for example (Çelik and Tekbıyık, 2016). Providing differing resources to support students of differing ability was also noted and explored more in point 8 below.

8. **Differentiaition:** some papers firstly considered ways of scaffolding students of differing learning abilities during EOC. This may include, for example, developing differing resources for students of differing ability. Some papers noted the difficulties some students experienced if this was not the case. This may mean, for example, that some students or younger students engage in scaffolded and guided approaches to inquiry (Affeldt *et al.*, 2015)Appendix 2B for pedagogy model).

9. **Outcomes/impact:** in general, the reviewed papers reported positive outcomes and impact of EOC on students learning, knowledge, motivation, interest and enjoyment. Physchomotor outcomes were not reported, however the importance of body movement when learning was noted (Margolin *et al.*, 2021).

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10. **Research Paradigms and Instruments:** various approaches to research and research instruments emerged across the reviewed articles. If the focus was on assessing students knowledge and content learning from EOC, pre and post testing of cognitive knowledge were frequently used. These often consisted of closed quantative questions, with some open-ended questions for students to give their views. If the focus was on motivation, for example, pre-existing validated tests were used e.g. Motivation (Chen and Chen, 2018), scientific skills (Çelik and Tekbıyık, 2016). Affective outcomes were also frequently assessed through qualitative methods consisting of, for example, interviews and focus groups.

11. **Research-practice model:** Some effective approaches used in the design of interventions and data collection for research purposes was presented in the country literature reviews. They focussed on embedding data collection as part of the intervention in order to evaluate the impact of educational tools on the learner as well as contributing to the quality of the intervention. This dual nature of data collection tools focussed on a natural collection of data without impeding on the learner's experience of the intervention. Such tools included the use of zines (learning portfolios – See Appendix 4M), or self-evaluation tools that both added to the research and practice outcomes of the initiative (NUIG, 2021; SySTEM 2020, 2021).

12. **Need for longitudinal data:** many studies did not include longitudinal data, to consider the impact on students learning after, for example, a six month or year period. Some stressed the importance of such findings to support our understanding of the impact of EOC practices on students learning (Todd and Zvoch, 2019).

13. **Gender or geographical differences**: Geographical differences were not considered, probably due to the fact that studies tended to consist of one cohort of students within a specific context. Gender differences were considered in some instances, however these studies largely targeted female students and didn't always include either a mixed gender group or an all-male group for comparisons purposes (see for example Levine *et al.*, 2015).

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Appendices

Appendix 1: Summary of each paper in the European/International Systematic review

Each paper is summaries within this appendix and presented thematically based on European papers, USA based papers, and papers from China and Taiwan. There is a brief section that summarises the research found in other countries across the globe that was found during the search.

Europe

In Europe it appeared that there were more museum and filed trips which may reflect the rich history across countries in Europe and the variety of landscapes. Furthermore, there were many theoretical papers outlining museum learning models that could be implemented by researchers in the future. these are not included here as they did not meet the search inclusion criteria.

Field Trips

Field trips were used in many countries to enhance and facilitate learning across primary and secondary school groups. The most common country that used field trips for learning in Europe was Germany. One study in Wales in the UK sought to bring students to outdoor locations to make music, in order to promote interaction with nature, creativity with musical expression and history learning (Adams and Beauchamp, 2018). Also, in the UK researchers have also assessed the impact of bring students to a two day outdoor learning centre residential program that focused on the topic of Vikings (Harris and Bilton, 2019).

A study sought to investigate non-formal student laboratories to promote learning into sustainability and chemistry-based topics. This was for individuals from both an advanced educational background and those from a disadvantaged background in Germany to give them the opportunity to see if they wanted to pursue science as their future career (Affeldt *et al.*, 2015). Researchers in Germany have also used residential camps in order to support outdoor learning, motivation for learning and children's science and geography education (Dettweiler *et al.*, 2017).

Again, in Germany, they used a field trip deign to support religious education and found that this led to better learning for students as they asked them to engage all their senses when in the church setting. They also learned about the history of the church building however, found that those who came from a religious household always knew more about the subject that those that did not (Riegel

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and Kindermann, 2016) (see Appendix 2R for pedagogical model). Germany researchers also used field trips to forests to increase English language learners' competence. They had the students engage in the field trip and talk and write about the experience in English. They then did presentations to a paired school in the USA about the field trip in English. They found that the students really enjoyed this way of learning and that their competence in the English language increased (Meyerhöffer and Dreesmann, 2021) (see Appendix 2O for pedagogical model).. Also in Germany, students were taken on a field trip to encourage learning of the freshwater cycle. They were taken to a Bavarian national park and exposed to learner centred and cooperative learning which increased the groups learning in the short and long term (Schneiderhan-Opel and Bogner, 2021). Finally, researchers in Germany also found that bringing students to a waste treatment plant was helpful in teaching them about the reduce, reuses, recycle and recover module of sustainable practices for the environment (Stöckert and Bogner, 2020).

A village school in Turkey also employed field trips to enhance education of geography such as, rock, soil formational, erosion and fossils (Çelik and Tekbıyık, 2016). Field trips to science centre after teaching in the classroom in Turkey have also shown to enhance and consolidate students learning of complex subjects in physics (Kanlı and Yavaş, 2021).

A school in Slovenia utilised tablets while on a field trip to the beach to support students learning about geography. In this way they were able to have resources to identify common sea creatures and have a place to reflect on their learning in real time (Cotič *et al.*, 2020) (see Appendix 3F for pedagogical model)..

French researchers are also utilising field trips to support learning, in this study, space and gravitation was the subject choice. In this research students went to a space museum in order to enhance their learning of the topic, their results indicated that their students benefited greatly from the field trip in comparison to the control (Frappart and Frède, 2016).

Researchers in Finland have also highlighted the benefits of field trips. Their study followed a class of students who engaged in classroom learning about land formation, which was then followed with a field trip to a national park to see and experience what they had learned outside of the classroom. This was further consolidated with further learning at the centre after the field trip (Kärkkäinen *et al.*, 2017).

In Denmark, researchers have evaluated a virtual reality field trip. They argued that this can be used when a location is too difficult, dangerous, or expensive to access in real life. Their experiment assesses the learning from a virtual reality field trip that investigated the consequences of climate change in Greenland. They found that the students were much more interested when using the virtual reality (Petersen *et al.*, 2020) (see Appendix 3Q for pedagogical model)..

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Museum Learning

Many countries also used trips to museums to enhance students' engagement with a variety of educational topics. Research was conducted on collaborative learning activities in museums in Spain to promote teamwork and social interaction to help support learning about history (Alonso *et al.*, 2019) (see Appendix 3D for pedagogical model).

Science centres in Turkey have used the 'Magic Flask' activity that build an environment for science teachers to discuss the nature of science in an informal way. This exercise can be used with student to aid their reflection on scientific concepts and can also be used in the classroom if preferred (Eren-Sisman and Koseoglu, 2019).

In the UK museum learning has been enhanced suing digital technology. The augmented reality was able to provide students with extra information on the exhibits in real time as they made their way around the museum. Through augmented reality they were able to increase students learning in comparison to previous visits that did not include the augmented reality technology (Moorhouse, tom Dieck and Jung, 2019) (see Appendix 3P for pedagogical model)..

In Finland, students were brought to a planetarium with interactive exhibits in order to increase their knowledge about space and mars. They students enjoyed this experience, but they found that when the students already liked science that they were more enthusiastic about the field trip. Overall however, students' knowledge was stable six months posts field trip (Salmi, Thuneberg and Bogner, 2020). This was also replicated through 'edutainement' to support students learning of dinosaurs in a museum in Finland (Salmi, Thuneberg and Vainikainen, 2017). Students in Finland were exposed to a museum exhibition where they were able to engage with eleven interactive hands on science exhibits to aid their understanding of maths. Thereafter, there were encouraged to build and create different structures to bring an element of art and creative into the learning process (Thuneberg, Salmi and Fenyvesi, 2017).

Other

An interesting development in education outside of the classroom utilities technology and apps in Germany. This can be seen in research supporting maths learning, using an app that you take outside and follow in the natural environment on a 'maths trail'. The app gives hints and tips and where to go and the user can receive real time instant feedback when they solve puzzles and questions (ARIOSTO *et al.*, 2021).

A study in Greece advocated for the use of technology to support learning while on field trips. They used a mobile app that was create for students to use when they visited a local botanical garden. They were then able to scan plants to get more information on them in real time. They were also able

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to test their knowledge with a quiz to assess learning. The feedback form the students was that they enjoyed the program and that they liked how mobile technology was being integrated into their learning (Nikou and Economides, 2015). Another study from Greece used a large model to engage students in learning about history. They found that when they allowed students to engage in this way that they found they were more motivated to learn (Triantafyllidou *et al.*, 2018).

A meta-article that brought together the results of six exhibitions from four countries (Sweden, Latvia, Estonia and Finland) across of range of science and geography subjects, they found that engagement with interactive exhibits with hands on opportunities for learning was very beneficial for students learning (Thuneberg and Salmi, 2018).

In Northern Ireland, science education came to the school from Universities in order to support the learning of students and broaden their understanding of the subject (Dunlop, Clarke and McKelvey-Martin, 2019).

United States of America

The research found that was completed in the USA was more focused on bringing children to areas outside of the classroom to engage in learning in a variety of outdoor settings. This may be a result of the geographical space that they have in the USA and the variety of landscapes available.

Field trips

In the USA field trips to promote outdoor play were used for students living in urban areas in an attempt to increase their interest in the outdoors (Beyer *et al.*, 2015).

Some research utilized computer programs to enhance learning experiences. One such study used this approach to support education about the environment and geoscience (Bhattacharya, Carroll Steward and Forbes, 2021).

Field trips are popular in the USA with researchers showing the benefits to science and geography knowledge when students are sent on a residential high school program to live in a mountain setting in the wilderness. In this study they compared different field trips including ski trips and trips to hotter parts of the country including Florida (Giamellaro, 2014).

Field trips that then include a draw and explain assessment after supports the learning od aquatic science in secondary school students in the USA (Jose, Patrick and Moseley, 2017).

A full time, weeklong chemistry camp was assessed for changing the participants attitudes towards science through hands on experiments, field trips and significant interactions with scientists in the

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field. This was for girls only and did increase their reports that they would like to enter into STEM careers (Levine *et al.*, 2015).

In the USA they attempt to increase students' development of social responsibility, character development and leadership skills thought outdoor education practices, one in particular called 'Outward Bound' which is a residential program for students aged 14-18 years (Orson, McGovern and Larson, 2020).

Summer workshops to support students learning about climate change were found to be helpful. Students created games for others about climate change with interactive elements that aided learning, in this way they gained knowledge about climate change but also gained skills in programming and game design (Puttick and Tucker-Raymond, 2018).

In the USA researchers promoting science engagement for girls assessed an informal outreach program that allowed for hands on learning and peer mentor involvement. They found that those that attended the program were more likely to have an affinity towards STEM subjects (Todd and Zvoch, 2019).

In the USA they assessed a four-day summer camp that sought to increase STEM topic interest in youths through experiential learning. They found that those that attended had direct experience with nature, access to authentic technology and engaged in activities that promote collaborative teamwork. The found that the students were more likely to see themselves in scientific careers in the future and to be more knowledgeable about the process of scientific research after attending the camp (Ghadiri Khanaposhtani *et al.*, 2018).

Museum Learning

A museum in the USA trialled a tabletop interactive exhibit on evolution and found that children's engagement with it enhance their museum experience and learning of this topic (Horn *et al.*, 2016).

Using projective reflection was found to increase students learning in a science museum visit where they used augmented virtual learning to engage in city planning. This helped the high school students to see whether or not they would like a career in a STEM subject in the future (Shah *et al.*, 2021).

Other

Researchers implemented school gardens in an urban USA city to not only increase sustainability goals but also to give students a hands on learning experience (Fisher-Maltese, Fisher and Ray, 2018).

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A novel initiative that brought fishermen, primary school students and teachers together from island and coastal communities via an online platform to promote experiential learning for students in the USA was found to be beneficial to the students learning of geography and marine life (Kermish-Allen, Peterman and Bevc, 2019).

Researchers in the USA asked teachers to implement the ‘Playground Physics’ program when they were teaching physics classes throughout the year to their middle school students. This was the integration of body movement interactions with the physical environment when learning about physics to increase knowledge. In comparison to the control the children that engage in the playground physics were knowledgeable about motion, force and energy (Margolin *et al.*, 2021).

Bringing the elements, the students are learning about into the classroom from outside has been found to enhance learning. In one study about marine life and the importance of conservation, researcher brought sea urchins into an afterschool’s club for hands on experiential learning. They found that this was beneficial to the students and their inquiry based learning (Roth and Reynolds, 2020).

China and Taiwan

China and Taiwan appeared to use more augmented reality and technology in their research to give students access to field trips and museums. This was seen to be more accessible than visiting their sites themselves in most cases. This is perhaps due to their large population. Their results show that the students enjoyed the experiences and they found little difference in the augmented reality or virtual reality filed trips in comparison to the in person trips. Therefore, this could be a cost-effective way of supporting education outside of the classroom in urban environments or where these places are more difficult to access due to socioeconomic reasons.

Field Trips

Chinese researchers implemented virtual reality learning in order to support students with virtual filed trips when the actual location may be inaccessible. This was trialled with primary schools in China to support science education (Cheng and Tsai, 2020).

Researchers in Taiwan have used augmented reality technology on mobile devices in order to enhance outdoor learning of geography with successful results (Huang, Cen and Hsu, 2019).

Mobile technology using augmented reality to complement education outside the classroom was used again to enhance learning of plants and trees. The researcher used a mobile app that would engage students with a geo-tracking device. This gave the program the ability to know where the student was

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and bring up relevant information to what they were looking at to give them more learning in real time (Lo, Lai and Hsu, 2021) (see Appendix 3N for pedagogical model).

Museum Learning

In Taiwan students were given a mobile tag that would provide them with information when they reached different exhibits of a museum to enhance their learning experience of natural science. It also allowed teachers to monitor the students learning in real time (Chen and Chen, 2018).

In order to bring the museum experience to the classroom, researchers developed a multimedia system where students could enhance their learning without having to go to the museum in China. This was to support school that may not have the time or the resources to access the museum itself and so the students were about the learn about famous building, by touring the museum virtually in a toy car (Chou *et al.*, 2015) (see Appendix 3E for pedagogical model)..

Chinese researchers have combined technology and museum learning in research to better support primary school children's learning of plants and Chinese medicine. This physical mobile learning model supported the student's engagement with the material they were learning in the museum and botanical garden in Taiwan (Hsu *et al.*, 2016) (see Appendix 3G for pedagogical model). The blended approach to museum learning was also used to support the students learning of botany, geology and anthropology (Hsu and Liang, 2017) (see Appendix 3I for pedagogical model).. This model was used again by the same authors and children were given a program called CoboChild that allowed them to interact with exhibits in the museum. The children were able to review their learning and there was an option for them to save a send materials to others (Hsu *et al.*, 2018) (see Appendix 3H for pedagogical model)..

Researchers in China also found that when comparing a virtual museum trip to an in-person museum trip there was little difference in student preference. They found that a virtual trip was easier to facilitate than an in person trip in many cases (Ying *et al.*, 2019).

Other Countries

There was a variety of research papers found that were completed in other countries across the globe. These are listed here as they are felt to be of import but are not analysed in detail further.

