How to develop and implement teaching projects in outdoor education

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Abstract

Learning through projects can raise interest and motivation, and support the construction of competencies, disciplinary, and interdisciplinary knowledge via working on real-life problems in realistic settings. One form of project-based learning is outdoor education, that is, situating learning and instruction in settings outside the regular classroom. We present a course for students in the teacher education program at ETH Zurich that implements project-based education on two layers: the course itself is project-based, and the pre-service teachers create project-based outdoor teaching units during the course. We describe how we balance freedom and guidance, and scaffolding in the course design. In addition, we report how students respond to and evaluate our course, and discuss challenges and opportunities for lecturers. By presenting sample projects and insights from the implementation and continuous development of the project-based course, we aim to inspire and guide lecturers at ETH Zurich and other universities who consider implementing project-based courses in their teaching.

1. Introduction

Authentic project-based learning environments can serve as an effective and motivating instructional approach in higher education. Learning through projects has the potential to stimulate learners' motivation and interest, benefit the construction of diverse knowledge and both intra- and interpersonal competencies simultaneously, and allow learners to get in contact with authentic challenges and demands they will encounter in their future work (e.g., Boss & Kraus, 2018; Chen & Yang, 2019; Wijnia, et al., 2017; Wijnia et al., 2024; Zhang & Ma, 2023). However, to realise this potential, project-based learning environments need to balance freedom of the learners with teacher guidance and scaffolding. Achieving this balance is of particular importance for outdoor project-based learning (for a broad overview of outdoor learning see Jucker & Au, 2022).

In this article, we describe a course that implements outdoor project-based learning in the teacher education program at ETH Zurich. Essentially, this course makes use of project-based learning on two layers: A) Our students who will become Gymnasium teachers in STEM subjects are tasked to create a teaching unit that they could perform with Gymnasium pupils (the Gymnasium is the highest secondary school track in Switzerland which, after successful graduation, provides direct access to universities). B) We organize the whole course to result in a project-based outdoor weekend, for which the students also need to prepare food and

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shelter. This format follows a train-the-trainer structure[2], insofar as it aims to enable pre-service teachers to conduct outdoor learning in their future job.

In the following, we first discuss foundations of outdoor project-based learning in general, and the peculiar aspects that need to be considered. Afterwards, we describe our course. In the third part, we reflect on our experiences over several iterations of the course and we discuss how our specific experiences may inform other outdoor-based learning opportunities such as field trips and excursions.

1.1 Foundations of outdoor project-based learning

Project-based learning can have a substantial effect on learners' motivation (Wijnia et al., 2024) and academic achievement (Chen & Yang, 2019) compared to traditional instruction but needs to be implemented carefully taking various pitfalls into account to be effective. The first differentiation regards the type of outdoor learning (Rickinson et al., 2004; see also Imhof, 2016): Outdoor learning activities that focus on adventures can be categorized as *outdoor adventure activities*; learning activities that are carried out in the immediate school environment can be categorized as *school ground and community projects*; and learning activities that involve visiting a place to explore something can be categorized as *fieldwork and outdoor visits*.

Outdoor project-based learning could be subsumed under the fieldwork and outdoor visits category. However, it does not put a specific site in focus, but focuses on how to plan and implement project-based learning. Outdoor project-based learning is typically interdisciplinary, and results in a product at the end of the unit (e.g., a soup, a catapult, a solar cooker, a pyrolysis cooker, a drawn map; see Table A1).

In so-called WEIRD (westernized, educated, industrialized, rich, democratic) countries, formal education in schools and universities mainly takes place indoors. However, outdoor learning warrants itself for some topics, that either cannot be taught indoors for practical reasons (e.g., shooting a water rocket as high as possible) or that offer a direct experience 'in-vivo' (e.g., which plants are growing in this area). Ayotte-Beaudet et al. (2017) identified two main reasons for outdoor education: increasing environmental concerns and enhancing science education. The idea is that knowing one's environment is a prerequisite for protecting it. Project-based learning that is based on real-world problems and allows for reflection is also an important component of transformative learning (e.g., Getzin & Singer-Brodowski, 2016). Another strength of outdoor education is that it allows for drawing links between subject areas, enabling interdisciplinary projects. Table A1 in the appendix lists examples of teaching units from various iterations of our course illustrating how different topics and subjects can be combined.