In Iran, researchers implement a flipped classroom model where students engaged in learning outside of the classroom (Aghaei *et al.*, 2020). Research using outdoor experience that included multi day trips, or residential programs were found to be helpful for students learning. Once such example was a 'earth education centre' project in New Zealand where outdoor learning supported learning about the environment (Baierl, Johnson and Bogner, 2021). Field trips were also utilised to enhance learning

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inside the classroom for students in New Zealand to support their learning about local and native birds (Chen and Cowie, 2013). Additionally, researchers in New Zealand have also trialled digital technologies, such as Moodle to support learning experience outside of the school for secondary school children (Coll and Coll, 2018). Supporting girls to engage more in STEM education was the focus of many papers. One such paper sought to increase girls access to STEM through visits to high tech companies and meeting with female role models in the industry in Israel (Bamberger, 2014). Also in Israel, they found that interaction with exhibits in a science museum increased learning (Shaby, Assaraf and Tal, 2017). Students in Australia were allowed to engage in experiential learning within a museum setting of extracting the DNA from samples stored in the museum. They each had a mentor that guided their learning and enhanced their scientific knowledge (Chiovitti *et al.*, 2019).

In Japan researchers have assessed the benefits of field trips for educating secondary school students on the topic of sustainable development. The students were allowed to form small groups and to choose an area of sustainable development that best suited their personal interests, thereafter they were brought on a field trip that best matched their interests, for example, if they chose environmental conservation then thy were brought to a recycling plant. After the tour of the location there were given more information on their topic of interest and the chance to share their experiences with ither students (Ho and Inoue, 2020).

In Canada they assessed the outcomes when students were taught about climate change from their own teacher, versus an expert from outside of the classroom. They found that they learned ore from their own teacher in comparison to the expert and therefore suggested that when experts want to impart knowledge that they should support teachers to do so rather than trying to do it themselves (Porter, Weaver and Raptis, 2012).

In Malaysia, they created a program where students were exposed to hands on learning experience in an informal learning environment which increased their science knowledge (Mohd Shahali *et al.*, 2019). In Thailand they utilised a virtual reality field trip with inquiry-based learning to enhance science learning for secondary school students. They found this to be successful and useful for knowledge acquisition (Sriarunrasmee, Suwannatthachote and Dachakupt, 2015). Researchers in Indonesia found that utilising virtual reality had a positive effect on students' history knowledge (Utami *et al.*, 2019).

Researchers in Indonesia assessed ten schools that engaged in field trips and found that although the students always reportedly enjoyed the trips and had fun, that there was little learning that they would bring back to the classroom. The researchers highlight how if the goals of the field trip are not explicit, and the trips are not planned to be in line with the student's curriculum that the students in class performance on maths did not improve after the field trips. Therefore, they advocate for less of a focus on fun and enjoyment and more of a focus on giving experiences that replicate what they are learning in class so as to increase the students' knowledge base and build on the content of their formal teaching (Khotimah, Budi and Sumantri, 2019).

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Appendix 2: Pedagogical Models from European/International Review

Appendix only include models from papers from Europe, China and Taiwan, and USA.

Appendix 2A

(Adams and Beauchamp, 2018)

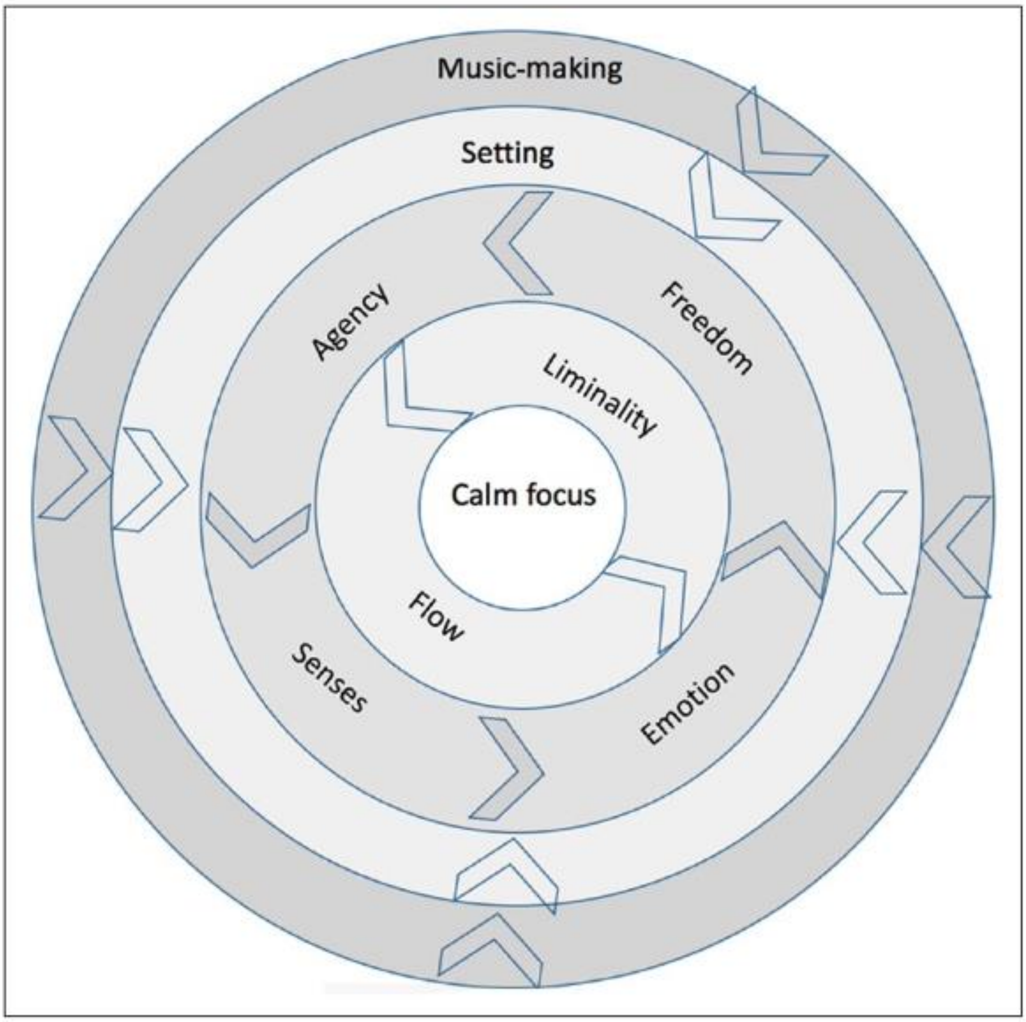

Figure 1. Model of music-making outdoors for pupils aged 7–10 years.

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Appendix 2B

(Affeldt *et al.*, 2015)

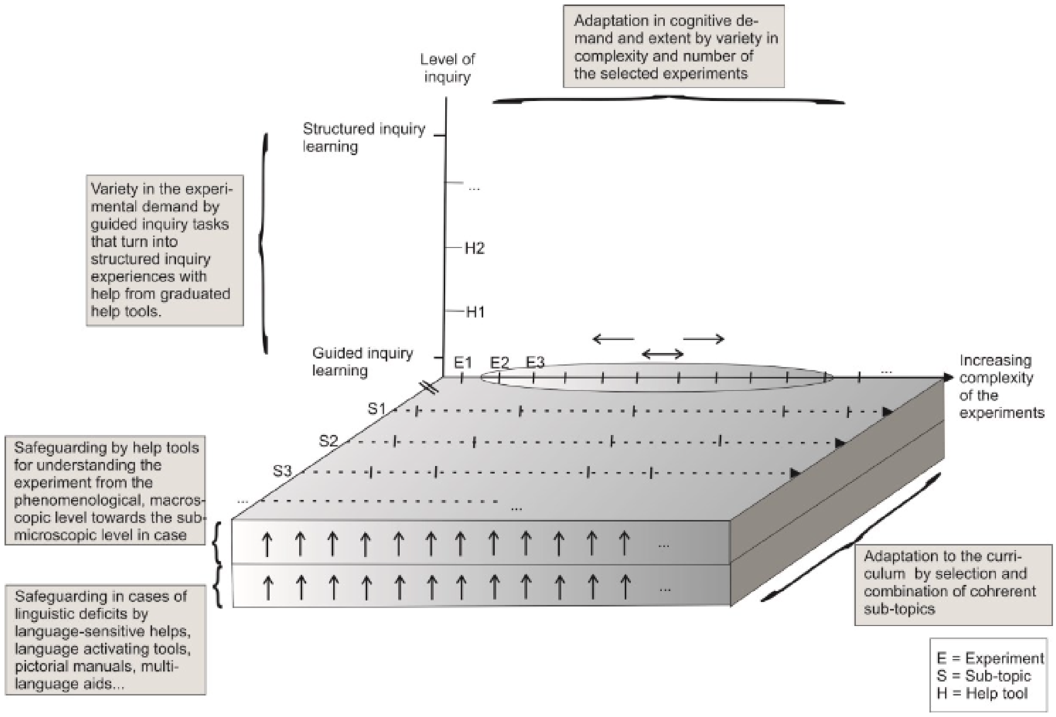

Figure 1. Model of differentiated learning environments in SLs. The figure shows the structure of highly differentiating teaching and learning environments, which are developed and tested for use in SL environments within the present project. Each of the learning environments consists of three to five sub-topics, which each are composed of four to six individual experiments. The various experiments in each sub-theme vary in their complexity and depth of cognitive demand with respect to the learning group. This allows for a flexible adaptation of the learning environment to match all students' personal interests, prior-knowledge, and cognitive and problem-solving capabilities. Graduated aids allow for different levels of inquiry from guided to structured inquiry learning. Additional aids support understanding and help reducing linguistic deficits.

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Appendix 2C

(Bhattacharya, Carroll Steward and Forbes, 2021)

Evidence-Based Reasoning Framework applied to develop for non-model and model-based activity in the context of the phenomenon of global increase in average surface temperatures.

	Elements of the EBR Framework	Non-model-based Activity	Model-based Activity
1.	Premise	Students investigate the phenomenon of global increase in average surface temperatures using data-sets from NASA-GISS	Students investigate the phenomenon of global increase in average surface temperatures using "big data" from a global climate model
2.	Analysis of data	Using NASA dataset from 1881-2017, students calculate temperature anomalies to re-create the NASA-GISS temperature anomalies graph. interpret the increase in average global temperatures	Students use "big data" for producing a time series plots of surface air temperatures by executing two climate simulations through a global climate model. Students compare (Modern_PredictedSST) simulation (a reference period, or control run) to a simulation where climate is changing (IPCC_A1FI_CO2) for calculating temperature anomalies.
3.	Interpretation of evidence	• Using the re-created NASA-GISS graph, students analyze the following information- o What is the main idea communicated by the graph? o Describing the type of graph, X and Y axes. o What do black dots represent? What does red curve represent? o Describing the variable being plotted on the graph and its relation to the context. o Identifying the time period over which change is occurring.	• Using the time-series plots that show a sequence of temperature data as it changes through time, students analyze the following information- o What is the main idea communicated by the graph? o Describing the type of graph, X and Y axes. o How much does the surface temperature change between 1960-2016 in each graph?

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Appendix 2D

(Alonso *et al.*, 2019)

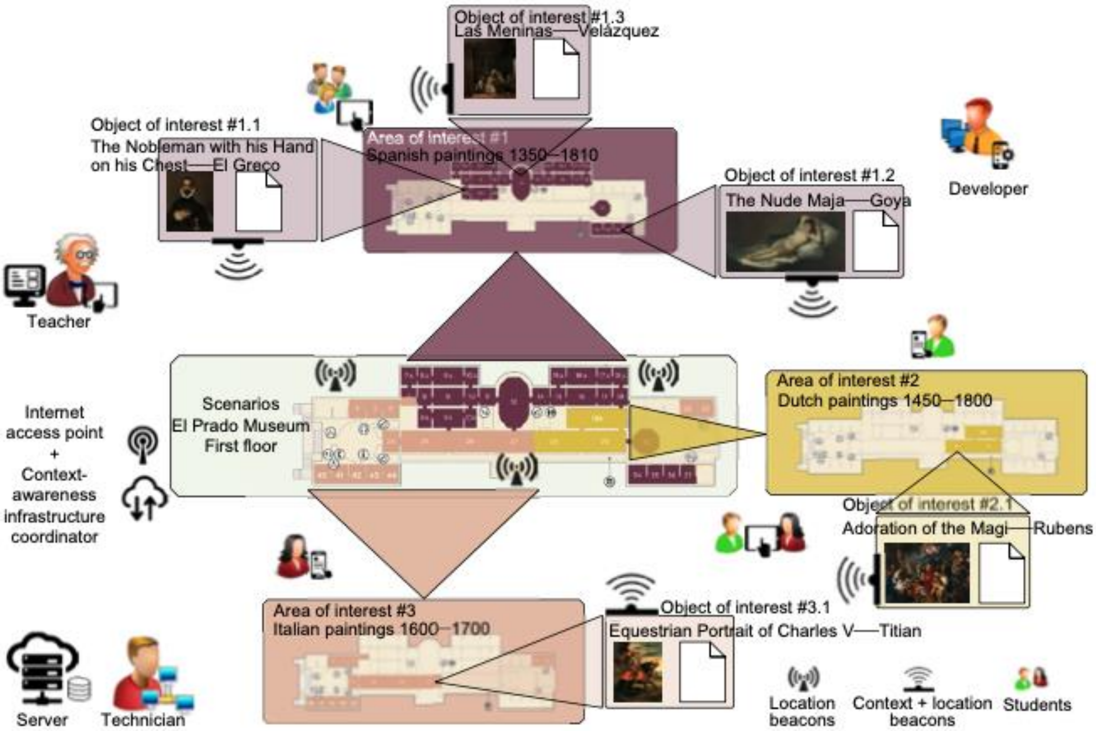

Fig. 1 **An infographic showing an example of a CAFCLA deployment in the El Prado Museum with three different roles (teacher, student, and developer), the structure followed to contextualize the learning environment (scenario, areas, and objects of interest), and the hardware infrastructure to be deployed**

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Appendix 2E

(Chou *et al.*, 2015)

Fig. 1. System concepts (see text for explanation).

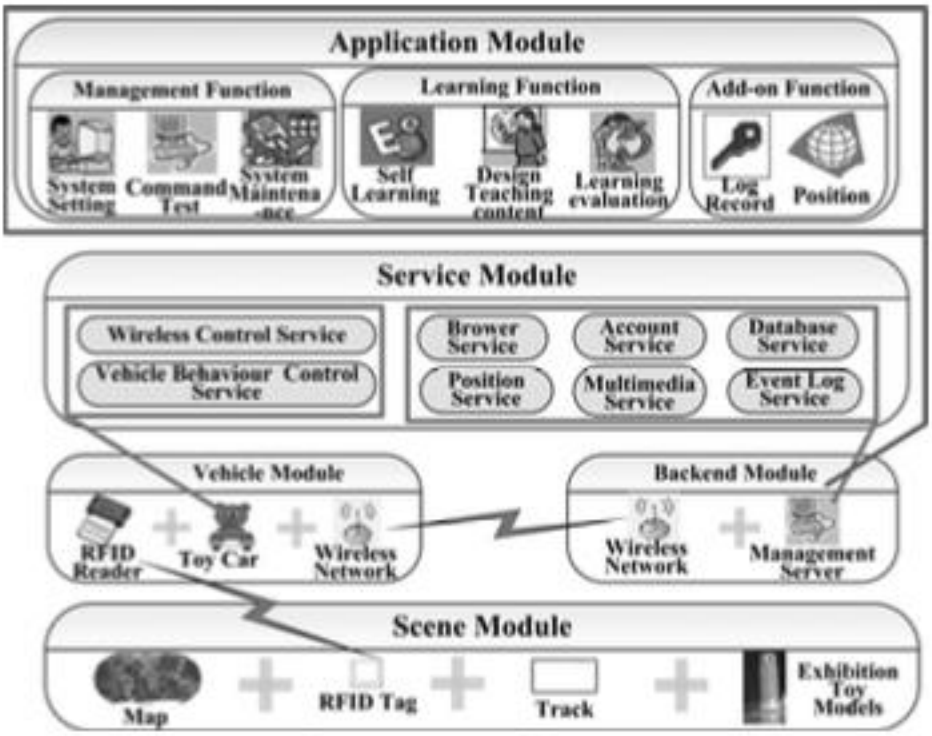

Fig. 2. System architecture.

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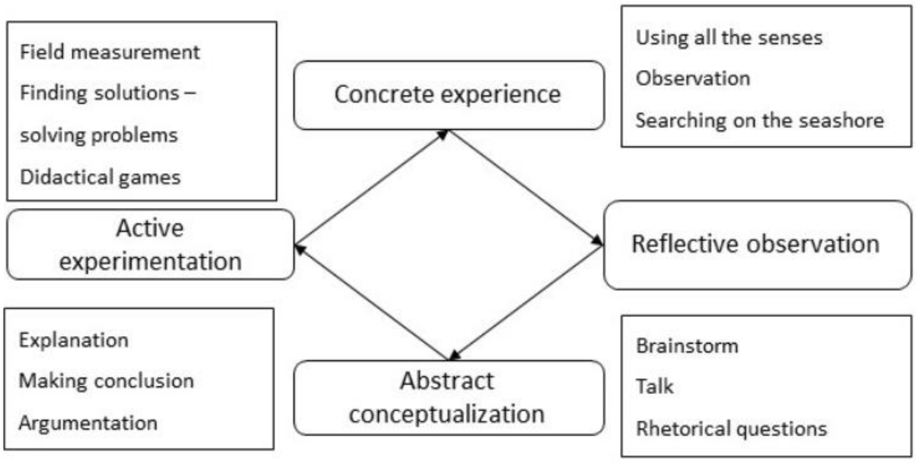
Appendix 2F

(Cotič *et al.*, 2020)

Figure 2
MNSL-model based on Kolb's experiential learning cycle



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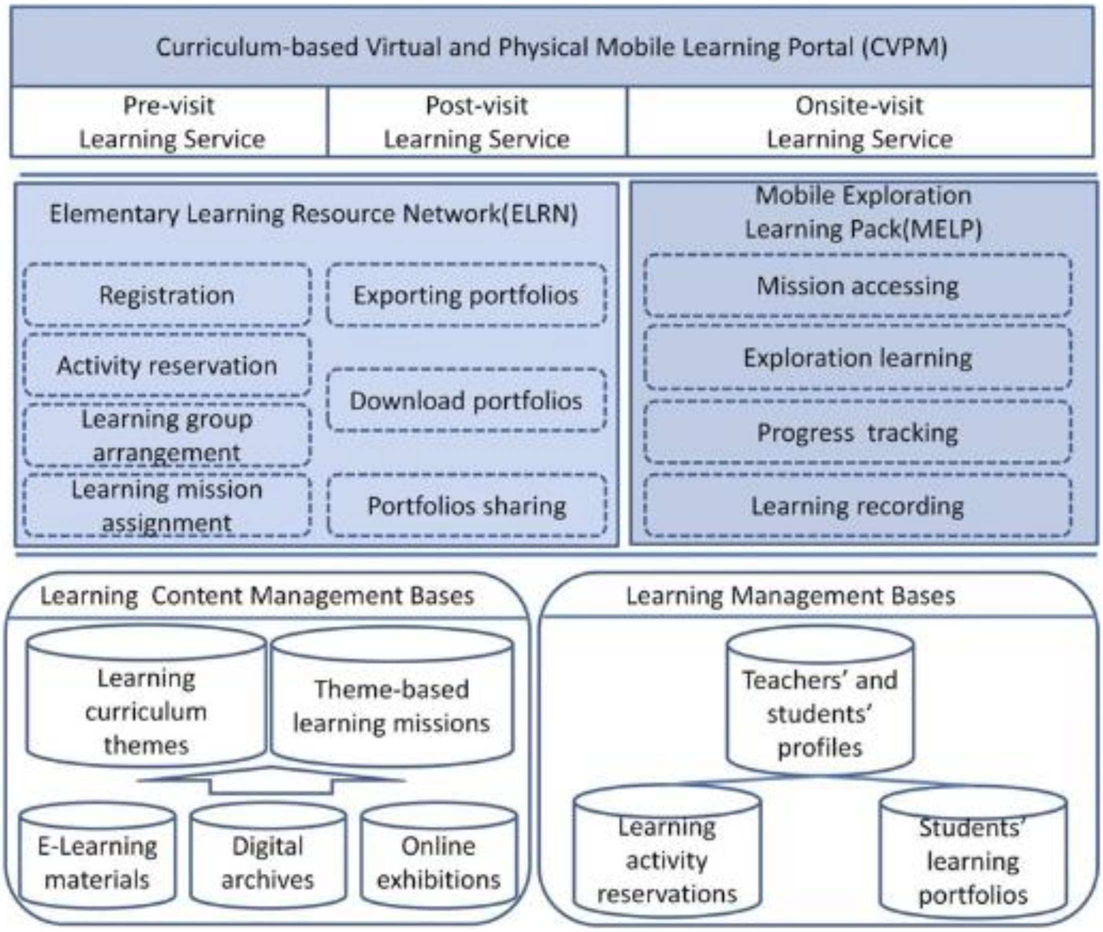
Appendix 2G

(Hsu *et al.*, 2016)

The curriculum-based virtual and physical mobile (CVPM) learning system framework



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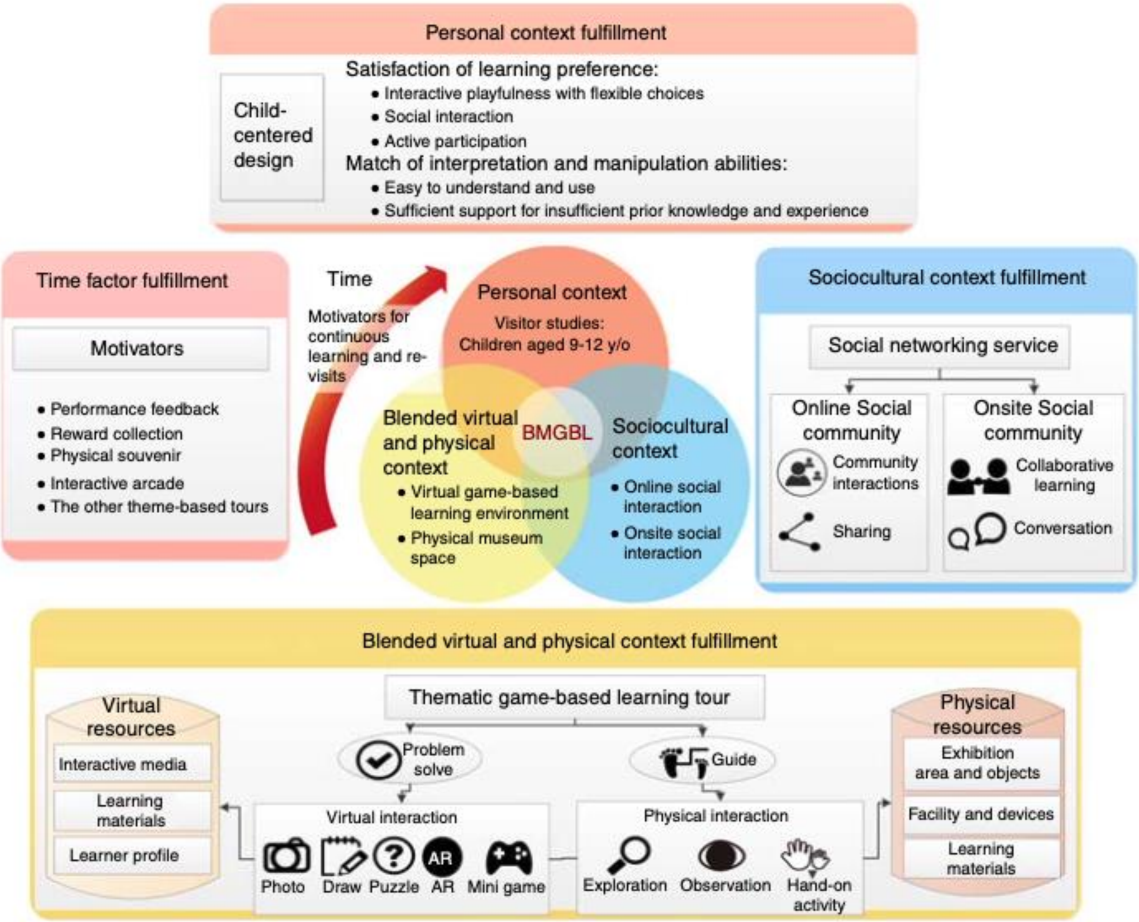
Appendix 2H

(Hsu *et al.*, 2018)

The contextual model of learning (CML) realization design of CoboChild



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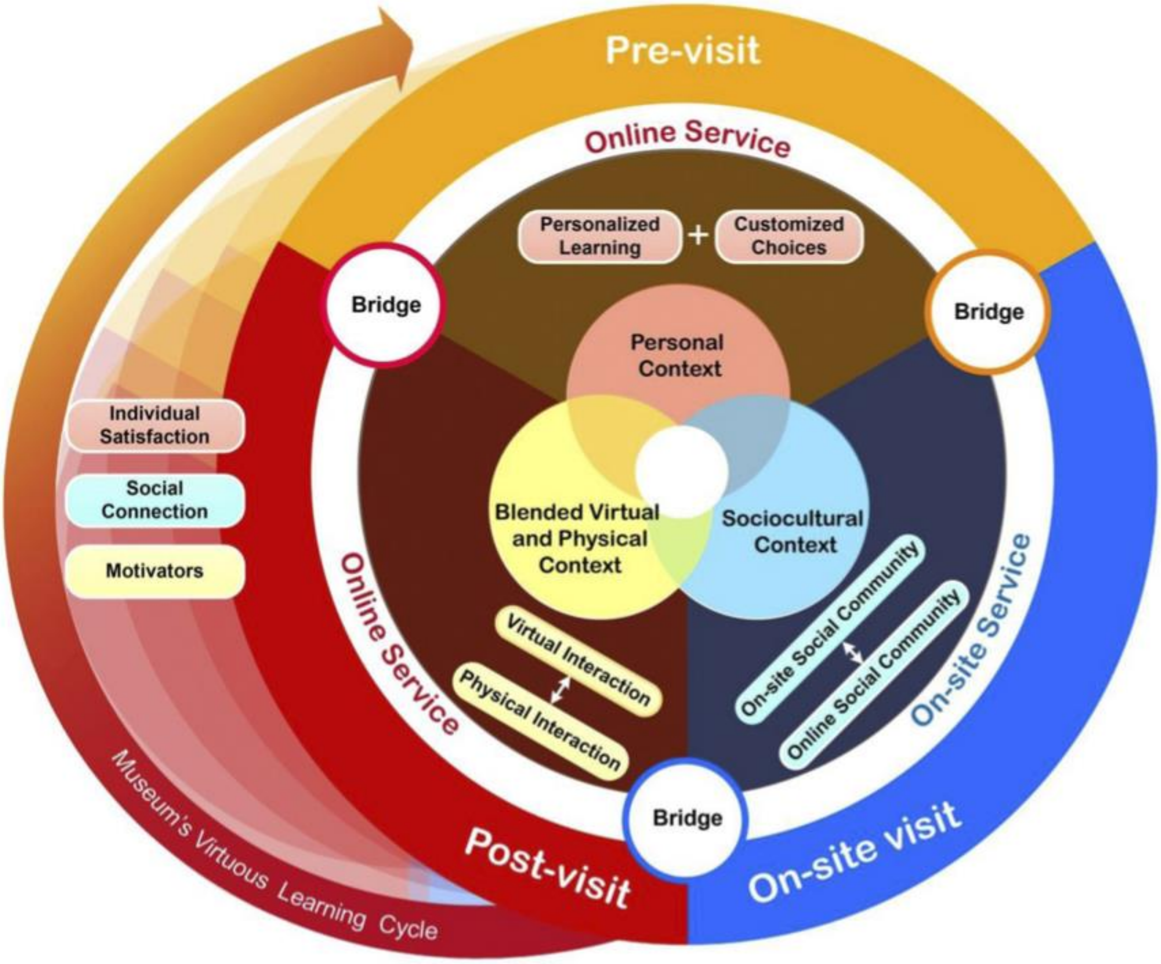
Appendix 2I

(Hsu and Liang, 2017)

The conceptual design of the on-site cyclical learning model (OOCLM)



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Appendix 2J

(Harris and Bilton, 2019)

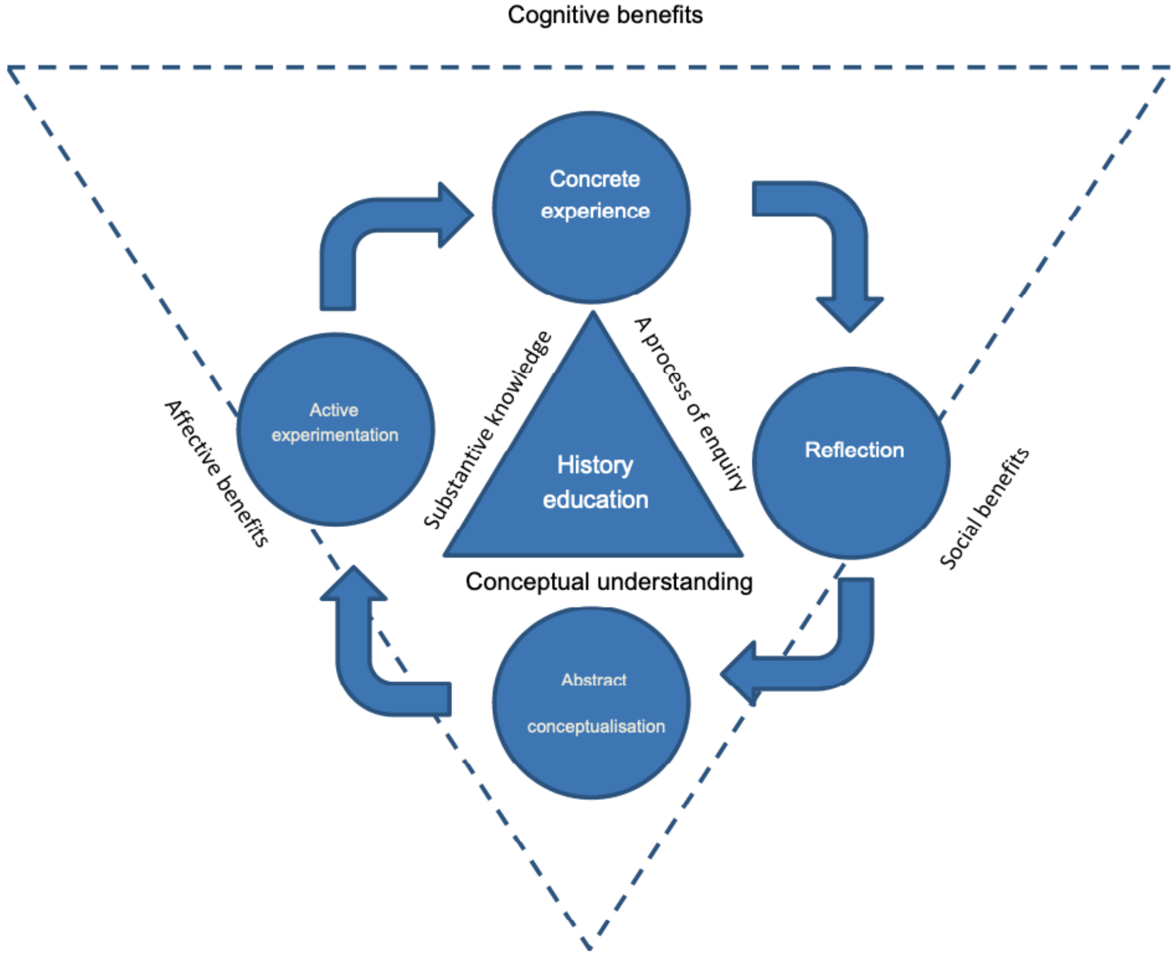

Figure 1. Exploring the relationship between the benefits of outdoor learning, Kolb's (1984) experiential cycle of learning, and the dimensions of history education.