Implementing project-based learning in an outdoor setting is typically more resource-intensive than staying indoors. For example, travel needs to be organised, potential safety issues assessed, and materials transported. Ayotte-Beaudet et al. (2017) list several challenges that teachers meet when organizing outdoor education, ranging from planning concerns to inadequate preparation and a lack of time. We suggest that these additional requirements should not be seen as additional costs, but rather as part of project-based learning given that its aim is to learn with authentic challenges. Making challenges authentic often requires leaving the classroom. Besides the higher resource intensity, planning outdoor project-based learning needs to consider four aspects: structure and alignment, assessment challenges, situatedness, and equity issues. We will discuss these four aspects using the building a solar cooker as an example (see Figure 1).

[2] We thank an anonymous reviewer for this categorization.

Figure 1: Self-Made Solar Cooker constructed out of a cardboard box, aluminium foil, transparent film, and glue.

1.2 Structure and alignment

Project-based learning activities need careful instructional preparation, similar to other forms of instruction. Biggs (1996) coined the term 'constructive alignment' for this requirement. He emphasized the necessity of aligning the courses' objectives (learning goals), the teaching/learning activities, and the assessments *for* learning (i.e., formative assessment, Black & Wiliam, 2009) and *of* learning (i.e., summative assessment, Edelsbrunner et al., 2021). When planning project-based learning activities, the first step is thus to reflect upon the objective(s). What knowledge and competencies are learners expected to acquire through the course? In outdoor education, there are often multiple, intertwined objectives. For example, in our outdoor education course, we have the overarching aim that the students will develop learning materials suitable for an outdoor setting. In addition, they should develop social competencies in jointly planning an outdoor weekend and methodological competencies in how to structure an outdoor weekend, what aspects need to be considered, what resources are needed (e.g., setting up a camp, organizing cooking, anticipating dangers and how to deal with them), and how the outdoor units can be embedded in the 'normal' instruction (e.g., how it is prepared in the classroom and how the experiences from the outdoor units can be used in subsequent classroom lessons). With regard to the solar cooker example, the learning goals comprise that the learners can explain how sunlight can be used for heat generation, that learners can distinguish between different types of heat transfer (conduction, radiation, and convection), and that learners are able to build simple solar cookers themselves.

To align learning goals, instructional methods, and assessment(s), we recommend following a structured approach. Numerous frameworks or models (e.g., Biggs, 1996; Koedinger et al., 2012) and taxonomies of learning goals (e.g., Anderson et al., 2000; Bloom et al., 1956; Marzano & Kendall, 2006) aim to enhance and streamline planning of instruction. Each framework and taxonomy possesses unique strengths and limitations. Despite variations in terminology and structure, these frameworks and taxonomies are not fundamentally distinct. Rather, they seek to convey the same core principle – constructive alignment – but use different levels of granularity. Greutmann et al. (2020) synthesized the existing frameworks and taxonomies with the aim of providing a *pragmatic lesson planning taxonomy*. To make it pragmatic, that is, useful and manageable for everyday teaching, the pragmatic lesson planning taxonomy is less fine-grained than other taxonomies. However, it remains in accordance with the current state of research on learning and instruction. We assume that most educators are familiar with a taxonomy of learning goals. Given that no empirical research has yet competitively tested the taxonomies against each other, we refrain from recommending one. However, for planning and designing project-based learning activities, we urge educators to follow the core principle (constructive alignment) supported by a taxonomy of their choice: define learning goals, plan suitable instructional formats to achieve the goals, and plan the assessment of the achievement of the goals in advance.

Designing effective teaching projects for outdoor education requires not only following a structured lesson planning process, but also providing a clear structure regarding the environment in which these projects will take place: outdoors! In formal educational settings in Switzerland and Central Europe, most teaching takes place in school or university classrooms. In such cases, the room itself provides a well-structured environment. Entering and leaving the room can be seen as a *temporal* structure; the way how tables, chairs, projectors, whiteboards etc. are arranged provides *spatial* structure. Learners are used to rules or norms that structure the interactions in such classrooms – in pedagogical terms, the environment can be thought of as a third teacher (e.g., Strong-Wilson & Ellis, 2009). When teaching takes place outdoors, these familiar structures no longer exist. Thus, it is important to explicitly negotiate and define rules with the learners before going outdoors. Educators need to be aware that they have less control and learners have more freedom. Thus, precise schedules are necessary to provide orientation for all – where are we at what time? To make outdoor project-based learning effective, this planning needs to be part of the constructive alignment from learning goals to assessments.

1.3 Assessment

Assessment is necessary to make learning and competence development visible. This also holds for outdoor education. Based on the idea of constructive alignment, assessment should be designed during the instructional planning so that it aligns with the learning goals and the instructional setting and will thus provide valid information on whether learners reached the goals.

With regard to planning and implementing outdoor education, assessment thus requires adaption to the specific setting: Firstly, practical aspects are to be considered such as that it is often not possible for the learners to write and take notes (or complete formative assessment tasks). Formative assessment therefore needs to use other modes of indicating responses (e.g., fingers/hands, cards, or digital devices). Secondly, in contrast to learning in traditional formats, learners are at first glance more active in project-based learning, e.g., moving around, sitting in groups and chatting, building something following an instruction. However, superficial activity, such as following the steps of an instruction to create a solar cooker does not necessarily imply cognitive activation. Cognitive activation denotes that learners think and reflect on what they are doing (e.g., Schumacher & Stern, 2023). When they build a solar cooker, the instructional aim is typically not to just build it, but to understand why certain steps make a good solar cooker, why it works and so on (i.e., the learning goals), how it could be adapted if surrounding conditions change (e.g., strong wind picks up; clouds alternate with sunshine). Thus, it is important to not equate learners' overt active behavior in outdoor education with covert learning processes (Thurn et al., 2023). To promote cognitive activation, it is necessary to structure the outdoor learning activities accordingly. They need to include prompts to make learners think about what they are doing. These prompts should be defined or formulated based on the learning goals. At the same time, these prompts can also be used by the educator for formative assessment: Do the learners understand why a particular design of the solar cooker makes it more effective than another design? What physical principles capture this effectiveness? Taken together, we advocate that outdoor project-based learning is accompanied by formative assessments to scaffold and focus learners, and to make progress and learning visible to educators and learners.

With regard to conducting summative assessment in outdoor project-based learning, we want to stress that summative assessments need to fulfill several requirements, for example, they should be objective, reliable, and valid (for an overview see Edelsbrunner et al., 2021). Being outdoors can pose difficulties in having standardized and comparable conditions for each learner as the environment is much less controllable in comparison to the indoor classroom. At the same time, outdoor project-based learning should be embedded within the standard curriculum – it should be prepared and followed up in the classroom. For example, a summative assessment could consist of having learners collect and document their experiences made outdoors when returning indoors in the form of presentations, papers, or portfolios. These products could be used for summative grading purposes.

1.4 Situatedness

Learning is situated, at least to some extent (e.g., Anderson et al., 2000; Thurn & Daguati, in press). That is, learning occurs in specific situations at specific times, and these specificities are remembered together with the actual content to be learned. Accordingly, learners will often remember the specific project, where it took place and under what circumstances. On one hand, this often results in well-remembered events, as outdoor-projects are so different from the usual context. On the other hand, this situatedness may hinder the flexible transfer of the acquired knowledge and competencies to other projects, everyday demands, or subsequent learning within the classroom (e.g., Engle et al., 2012).