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Appendix 2K

(Huang, Cen and Hsu, 2019)

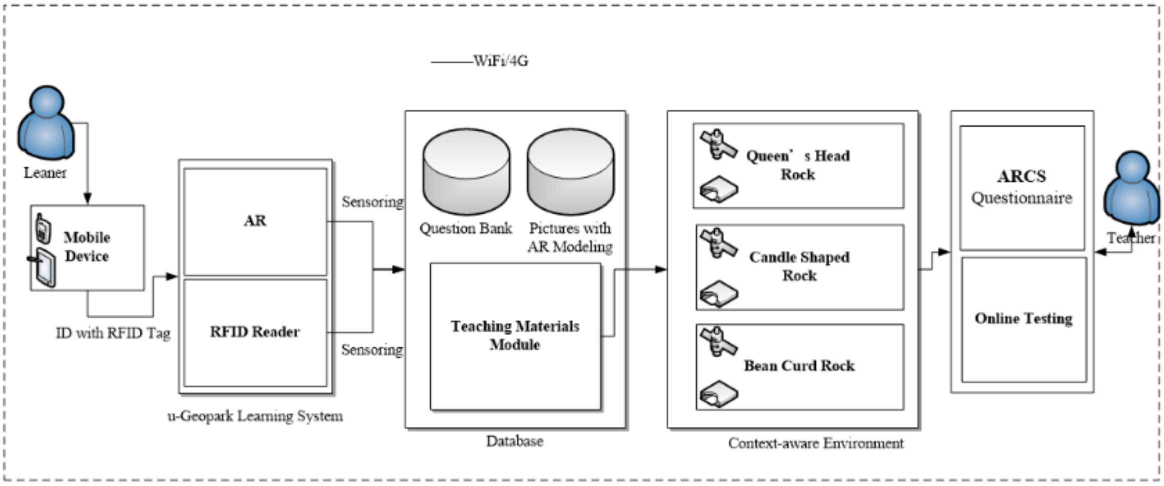

Figure 1. Ubiquitous learning system architecture diagram

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Appendix 2L

(Jose, Patrick and Moseley, 2017)

Table 3. The exhibits at science-technology centre paired with outcomes in physics curriculum.

Table 3. Continued.

Exhibits in SC	Explanations of the Exhibits	Outcomes in Physics Curriculum
 	One of the simple machines that make our lives easier is the pulley. Pulleys are a kind of leverage. There are two types: fixed and movable. Pulleys consist of fixed or movable rollers. The magnitude of the force decreases as the number of threads carrying the load increases in the pulleys. On the other hand, the path taken to the object increases as much as the number of ropes carrying it, which indicates loss from the road, gain from power. The test setup consists of fixed rollers. As the number of threads increases, the force that causes the masses to go up decreases.	

(*Continued*)

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Appendix 2M

(Kärkkäinen *et al.*, 2017)

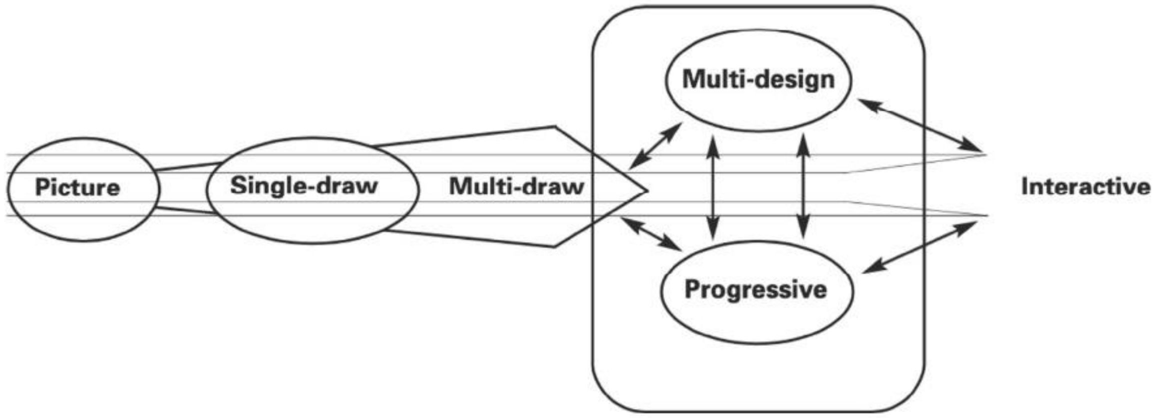

Fig. 1 Developing understanding of design drawing as shown by drawing types (Hope 2005, p. 51)

Appendix 2N

(Lo, Lai and Hsu, 2021)

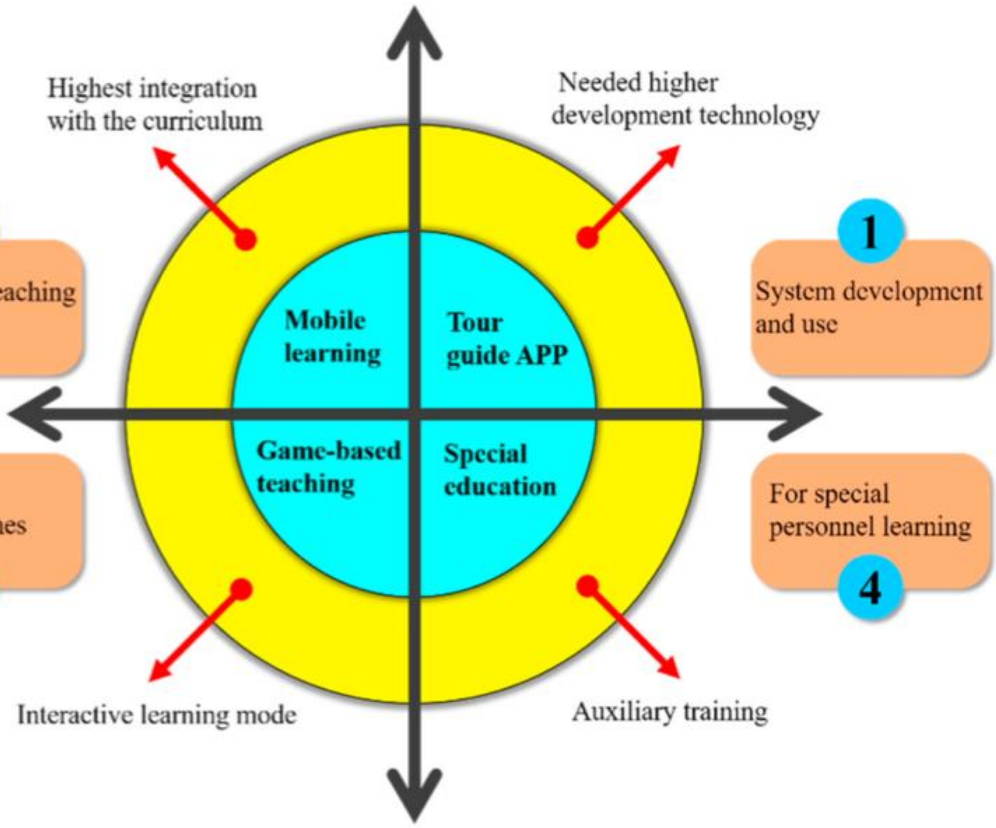

Figure 2. Classification diagram of AR-based learning applications.

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Appendix 2O

(Meyerhöffer and Dreesmann, 2021)

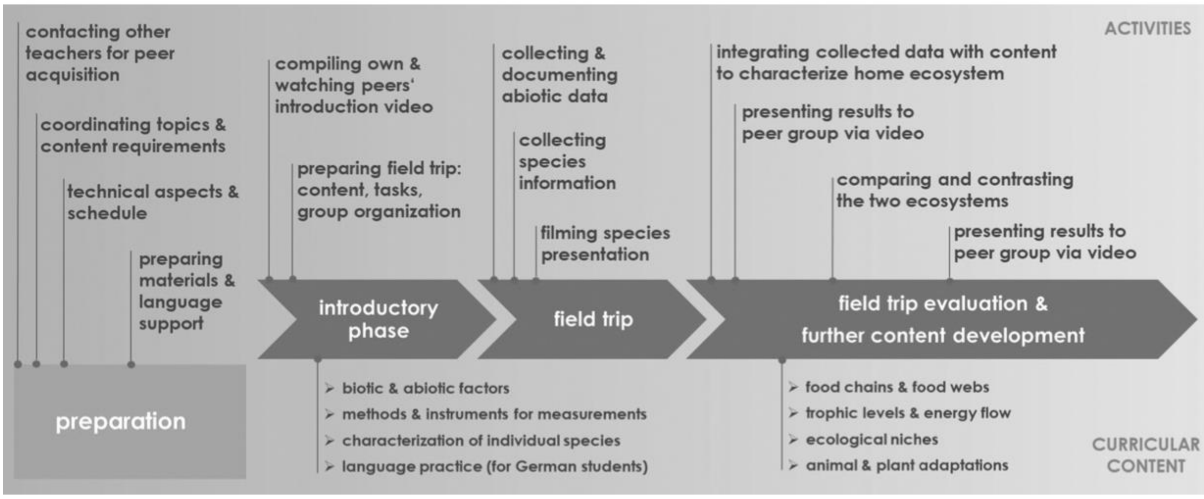

Figure 1. Overview of the instructional model for a peer video exchange in the curricular context of ecology.

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Appendix 2P

(Moorhouse, tom Dieck and Jung, 2019)

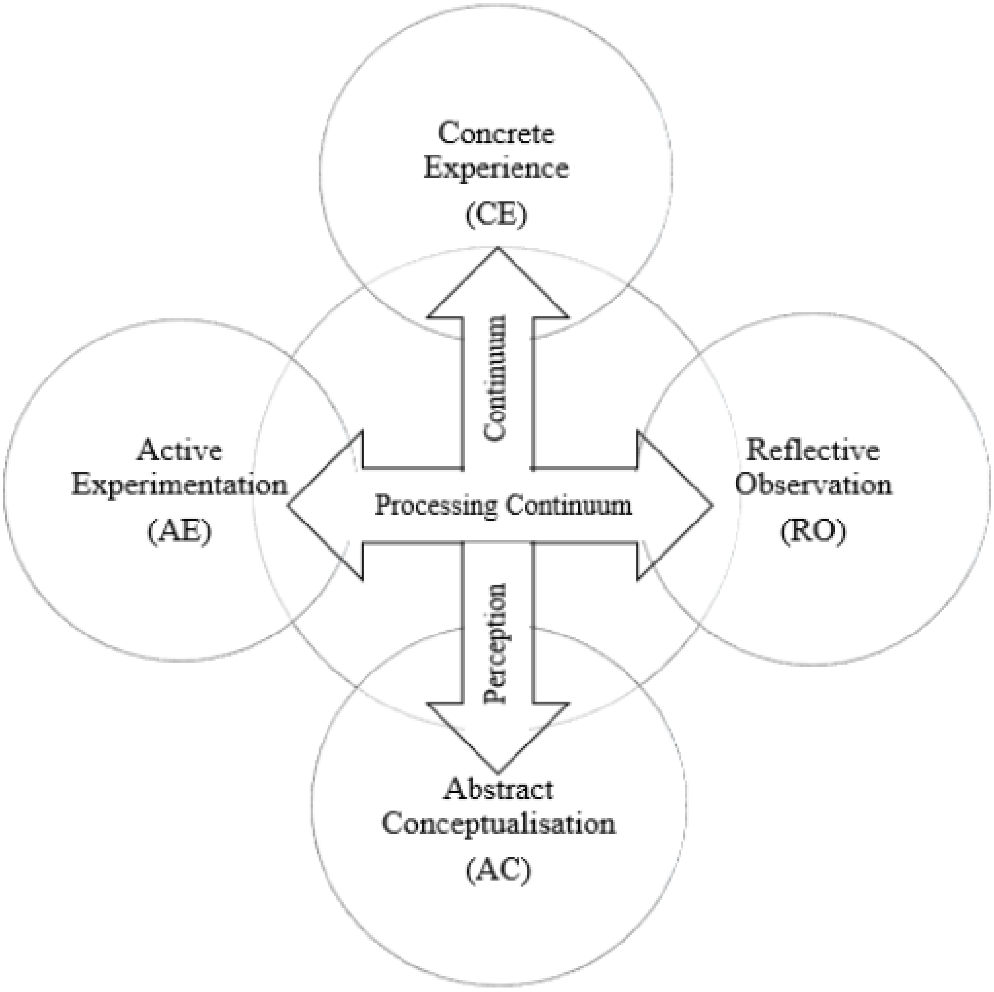

Figure 1. The Experiential Learning Cycle (Kolb, 1984)

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Appendix 2Q

(Petersen *et al.*, 2020)

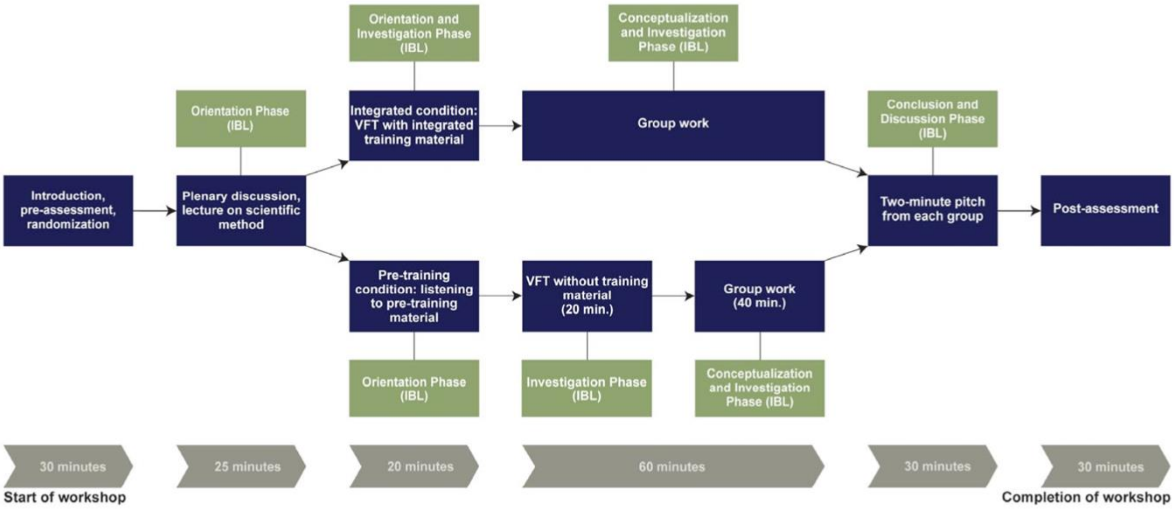

Figure 1: Overview of the workshop and its connections to the phases of IBL

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Appendix 2R

(Riegel and Kindermann, 2016)

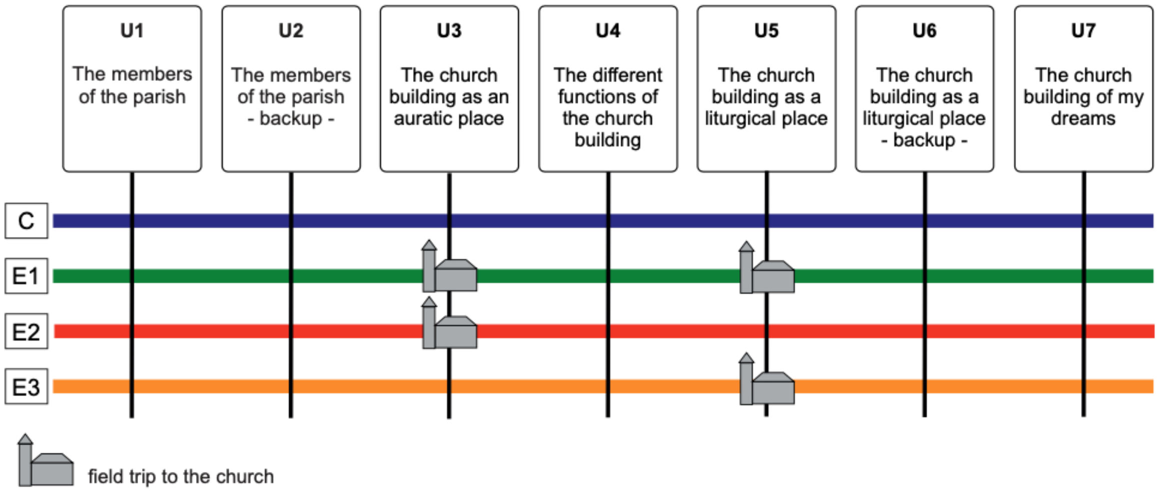

Fig. 1. The sequence with three different treatments (E1, E2 and E3).