Two distinct transfer challenges emerge in outdoor education. The first challenge occurs when learners go outdoors: They will do activities and work on projects for which they will need knowledge and competencies that they acquired in the regular classroom. When the outdoor project is finished and the learners return to the classroom, the second challenge occurs: Learners need to transfer the knowledge and competencies developed outside to inside the classroom. These two challenges are important to consider when planning outdoor education projects. Educators shall prepare with the learners why they will be doing certain outdoor activities and how these activities build upon the classroom instruction. After returning to the classroom, educators need to support learners in connecting their outdoor experiences with their subsequent indoor learning. As Engle and colleagues (2012) posit, the educators need to create an expansive framing connecting in- and outdoor, that is, being explicit about how knowledge is useful and can be applied in different contexts – for example, how the knowledge constructed in classrooms is important for the outdoor projects, how the outdoor project benefits understanding of general science principles, and why the project matters for continuing education in the classroom. Regarding the solar cooker, when dealing with the topic of solar energy use, educators could introduce the necessary prior knowledge about light absorption, heat transfer, heat radiation in class, and then proceed to the outdoor project of building a solar cooker (if there is not much time outdoors, cookers could be built indoors). By building different solar cookers, the learners can compare and contrast different types, helping them to overcome situated knowledge. Then the cookers are tested outdoors, where they may perform differently in different weather conditions. Back in class, the educator can connect the practical experience of building the solar cooker to the general topic of solar energy use. Again, these aspects highlight the necessity of planning based on constructive alignment. Moreover, it is helpful to communicate the learning goals to the learners (e.g., Reed, 2012) so that they know what the instructional focus of the outdoor project is and receive an advance organizer (e.g., Ausubel, 1960; Mayer, 1979). Optimally, the learning goals connect in- and outdoor learning to achieve expansive framing and thus counter situatedness and foster transfer.

1.5 Equity issues

Learners in project-based learning environments work together and co-create knowledge. They have different backgrounds, interests, knowledge, and competencies. Taking this diversity into account is highly important in outdoor education. Some learners may have a lot of experience being outside, others may spend most of their time indoors. Some may be afraid of certain things, others appreciate and seek challenges. These interindividual differences have to be considered when planning project-based outdoor education.

The heterogeneity of learners is an asset for outdoor education which is often based on group activities, cooperative, and collaborative learning. Learners can benefit from diversity when solving problems or building something together (e.g., the solar cooker as an energy-saving low-budget cooking device). When choosing a specific example for a general principle (e.g., solar energy use with a solar cooker), educators need to be sensitive to the fact that learners may have different interests (Berkowitz et al., 2022), especially as girls may be put off by too 'masculine' STEM topics.

It is important to help all learners achieve the desired learning goals, but also to give them the freedom to choose from a range of topics all suitable for developing the targeted knowledge and competencies and to choose the roles they want to take in group work. For example, some may be better at conceptualising what an effective solar cooker might look like, whereas others may be better at making it. One disadvantage of group activities is the strong knowledge interdependence (e.g., Deiglmayr & Schalk, 2015). That is, some learners may have some knowledge that others do not, as illustrated in the solar cooker example. Since there are typically learning goals which apply to all learners, it is important to design group activities in such a way that even if not everyone has to do everything, they at least learn what certain steps are needed for and how to achieve them. It can be helpful for the success and the acceptance of an outdoor project, if learners are involved in the planning of the activities from the beginning.

2. A course on outdoor education

At Swiss Gymnasia, project-based approaches (project weeks, field trips, etc.) are increasingly becoming part of the curriculum. Teachers are expected to acquire the competencies to design and implement projects, to guide pupils, to foster efficient group-work environments, and to ensure the transferability of the knowledge and competencies acquired through the project. Within the teacher education programme at ETH Zurich, we have therefore designed a course on creating authentic project-based learning environments. The course pursues a broad overarching learning goal: preparing these future teachers for creating and running project-based approaches themselves. The participants in our course are pre-service teachers (denoted as 'students' in the following). During the course, students work in groups and develop a teaching unit that can only be taught outdoors, but which aligns with learning goals that are part of the curriculum and taught within classrooms. From the beginning of the course, all students are involved in the overall planning of an outdoor weekend during which they will test their teaching units.

2.1 Students in our course

Per iteration 10-20 students take part in the course. Our students are enrolled in the teaching diploma studies (except for sport teachers, who follow a different study programme). They differ in their domain-specific knowledge and expertise, as they study different STEM subjects, but also with regard to pedagogical knowledge, as they can choose this seminar freely at different time points in their teacher education studies. To address the heterogeneity, we encourage the students to form interdisciplinary groups, which has often resulted in creative teaching units (see Table A1 in the appendix).

2.2 Course development

The course is an elective semester-long 2 ECTS seminar embedded within the teacher training programme. A team of multiple lecturers teaches the course. One of the authors (H.G.) has been part of the team since the course's first development, ensuring consistency and constant improvement of its instructional structure over the years.

The course comprises in-class preparatory meetings, a project-based outdoor weekend, and a feedback and reflection session (see A to C in Figure 2). The following sections provide a detailed overview of these components.

Figure 2: Course Structure.

The course places a strong emphasis on the project-based teaching units presented during the weekend. In terms of constructive alignment, our instructional method aligns with the learning goal, as it provides sufficient guidance for the future teachers to experiment with project-based learning in a safe setting. We present the learning goals and the course requirements at the very beginning. Our teaching mode combines the principles of freedom and self-directed learning with guidance and scaffolding. It requires students to constantly reflect on their project, requesting them to provide regular updates to the lecturers, while empowering them with sufficient responsibility to ensure the success of the weekend and their projects. Whereas we ask the students guiding questions to make them aware of possible difficulties, we do not necessarily provide them directly with alternatives or solutions to challenges they may encounter during the weekend. That is, it is also possible that a teaching unit that the students have created for the weekend might fail. We consider such failures valuable and productive for learning, that is, the possibility of failure is a design feature of the course (see e.g. Simpson et al., 2020). Learning through experiencing challenges or even mistakes has a high potential to provide valuable and sustainable learning experiences if the learners are prompted to reflect on challenges, failures, and successes. We however make sure that students are not failing with regard to security issues.

2.3 In-class preparatory meetings

We usually conduct three to four preparatory meetings during the semester (Figure 2A). Before the first meeting, we send a welcome e-mail to the students with an initial assignment: we require the students to identify a topic, question, or content from their subject that would be particularly suitable for project-based outdoor teaching units. The first in-class preparatory meeting starts with an introduction to the principles of outdoor education, accompanied by illustrative examples of past projects. Students are required to reflect on their own learning trajectory during school and on projects that they have experienced outdoors. Often these projects belong to the category of fieldwork and outdoor visits. We then emphasize that our course focuses on outdoor project-based learning.

By showing past projects and prompting the students to reflect on their own experiences in outdoor projects, we aim to circumvent situatedness and activate prior knowledge. Subsequently, we discuss the advantages and disadvantages of the projects they experienced in school. In this meeting, we also ask the students to form groups and share their initial ideas about topics suitable for outdoor projects.

In the second meeting, we ask the students to decide which of their ideas they would like to pursue. We provide information about the specific challenges of outdoor education regarding teaching and assessment. We also ask students to assign themselves to tasks regarding the weekend, such as planning the logistics, shopping, cooking, or waste management. To ensure efficient group work, we ask for regular updates from each group.

At the third meeting, the reconnaissance meeting (see below), the students travel to the site where the outdoor weekend will take place. This meeting is an opportunity for students to familiarise themselves with the area, and to check the feasibility of their proposed teaching unit. At this meeting, students are also required to give a short presentation of their teaching unit and to respond to questions or feedback from the lecturers and their peers in order to encourage reflection, constructive debate, and effective further development of the unit.

In the fourth meeting, we discuss final tasks, including purchasing food and beverages, cooking, and the allocation of sleeping space in tents. We encourage the students to consider all aspects of the weekend, providing only guiding input if necessary. Additionally, we inquire about potential risks or challenges such as adverse weather conditions or changes in the flora since the reconnaissance meeting. This inquiry triggers students to develop alternative plans in case of such occurrences.