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Appendix 3: Research Instruments

Appendix 3A

(Baierl, Johnson and Bogner, 2021)

Table A1. Thirteen system knowledge items and their multiple choice answers; there is always one correct answer, so the students could score up to thirteen points.

	Questions	Multiple Choice Answers
1	Only _________ can turn sinlight energy into food.	∘ Animals ∘ Plants ∘ Water ∘ Air
2	Which of the following shows a food chain inproper oder?	∘ Sun → animals → plants ∘ Plants → sun → animals ∘ Animals → sun → plants ∘ Sun → plants → animals
3	Which of the following would there be the greatest number of in a food chain (munchline)?	∘ Plants ∘ Animals that eat plants ∘ Animals that eat animals ∘ They are all equal
4	Which of the following is most true	∘ I am made of new materials that have never been part of anything else before. ∘ I am made of recycled materials that have been part of other things in the past.
5	The materials that everything is made of:	∘ Stay in one place forever. ∘ Move in a line, never returning to where they started. ∘ Move in circles, often returning to where they started.
6	"I can do just one thing wihtout affecting anything else." This statement is:	∘ True ∘ False ∘ Sometimes true, sometimes false
7	Which of the following is most true?	∘ Everything is constantly changing. ∘ Nothing is changing. ∘ Some things change, but some never do.
8	If a place is now a desert,	∘ It could never be an ocean. ∘ It may someday be an ocean. ∘ It will for sure someday be an ocean.

Table A1. *Cont.*

	Questions	Multiple Choice Answers
9	Where do plants get the energy they need to live and grow?	∘ Sun ∘ Water ∘ Soil ∘ Sun, water, and soil
10	Take a look at you pencil. Where the materials that make your pencil ever part of something else?	∘ Yes, the materials were once part of something else. ∘ No, they were never part of something else.
11	Animals use energy that helps their bodies to live and grow. They get that energy directly from:	∘ Sun and water ∘ Plants and sun ∘ Plants and animals ∘ Water and plants
12	People use energy that helps their bodies to live and grow. They get that energy directly from:	∘ Sun and water ∘ Plants and sun ∘ Plants and animals ∘ Water and plants
13	Imagine a ship has wrecked at sea spilling toxic chemicals into the ocean. Could those chemicals end up inside your body?	∘ Yes ∘ No ∘ Not sure

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Appendix 3B

(Bhattacharya, Carroll Steward and Forbes, 2021)

Student interview protocol.

Thanks for talking with me today. I want to ask you some questions about the past couple weeks where you have investigated increasing average global temperatures using EzGCM. There are no right or wrong answers. We want to know more about your experience and learning, so please feel free to refer to your student task document during our conversation.

1. You used a computer-based Global Climate Model- EzGCM to explore the average increase in global temperatures.
   - Can you describe EzGCM in your own words? What is it? What does it do?
   - How do global climate models help us understand the Earth's climate?
2. In Lesson 3, you used [blinded model name] to run two climate simulations and produce a time series of surface air temperature for each simulation. one simulation (Modern_PredictedSST) was used as a reference period (control run) and was compared to a simulation (IPCC_A1FI_CO2).
   - What scenarios do control run and the simulation represent?
   - Why do we need a control simulation?
3. We compared the control run to a simulation where climate is changing (IPCC_A1FI_CO2). What information did this comparison give you about trends in Earth's global surface temperature?
   - Is the Earth's average surface temperature increasing globally?
   - Are they increasing at the same rate?
   - What evidence can you provide in support of your answer?
   - How would you use EzGCM to generate your evidence for increase in Earth's surface temperature?
4. What are temperature anomalies?
   - How do temperature anomalies help us in understanding the trends in global surface temperature?
   - What is the difference between anomalies calculated with hand/excel/google sheets (graph on top) and the model based anomalies (graph on bottom)?
   - Then we created another graph using temperature values from the [blinded model name] (see data below). How does the climate model temperature anomaly time series (see graph on right) compare to the observed temperature anomaly from Lesson 1 (see graph on left)? Why do you think this is? Please explain your reasoning.
5. In lesson 4, you used [blinded model name] to investigate 2 different types of increased carbon dioxide scenarios: The first scenario (IPCC_A1FI_CO2) has gradually increasing atmospheric carbon dioxide levels while the second scenario (Doubled_CO2) has exactly double the 1958 atmospheric CO2 amount (*instantaneous change* simulation).
   - Do you think CO2 concentrations are causing increase in surface air temperature? Why or why not? Please explain your reasoning.

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Rubric adapted from Evidence-Based Reasoning Framework (Brown et al., 2010) for assessing student understanding about the phenomenon of increase in average global surface temperatures.

Components	Scores	Explanation
1. Using data for comprehending the context-phenomenon of global increase in average surface temperatures.	**2**	Student is able to identify variables and describe data and trends in the graphs. Student uses this information to describe the global increase in average surface temperatures.
	1	Student is able to identify the variables and trends in the graphs. Student describes the global increase in average surface temperatures.
	0	Student uses prior knowledge to describe global climate change. Variables or trends are not identified
2. Interpretation of evidence for explaining the correlation between temperature and carbon dioxide concentrations in the atmosphere	**2**	Student identifies the variables and trends on the graphs from [name blinded] to describe the relationship between carbon dioxide concentrations in the atmosphere and increase in average surface temperature.
	1	Student identifies the variables and trends on the graphs from [name blinded] but does not use this information to describe the relationship between carbon dioxide concentrations in the atmosphere and increase in average surface temperature.
	0	Student does not identify the variables or trends on the graphs from [name blinded]
3. Application of evidence in producing a claim	**1**	Student uses observations from data and evidence from [name blinded], for making a prediction about the average surface temperatures in the future
	0	No rules are evident for student's prediction made about the average surface temperatures in the future

Appendix 3C

(Çelik and Tekbıyık, 2016)

Scientific Process Skills Test Sample Question

The table below shows the humidity rates and heat amounts of various types of coal used by different apartments. The table also shows the views of the residents from these apartments regarding the warmness in their houses as well as coal prices per ton. Based on this information, please answer the following questions:

Apartments	The type of the coal	Humidity rate of the coal	The amount of heat emitted from the coal	The views of the apartment residents	Coal price per ton
1st Apartment	Peat coal	75%	Low	*Our house is hardly warm. We are always cold. We need to use 5 tons of coal to feel warm.*	₺ 200
2nd Apartment	Brown coal	50%	Medium	*Our house is warm to some extent. We sometimes feel cold. We need to use 2 tons of coal to feel warm.*	₺ 400
3rd Apartment	Hard coal	5%	High	*Our house is very hot. We never feel cold. We need to use 1 ton of coal to feel warm.*	₺ 600

a) According to the table above, what may be the reason for that hard coal is capable of heating more than peat?

b) Considering the amount of the coal used by apartments for heating, which ones is more efficient and cost-efficient? Why?

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Appendix 3D

(Fisher-Maltese, Fisher and Ray, 2018)

Table 1 Sample of questions from our pre-/post-test

Measure	YES	SOMETIMES/MAYBE	NO
I like eating vegetables			
I like spending time in the school garden			
I help cooking food at home			
It is important that my school has a garden			
I know how to take care of the garden			
Learning how to garden is important			
I eat things grown in the school garden			
I like working with other students in the garden			
I will try new foods at least once			
I read the nutrition label on foods I eat			
I throw all my trash in a trash can when I am outside			
I think it is important to be physically active (play, sports, run, jump rope, etc.)			

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Appendix 3E

(Jose, Patrick and Moseley, 2017)

The Draw-an-Environment Test (DAET) was modified by changing the drawing prompt from ‘My drawing of the environment is ...’ to ‘My drawing of the local delta environment is ...’ This statement appeared at the top of the page with the statement ‘Explain your drawing’ near the bottom of the page. Between these prompts, the paper was blank, leaving space for the student drawing. This modification resulted in a name change to the DALET.

Appendix 3F

(Lo, Lai and Hsu, 2021)

Student Questionnaire Questions
Personal Information
1. Gender
2. Age

Experience of Using Information Applications
1. Do you have computer equipment at home?
2. Is the computer at home connected to the Internet?
3. Have you ever used a mobile phone or tablet?

Digital Literacy Background Information
1. Do you search for information online?
2. Do you use email?
3. Do you use word processing software?
4. Have you ever used mobile applications?
5. In order to meet your needs for mobile vehicles, do you think it is easy to download the application and use it?

Perceived Usefulness
1. I think using this AR application can speed up my learning.
2. I think using this AR application can improve my learning effectiveness.
3. I think using this AR application will make it easier for me to understand the learning content.
4. I think using this AR application can improve my learning skills.
5. I think using this AR application is helpful for my study.

Perceived Ease of Use
1. The download method provided by this AR application is very easy for me to use.
2. The interface function provided by this AR application is very easy for me to use
3. The learning screen provided by this AR application is clear and easy to understand to me.
4. The teaching function provided by this AR application makes it easy for me to complete learning.
5. This AR application is very convenient to use, which makes me think it is usable and easy to use.

Attitudes Toward Using
1. When using this AR application, I prefer to use computers, mobile phones, and other mobile vehicles to learn.
2. When using this AR application, I am confident that I can keep up with the development trend of new technology.
3. When using this AR application, I can learn happily.
4. When using this AR application, I don’t feel anxious about learning.
5. Because this AR application is easy to use, I prefer to use computers, mobile phones, and other mobile vehicle-related devices to learn.
6. Because this AR application is easy to use, it gives me confidence that I can keep up with the development trend of new technologies.
7. Because this AR application is easy to use, it allows me to study happily.
8. Because this AR application is easy to use, so I don’t feel anxious about learning

Behavoral Intentions to Use
1. If I have the opportunity, I hope to use this AR application frequently.

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2. If there is a chance, I am happy to let more people know about this AR application.
3. If there is an opportunity, I hope that the learning content of other subjects can also develop AR applications.
4. If I have the opportunity, I hope to use mobile vehicles for augmented reality courses.

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Appendix 4: Partner Country Pedagogical Models

Appendix 4A (Finland): Pedagogical model: Real-world learning model

Real-World Learning Model

Anna Kettunen, SYKLI Environmental School of Finland, and Maria Aroluoma, Nature educator, Finnish Nature Centre Haltia

The Real-World Learning Model was developed by an international network of environmental educators from the UK, Croatia, the Czech Republic, Germany, Hungary, Spain, Netherlands, Nigeria and Turkey. The Real-World Learning Model provides a comprehensive and flexible vision for learning about sustainable development – a mode for thinking, reflecting, and existing. In particular, it emphasizes on the importance of outdoor learning!

Effective environmental education and outdoor learning include six elements that are presented in the Real-World Learning model:

1. FRAMES

Do the frames provide a structure and story for better learning?

Frames strongly influence how we understand and interpret the world around us. The word "nature" provokes various memories and emotions. In this model, the frame is found in the palm of the hand, ensuring that values, empowerment, experience, transferability, and understanding are connected to a solid and sustainable learning experience.

At its best, frames guide the teacher and learners, allowing for self-directed learning. Frames also provide the learner with a deeper understanding by collecting details into a bigger picture and common story.

2. VALUES

Are the promoted values consistent with a sustainable lifestyle?

Values affect attitudes and actions. Taking care of the well-being of people and the planet is essential in promoting a sustainable lifestyle.

3. EMPOWERMENT

Are learners involved in building a sustainable future?

Empowerment brings learners to the center of the learning experience: We need to recognise and express our ability to act, influence and make a positive change. Participating in activities for the environment enables students to collaborate and take responsibility for their own learning. Everyone can make a difference. The experience of empowerment can help students to act sustainably also in the future.

4. EXPERIENCE

Can learners get in touch with nature?

Learning from nature is a holistic experience - the details of nature can be looked at, felt and touched. In nature, the curiosity of the students often awakes - they see the connections around them and realize they are one part of a larger whole.

5. TRANSFERABILITY

Does the learning process include different aspects of life?

Sustainable development encompasses all aspects of life. Therefore, it is important to help learners combine knowledge, such as scientific concepts or natural phenomena, with personal experiences, activities, and values. This gives learners the opportunity to establish connections locally, globally, and also in relation to nature.

6. UNDERSTANDING

Does the learning process include scientific concepts?

Understanding scientific concepts such as life cycles or climate change require an understanding of the complex chains of life-sustaining interactions. It requires scientific knowledge to be combined with feelings, values, and all of humanity. Exploring the concepts of life in this holistic way develops sustainable thinking and action.

Each element is important in itself, but combining the elements into a whole leads to a deeper and more meaningful learning experience.

The original model can be found at **www.rwlnetwork.org**.

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Reference: Laine, Aulikki, Elonheimo, Meri & Kettunen, Anna 2018. Leap into the Outdoor Classroom: Guide to Teaching Outdoors.

https://ulkoluokka.fi/wp-content/uploads/2020/02/ulkoluokka-enkku-nettiin.pdf

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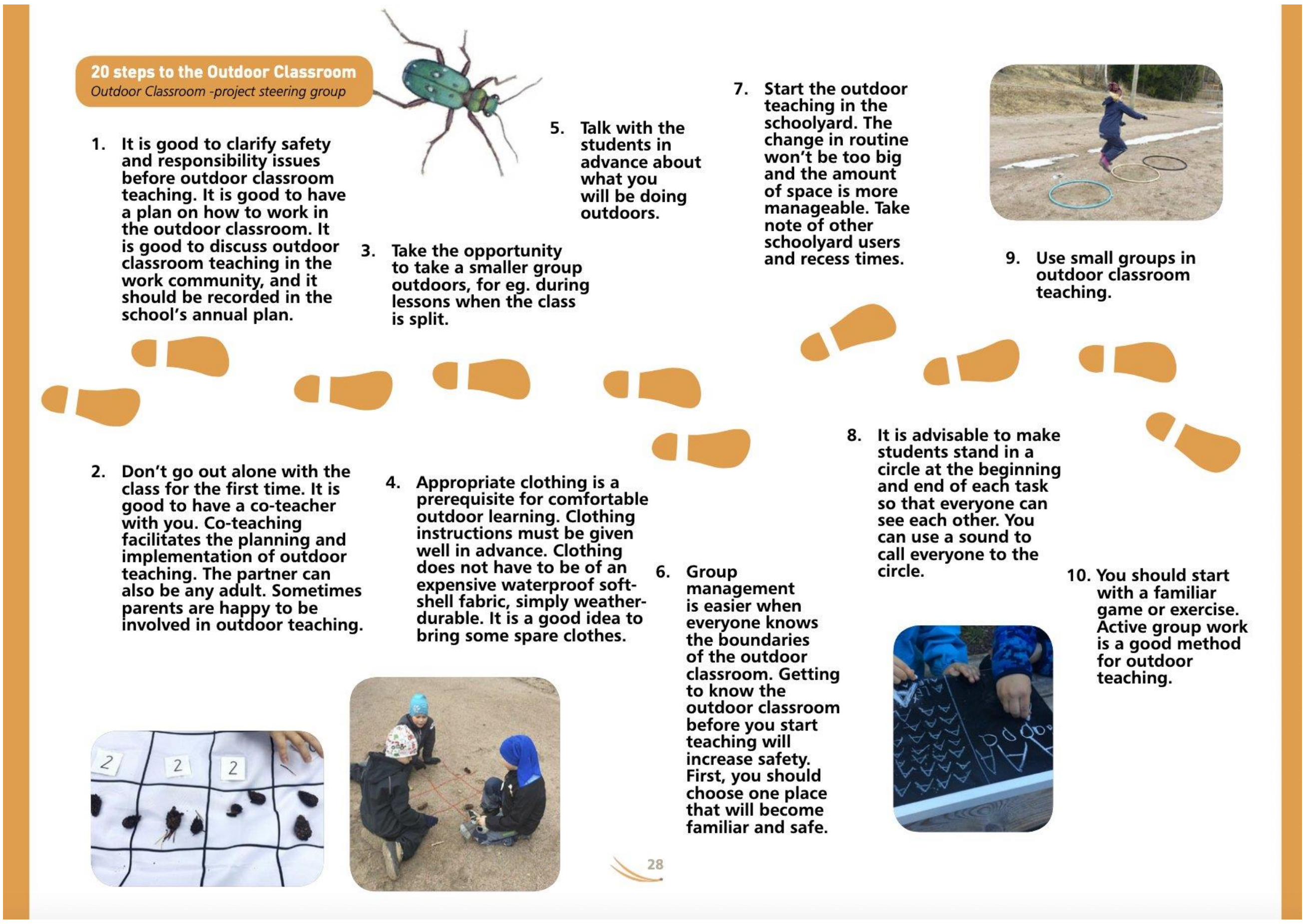
Appendix 4B (Finland)

20 steps to the Outdoor Classroom



20 steps to the Outdoor Classroom

Outdoor Classroom -project steering group

1. It is good to clarify safety and responsibility issues before outdoor classroom teaching. It is good to have a plan on how to work in the outdoor classroom. It is good to discuss outdoor classroom teaching in the work community, and it should be recorded in the school's annual plan.

2. Don't go out alone with the class for the first time. It is good to have a co-teacher with you. Co-teaching facilitates the planning and implementation of outdoor teaching. The partner can also be any adult. Sometimes parents are happy to be involved in outdoor teaching.

3. Take the opportunity to take a smaller group outdoors, for eg. during lessons when the class is split.

4. Appropriate clothing is a prerequisite for comfortable outdoor learning. Clothing instructions must be given well in advance. Clothing does not have to be of an expensive waterproof soft-shell fabric, simply weather-durable. It is a good idea to bring some spare clothes.

5. Talk with the students in advance about what you will be doing outdoors.

6. Group management is easier when everyone knows the boundaries of the outdoor classroom. Getting to know the outdoor classroom before you start teaching will increase safety. First, you should choose one place that will become familiar and safe.

7. Start the outdoor teaching in the schoolyard. The change in routine won't be too big and the amount of space is more manageable. Take note of other schoolyard users and recess times.

8. It is advisable to make students stand in a circle at the beginning and end of each task so that everyone can see each other. You can use a sound to call everyone to the circle.

9. Use small groups in outdoor classroom teaching.

10. You should start with a familiar game or exercise. Active group work is a good method for outdoor teaching.

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11. Start with one or a few 15-30 minutes exercises. You can find many ideas with Species Cards from: ulkoluokka.fi/materiaalit/. Keep a relaxed schedule, so there is time to take in the natural surroundings.

13. Own your outdoor classes. Take advantage of your own strengths!

15. Ready-made lessons and plans can readily be found on the Internet. For e.g. MAPPA, the Finnish Material Bank for Environmental Education is a good source. www.mappa.fi

17. Many organizations provide in-service trainings for teachers. Take advantage of training opportunities to make outdoor teaching easier to begin.

19. Invite an expert to school: a bird-watcher, scout, leisure fisherman, nature enthusiast, backpacker.

12. Be forgiving towards yourself when starting outdoor teaching. New environment will offer a lot, but it will take some time time for the teacher and pupils to get adjusted to the new teaching style.

14. There is more than information-based learning. In the outdoor classroom, know-how and skill-oriented education is easy to apply.

16. Various organizations lend supplies for outdoor teaching. For eg., nature and environmental schools lend outdoor teaching materials.

18. Go with a class to a nature school and apply what you learn from the nature school teacher. Find someone who can advise. www.lyke.fi

WWF, Essi Aarnio-Linnanvuori

20. Network! Find other outdoor teachers from Facebook groups and learn from them.

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Reference: Laine, Aulikki, Elonheimo, Meri & Kettunen, Anna 2018. Leap into the Outdoor Classroom: Guide to Teaching Outdoors. https://ulkoluokka.fi/wp-content/uploads/2020/02/ulkoluokka-enkku-nettiin.pdf

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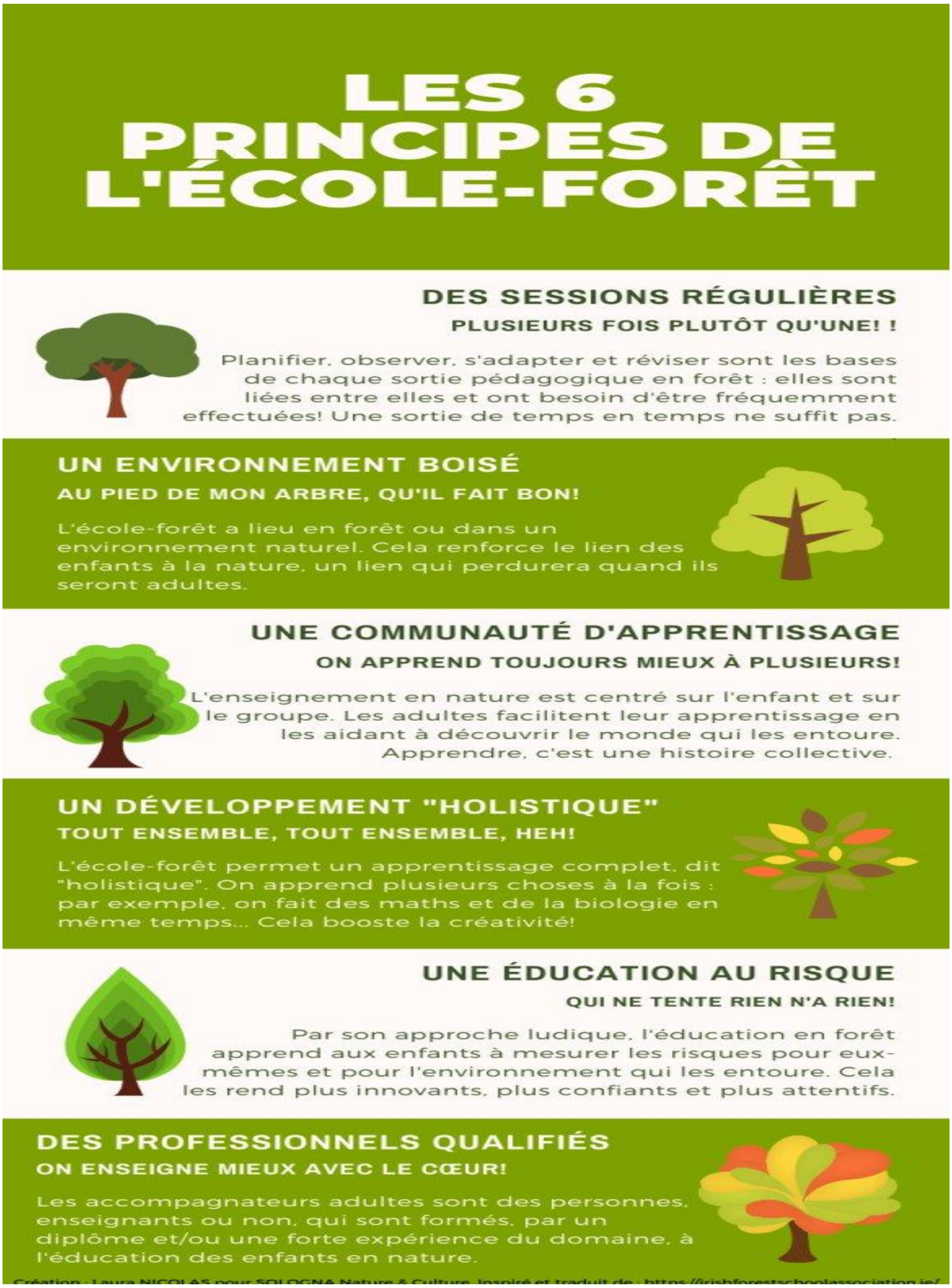
Appendix 4C (France)

The six principles of forest school by Laura Nicolas, University Paris-Est Créteil (https://mapetiteforet.fr/la-sylvopedagogie/)



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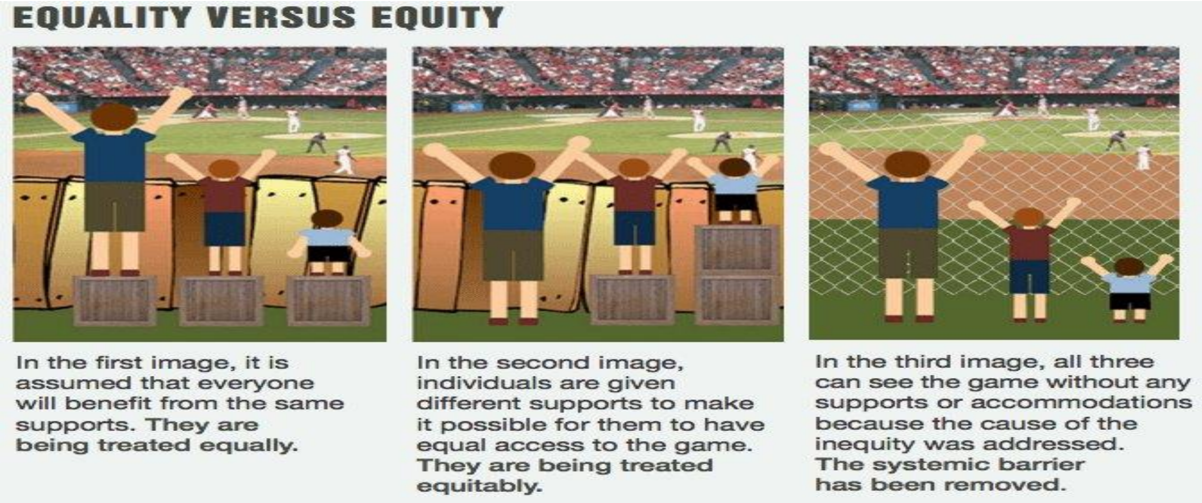
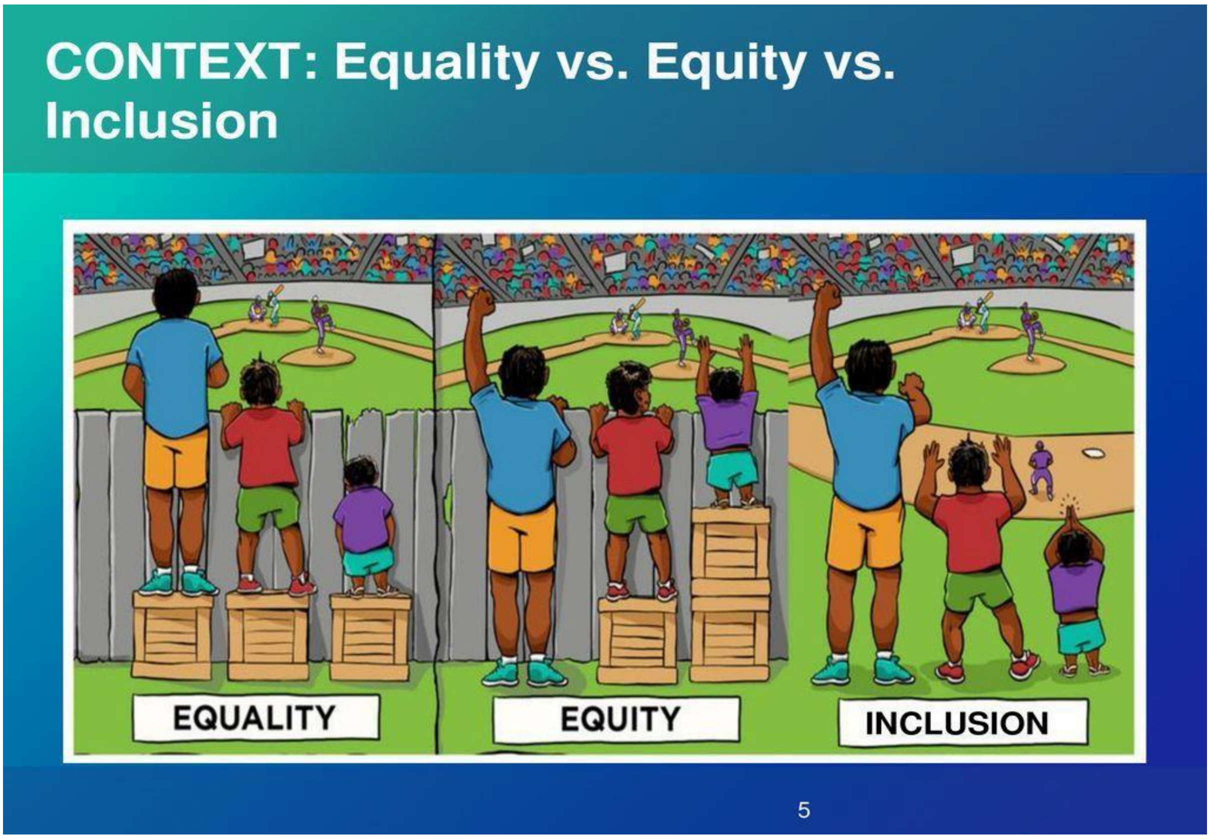
Appendix 4D (France)

The concepts of equality, equity and justice (inclusion) by City for All Women Initiative (https://www.cawi-ivtf.org/sites/default/files/publications/advancing-equity-inclusion-web_0.pdf)





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Appendix 4E (Hungary)