2.4 Reconnaissance

In order to gain an understanding of the local conditions, it is essential that teachers conducting an outdoor project know the area where it will take place beforehand. Reconnaissance means visiting the site and the camp's surroundings and determining suitable locations for the planned activities. If a campsite is planned, it is important to check whether the infrastructure is suitable and that there are adequate cooking facilities (e.g., enough wood for a fire) and sanitary infrastructure (toilets, water supply, etc.). In addition, the list of materials is checked and completed and the transport of materials is planned, specifying the time and place. A reconnaissance is also necessary for identifying potential safety risks, such as rotten wood or dry branches that could fall down in a storm. We look out for such risks and include them in our planning. A short reconnaissance report is written to record the information gathered. In addition to the basic conditions of the weekend (arrival and departure, meeting point, location of the camp, etc.), this report contains specific information on the planned project-based teaching units and the preparation of a bad weather programme.

In the specific case of our seminar, we explore our location in Bremgarten on the river Reuss three weeks prior to the event. We chose this timing for the reconnaissance so that enough time remains to make any necessary adjustments but that the ecological conditions are likely to remain comparable to those of the weekend. Our aim is that all students take part in this reconnaissance, but sometimes students have other duties. In order to keep all students informed of the current status of the preparations, we send the reconnaissance report promptly and discuss it in the last preparatory meeting.

In addition to the reconnaissance with the students, one or two of the team of lecturers visit the site before the course starts. This allows for checking whether the overall conditions of the site remained suitable for the course (e.g., dry branches, whether the surrounding meadows have been mowed or not, and the water temperature and water level at the river). Potentially, additional measures have to be taken to use the site as planned. These visits are thus a point of reflection for the lecturers; during this visit we think through the whole course and – based on this reflection – learn about possible adaptions or improvements of our course.

2.5 Outdoor weekend

We conduct the weekend every year at the end of the spring semester (Figure 2B). To ensure maximal safety during the weekend, we have discussed and noted risks, safety issues and necessary preparations with the students beforehand (e.g., bringing sun and weather protection, protection against mosquitoes and ticks). Additionally, we adhere to the following principles on-site: we have a First Aid kit, a lecturer comes by car to be able to, for example, transport students in case of sudden illness or an injury, all students receive a printed document which compiles all safety information and telephone numbers. To cope with the low structuredness of the environment, we enforce sticking to a precise schedule: After arrival on Saturday morning, we start by setting up the tents and collecting wood for a campfire. We then remind all students about the facilities and potential risks, such as ticks in the forest. Afterwards, students have time to prepare their teaching units (e.g., setting up stations, checking for changes in the flora since the reconnaissance, checking technical equipment). After a snack for lunch, we discuss whether changes in the order of the teaching units are necessary (e.g., because of weather conditions), and then proceed with the first unit. That is, students present their teaching unit to their peers, who take the role of the learners. Each teaching unit lasts 90-120 minutes. The lecturers also participate as learners, but simultaneously take an observational perspective and take notes on the teaching unit. After each unit, the lecturers discuss what they have observed.

After two to three teaching units, the preparation of the dinner starts as a group activity. Whereas some students are responsible for lighting up the campfire, others fetch water, chop vegetables, or prepare the waste separation. The evening ends with the dinner, followed by discussions and games around the campfire.

The next morning, after camping in the woods and having breakfast at the campfire, we continue with the teaching units. For lunch, we eat the leftovers. The weekend is complemented by a team experience in which we practice river swimming at a nearby river with strong current. For homework, we ask the students to reflect on their teaching unit: what worked and what could be improved in future iterations of this unit?

2.6 Feedback and reflection session

The final session of the course takes place after the weekend (Figure 2C). We use this session for peer-feedback and feedback from us on the teaching projects. To enable the transfer from outdoor to indoor, students first present their own reflections on their teaching unit. Then their peers provide feedback and finally we voice our observations and ideas for improvement. As an (ungraded) summative assessment, students submit an essay summarizing their teaching unit and their reflections. We provide feedback on these essays.