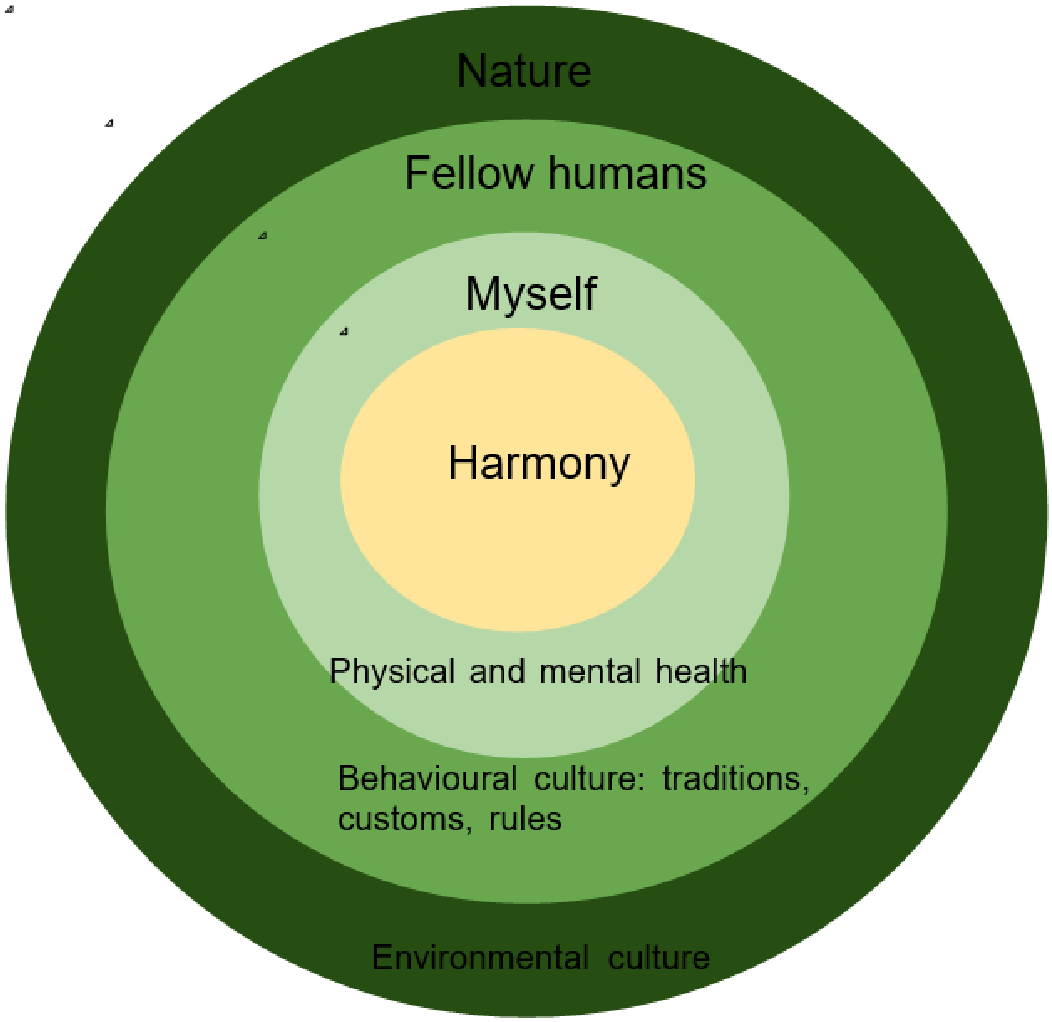

Figure 1.: Theoretical concept of Forest Pedagogy project

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Appendix 4F (Hungary)

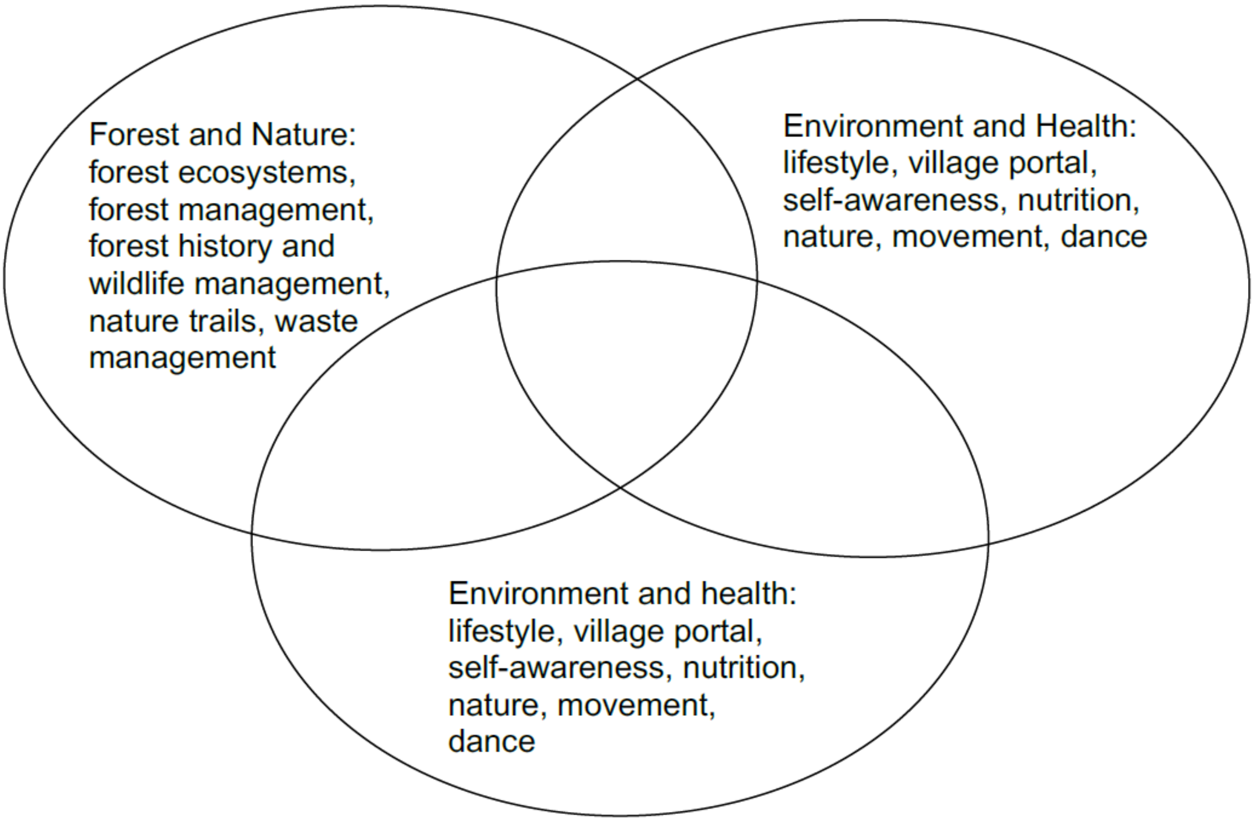

Figure 2.: Moduls of Forest Pedagogy project

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Appendix 4G (Hungary)

Urban Values Programme (UVP) - Activities and pedagogical experiences of UVP

Students will be accompanied on the thematic journey by an avatar. 5-6 lines of informative texts complement each station. These are linked to questions that develop reading and reading comprehension. In addition, observation, estimation, poetry recitation, logical deduction, internet information retrieval, and summarising are associated with each station. A compass shows the players the way. They have to discuss it, they have to decide which way to go. This is especially true for a walk in the woods, to go in the direction that will hopefully turn in the right direction (cooperation, orientation). An online programme was used to create the route map (Reddmenta.com). The teacher who developed the programme insisted on a paper route map. Real paper - real presence in space. It is useful to have an edited activity book (a division of labour, cooperation, communication of knowledge, multi-directional attention, text comprehension) Photo-taking is one type of task. It can be capturing an object or taking a selfie with the sculpture. Photography - the creation - forces the attention to the object to be presented. The didactic justification for self-photography (selfies) is given by constructivism: the person represented by the work becomes part of the group. The practical advantage of self-portraits is that you cannot cheat, you have to go to the scene.

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Appendix 4H (Hungary)

Stops/places	Exercise	Didactic aim	Observation
1.Soviet Republic statue	"Prepare a living sculpture of one of the players with the same posture as the sculpture. Upload a picture of it."	"Getting in the mood"	The young people posed, laughed and soon forgot that they were performing a "compulsory" task, they became motivated
	"You see a statue from 1955. With the block of flats as a backdrop, perhaps the last piece of socialist realism. Notice that the building is part of the composition, the building is in poor condition, in contrast to the nice park".	There is no specific task, just guiding the gaze by the avatar. A call for attention, - "see, not just look." - The natural (biological) and built environment as a whole.	They look around, paying attention to what they saw.
	"There is no wrong answer to this question. How do you like it? 1. ugly - 9 artistic perfection."	This task is not scored, taste is not "graded"! A "beauty contest" is a way of forming an opinion. This is particularly difficult in the case of a socio-realistic sculpture.	They were embarrassed. It was difficult for them to express their own opinions, they were waiting for each other.
	"On the four-metre pedestal stands a sailor holding his gun aloft. How tall do you think the soldier is?"	Observation, estimation, attention to detail.	They asked each other at length if the pedestal counted (text comprehension). Estimates here and later were close to accurate.
"Find him! (next stop) If you are in front of the sign, keep going."		Orientation, distance estimation, search - motivation.	They showed each other the direction, the distance. They argued about which way to

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			go, reassuring each other that "this way is go
2. Memorial plaque of Lajos Wolfner "He founded his tannery at the end of 1841. In 1884 he was granted the right to use the Hungarian state coat of arms. At the turn of the century, it was the only leather military equipment factory of the Hungarian Royal Army. Ferenc József conferred on him the title of nobility."	"Who is he? Lipót Aschner Gyula Ugró, Lajos Wolfner"	Ki kell mondani a nevet (konstrukció). Más helyi hírességek neve is elhangzik.	Könnyű kérdés, gyors válasz.
	"Answer the first question of the route map!: Why did he get a plaque?"	It was necessary to understand (use) the plaque and the telephone information text together. Understanding the text, getting the message right.	Focus on the whole of the information, positive reinforcement, correct answers.
	"If you face the plaque, what's across the road behind you on your left? K........ F..........Ó" (dog run - kutyafuttató)	The dog run (and weeping willow) is not a dominant piece of the urban image, but it is part of the environment, and the point is to look around, notice it, place it in the geographical space.	They were looking, paying attention to detail. "- There's an ice creamery over there (f and o) - can't be, it's far away, and not on the other side," it was said.
	"What tree stands opposite the house corner?" (weeping willow)		Not everyone knew the species.
"Once you have answered three questions, go to the next one station! Next..."		See above	See above

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3. Memorial plaque of Lajos Bródy	"When did the Újpest Municipal House work in this building?" A very tricky question because the text on the plaque is very (As many adults, including teachers, were shown the answer, they all got it wrong.) "We've made up some words. You have to put it on the waybill. You have to write them on the pass."	Reading comprehension; "pay attention to detail"; motivational provocation.	They got the answer wrong, were surprised by it, looked for the reason for the mistake. They carefully reread the top of the board.
	"We've put off a few words. You have to write them down on the road map."	Highlight key words.	We gave the first letter as a hint. The observation was not correct because the player was no longer paying attention to the content but to the form.
"Find this place. If you find it, go on..."		See above	See above
4. Synagogue	"Built between 1885 and 1886, it was one of Újpest's first representative public buildings. Due to the population explosion, it was enlarged in 1909 based on the plans of Lipót Baumhorn." "What does the word Friesian mean?"	Knowledge transfer; vocabulary; thought-provoking; developing a culture of debate.	The debate developed with real arguments. Relief or ribbon-like decoration running along the wall? (Both are true of the object seen.) They searched their memories, argued and convinced each other, voted. After the previous exercise, they were wary of being "tricked". (critical thinking)
	"Where are the figures in the frieze marching to?"	Pay attention to the details. The picture on the phone does not show the wagons -that answers the question -so they have to look up.	They look up, they analyse what they see.

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	"The frieze was carved by Edit Kiss Bán Kiss in 1947-1948, she was also deported in the autumn of 1944. On the first hill, they march towards the wagons, on the second they arrive at the base of tall chimneys, hunched figures push a candelabra, on the fourth Soviet soldiers arrive. Estimate the size and material of the frieze."	Knowledge, estimation.	They told what they could think of about the rocks (limestone vs. marble). In terms of size, they argued about the curved shape of the work, its optical illusion.
"Find the plaque! When you get there, continue..."		See above	See above
5. Monument of Vajk-István	"The pedestal and the plaque are embedded in the wall of the building. Read the plaque at the bottom, how was it possible?" (The municipality and the design office had already cooperated during the construction. The information is in the bottom corner of the building	A good example of cooperation; the information is not noticed without help, but if it is pointed out, it can provide a positive experience; knowledge transfer	
	"Another interesting thing is that it commemorates Vajk - István ... why are these two names together? Write it on the waybill!"	Confirming knowledge; unusual to mention the former and later names together.	They were hesitant, finding it difficult to remember the historical knowledge. "It's like a mother's maiden name," someone said of the funny simile.

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	Uploaded a selfie with Vajk!	The historical person becomes part of the team - construction	They were happy to do it
“Find the next station!”		See above	See above
6. The memorial plaque of István Károlyi	"How old was he when Újpest became an independent settlement?"	It had to be understood, it had to be figured out how, and it had to be calculated and written down on a piece of paper.	
	"We agree that memorial plaques should not be classified as statues? How many memorial plaques do you think there are in Újpest?"	Sensitisation; it's not the number that's important, it's building in their knowledge: these many memorial plaques are all bearers of our past.	They Googled it and were surprised to see how many.
"Walk to the statue by the entrance! go on..."		See above	See above

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7. Queen of Heaven parish	On a two-metre pedestal, a red marble cross about two metres high. How tall do you think the corpus is?	observe, estimate	they hesitated for a long time
	The corpus used to be painted. What could the material be?	Critical thinking, attention to detail	They could not believe their eyes. When they touched the corpus, they realized the sculpture was metal (acting learning). "Not everything is what it seems", someone said.
"Walk around the church! When you reach the marked point, go on..."		See above	See above
7/a. Short stop next to the church	"How many windows does the church have on this side?" Don't you think it's strange that the Town Hall and the church have their backs to each other and the square is split up by the buildings? Look at the picture and imagine a promenade to the Danube river, without a market building and car parking!"	Sensitisation	Most of the children are already tired.
"We'll walk behind the church ... when you get there, keep going..."		See above	See above

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Trianon Monument	"The statue was unveiled in 1937 in Újpest, on István Square. In the time since its inauguration, it has stood in front of a vocational school, among other places, and for a long time, it was also in a warehouse. In 2010, on the occasion of its reinstallation, it was inaugurated again. Questions on the Road map!"	inductive thinking	They focused not on the years but on the logical sequence.
	Read it - pick it up - upload it!" "On the pedestal, you see a quotation from Vörösmarty. Fill it up!"		They read and interpreted the text attentively. They cheerfully suggested to each other who should be the poet. They paid attention to the emotional message of the poem - whether their partner was saying it right.
Market and patisserie	"Make a sketch map of your route!"	Summary of experiences	There was a conflict of opinion between the children about the exact route.
	"Eat your reward cookies!"	Positive reinforcement	The programme ends with a sense of happiness.

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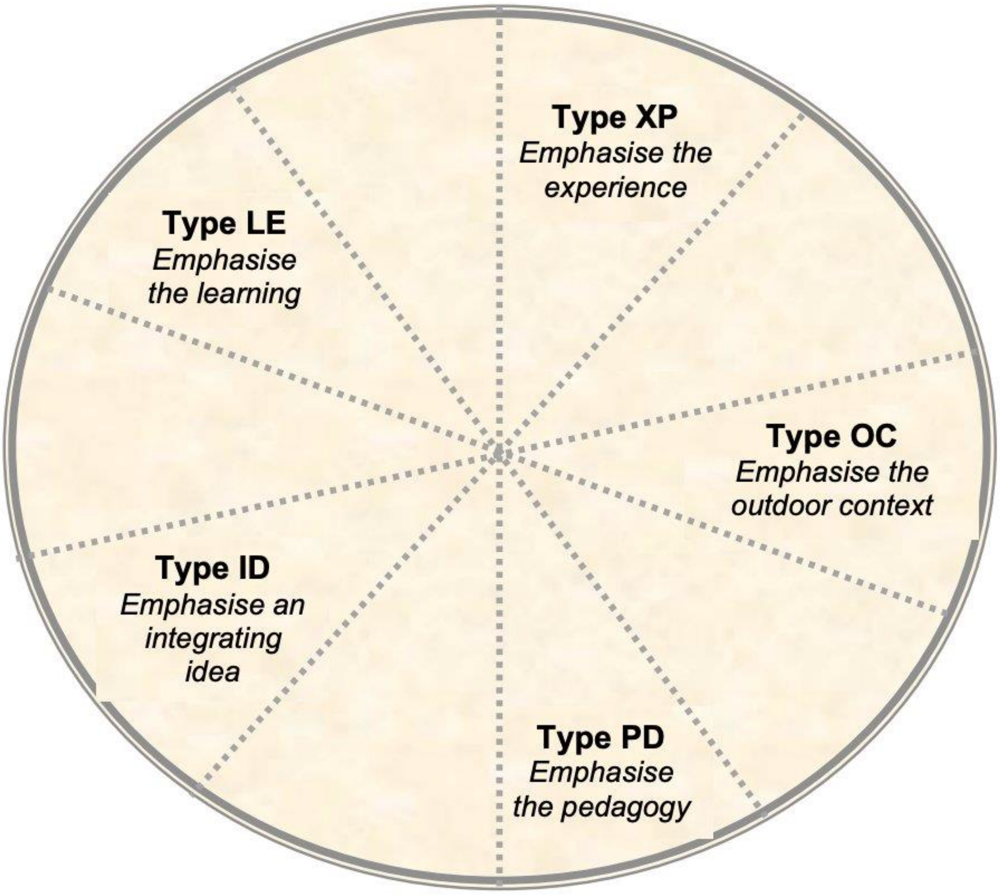
Appendix 4I (The Netherlands)

The range and effectiveness of approaches to outdoor education: towards a typology. National Foundation for Educational Research in England and Wales Dillon, 2005 (p.55-73).



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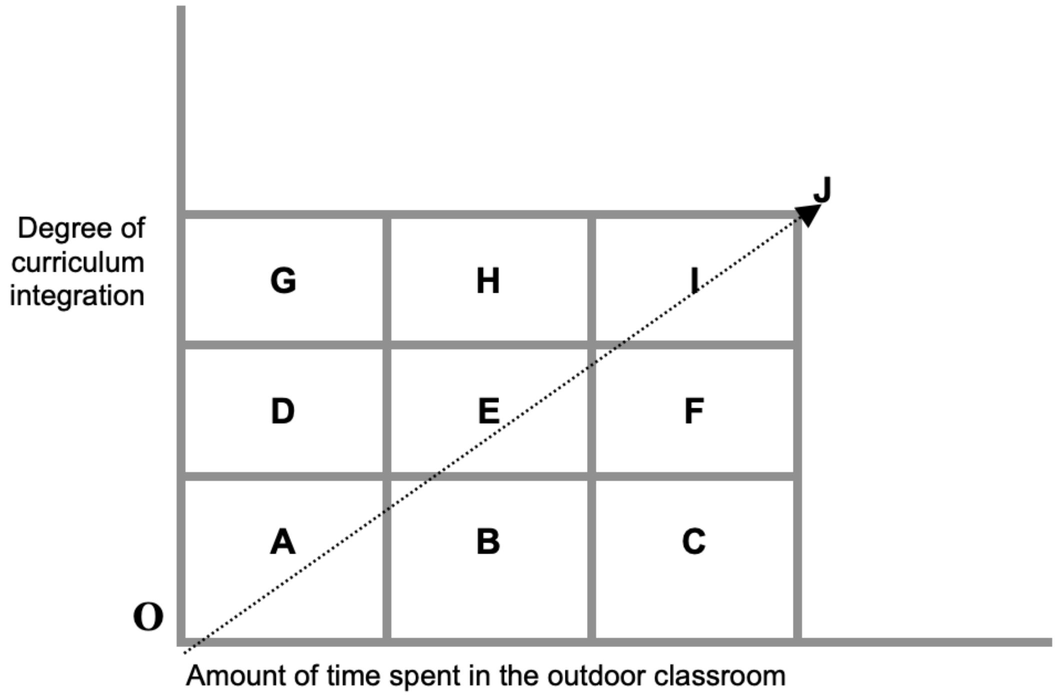
Appendix 4J (The Netherlands)

Different uses of the outdoor classroom. National Foundation for Educational Research in England and Wales Dillon, 2005 (p.47)



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Appendix 4K

In addition, we list **nine previous reviews** that can contribute to the OTTER tasks and deliverables. More details about selected works are in table T2.1_RUG.xlsx.

These reviews had relatively different questions from each other, and different goals than the OTTER literature review but are still worth considering given their contributions to the topic. Some evaluated programs rather than research articles, but they bring a well-grounded discussion with potential contributions to OTTER discussions.

Title	Year	Link	# papers
Landscapes of becoming social: A **systematic review** of evidence for associations and pathways between interactions with nature and socioemotional development in children	2021	https://doi.org/10.1016/j.envint.2020.106238	223
The outcomes of nature-based learning for primary school aged children: a **systematic review** of quantitative research	2021	https://doi.org/10.1080/13504622.2021.1921117	20
A **Critical Review** on the Impact of Combining Outdoor Spaces and Nature with Learning Spaces on Students' Learning Ability	2020	https://dergipark.org.tr/en/download/article-file/1221871	* critical review
'Do you need a kayak to learn outside?': a **literature review** into learning outside the classroom	2019	https://doi.org/10.1080/03004279.2018.1444074	173
Mental, physical, and social health benefits of immersive nature-experience for children and adolescents: A **systematic review** and quality assessment of the evidence	2019	https://doi.org/10.1016/j.healthplace.2019.05.014	84
Effects of regular classes in outdoor education settings: A **systematic review** on students' learning, social and health dimensions	2017	https://doi.org/10.3390/ijerph14050485	13
Environmental education **program evaluation** in the new millennium: What do we measure and what have we learned?	2014	https://doi.org/10.1080/13504622.2013.838749	*86 programs
An evaluation of characteristics of environmental education practice in New Zealand schools	2008	https://doi.org/10.1080/13504620701843343	*200 cases
Learners and learning in environmental education: A **critical review** of the evidence	2001	https://doi.org/10.1080/13504620120065230	100

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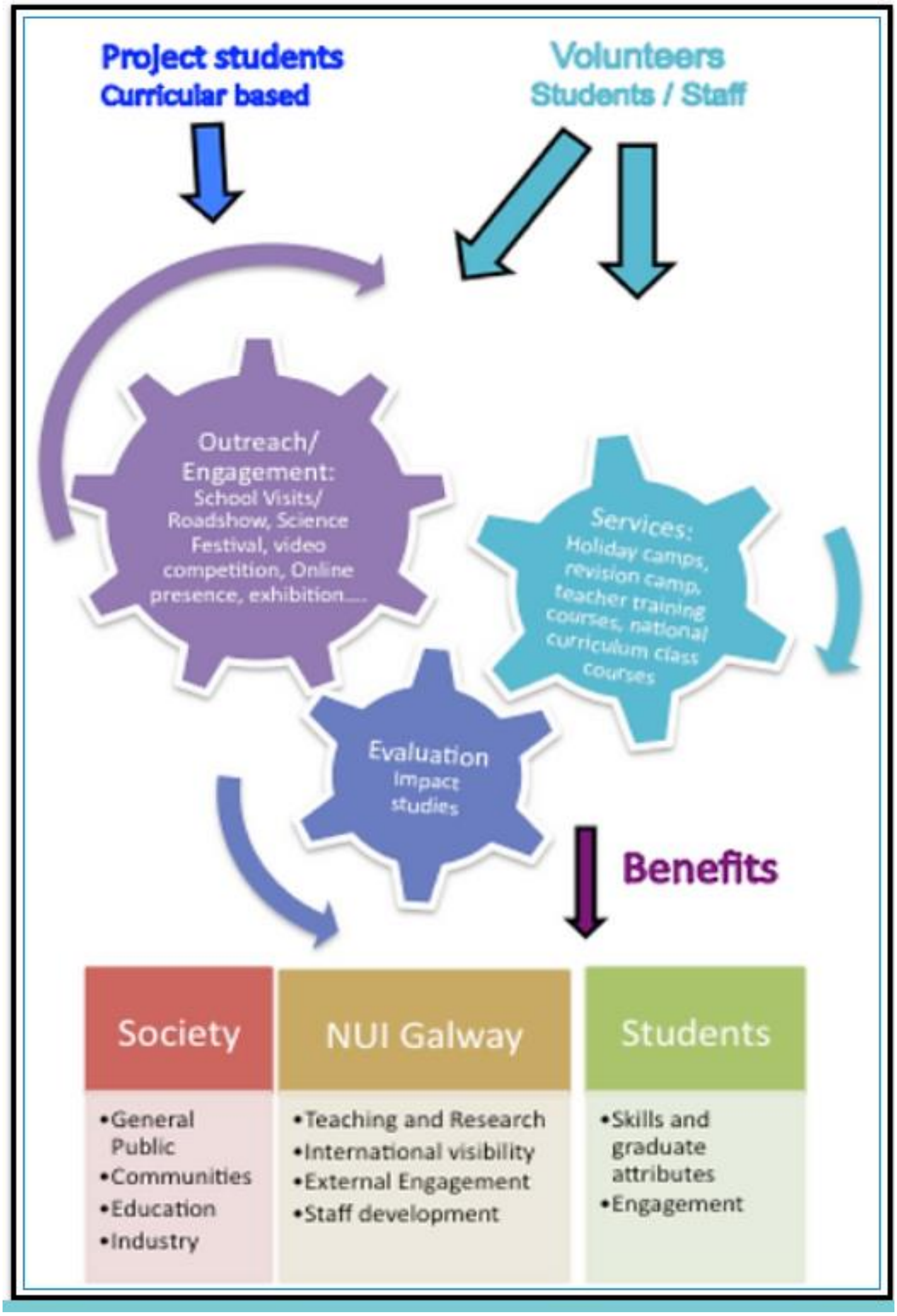
Appendix 4L (Ireland)

(NUIG, 2021)



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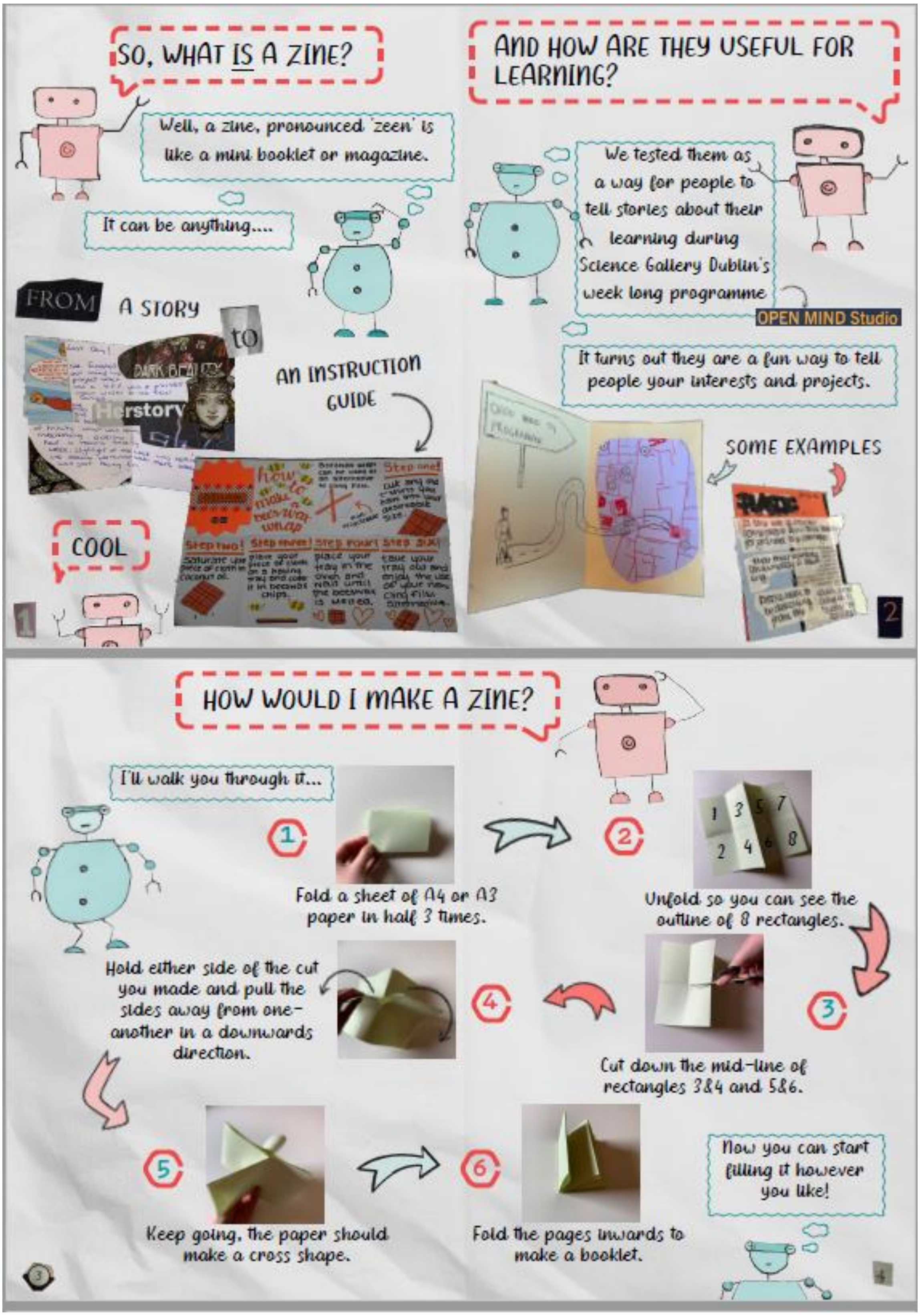
Appendix 4M

(SySTEM 2020, 2021)



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Appendix 4N (Spain)

https://aprendiendoalairelibre.es/resource/formulario-de-evaluacion-riesgo-beneficio/

APRENDIENDO AL AIRE LIBRE

DOCUMENTO DE EVALUACIÓN DE RIESGOS Y BENEFICIOS: EJEMPLO

Lugar / Actividad:		**Fecha:**	
Evaluador:		**Fecha de revisión:**	

La valoración media que le des al riesgo - baja, media o alta- está basada en tu propio juicio según consideres si los BENEFICIOS de la actividad u oportunidad pesan más que los RIESGOS.

ACTIVIDAD	¿Cuáles son los BENEFICIOS de la actividad para los niños?	Posibles peligros	¿Quién está en peligro?	PRECAUCIONES existentes para reducir el riesgo de lesiones	Riesgo medio PUNTUACIÓN: B/M/A
PLATAFORMA JUNTO AL ESTANQUE: Bordes y entablado resbaladizos en el estanque	El entablado permite el acceso al estanque y es un elemento fundamental para explorar el hábitat.	Resbalones, tropiezos y caídas. Cortes, rasguños y quemaduras por abrasión. Ahogamientos.	Jóvenes y adultos.	• Orillas poco profundas y con plantas para evitar que los niños entren de forma accidental. • No acceso a la orilla para los niños; uso únicamente del entablado o área de la "playa". • La parte más profunda se encuentra en el centro del estanque: mantenerse cerca de la orilla. • Perímetro del estanque limpio de follaje denso y/alto para que los límites de este sean visible pudiéndose evitar. • Plataforma libre de elementos que puedan causar tropiezos (por ej., redes, cubetas...). • Normas para el uso del estanque expuestas de forma clara y revisadas al principio de cada sesión.	Baja

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