3. Reflecting on the course

3.1 Students' evaluations

Across the years, our course has received very positive feedback. Here, we report students' feedback from the spring semester 2024. Students liked the fact that they were actively involved in co-designing the course. This course was perceived as something entirely different from other courses they had experienced so far. Students were positively surprised at how open and engaging outdoor education could be. They liked the creativity, interdisciplinarity, and variety of the teaching units. By observing the other groups' teaching units, they were able to identify elements that were effective and those that required modification. The sequence of the teaching units allowed for sufficient flexibility to adapt the units to, for example, meteorological conditions. Furthermore, the students expressed satisfaction with the feedback that they received from us. Many students highlighted the positive experience of river swimming, describing it as an engaging, professionally guided, and enjoyable activity.

As the entire focus of the preparatory sessions in-class was on planning the weekend and the teaching units, they also stated that they learned that carrying out outdoor education projects requires a lot of organization. As a result, they acquired considerable knowledge regarding organizational issues, such as packing, travel, safety, and the division of tasks. Nevertheless, some students indicated that they still did not feel confident to organize such projects with their future pupils on their own. In particular, outdoor classroom-management would require a different approach when working with secondary school pupils, in contrast to university students who are more receptive and engaged. The implementation of the teaching units with secondary school pupils would present some additional challenges and likely require some changes. Moreover, the students mentioned that it would be beneficial to receive information about the legal aspects, responsibilities, and duty of supervision in outdoor education. In terms of improvements, the students proposed that the weekend should not be held just before the end of the semester. Furthermore, they suggested that the teaching units are analysed and reflected upon directly at the weekend, for example while gathered around the campfire. We use this feedback to continuously develop the course.

3.2 Our reflections

We recognise that the course is time-consuming and resource-intensive. For lecturers being interested in organizing an outdoor weekend, we have tried to estimate the effort required for organization in Table 1.

Task	Time estimate
Seminar (preparation, teaching, reconnaissance)	20h
Weekend preparation (request authorisation for camping, contacting river swimming expert for workshop, preparing cooking utensils, wetsuits, …)	10h
Weekend itself (with 1 overnight stay)	35h
Giving Feedback to student projects	10h

Table 1: Estimated time resources per lecturer.

Even though the effort is quite high, we nevertheless believe that the benefits outweigh the costs. It is gratifying to observe how the students create interdisciplinary outdoor teaching units and how all students find the experience meaningful. The possibility to design and perform their own teaching unit, and to organize the logistics for the weekend grants the students a lot of autonomy. This is a core motivation. The resulting projects show that students take this opportunity seriously and construct creative, interdisciplinary projects (Table A1). Interdisciplinary projects are more in line with the concept of Bildung, which encompasses multidisciplinary cultivation, personal development, and maturation. By organizing the weekend, the students develop competencies in project planning, management, communication, and adaptability. Table 2 lists the competencies according to the ETH Competence Framework that our course fosters and/or assesses.

Domain	Subdomain	Status
Subject-specific Competencies	Concepts and Theories	assessed
	Techniques and Technologies	assessed
Method-specific Competencies	Analytical Competencies	fostered
	Problem-solving	assessed
	Project Management	assessed
Social Competencies	Communication	fostered
	Cooperation and Teamwork	fostered
	Leadership and Responsibility	assessed
	Sensitivity to Diversity	fostered
Personal Competencies	Creative Thinking	assessed
	Integrity and Work Ethics	fostered
	Self-awareness and Self-reflection	assessed
	Self-direction and Self-management	fostered

Table 2: Competencies addressed by our course based on the ETH Competence Framework.

Beyond these competencies of the ETH Competence Framework, the course also fosters competencies related to education for sustainable development such as anticipatory competency, competence in interdisciplinary work, and strategic thinking competency (de Haan, 2006; Rieckmann, 2011).

3.3 Transfer to other courses

Our course is in line with the Sustainable Development Goal 4 (Quality Education) particularly target 4.1. By making an extensive description of the course and examples available open-access we also contribute to the target 4.c: With this detailed description of an outdoor education course, we hope to provide ideas and inspiration for other university educators who already have experience with project-based learning methods, as well as for those who have no experience yet, but are trying to extend their teaching beyond the standard classroom. Moreover, whereas we report on a specific course, we believe that several of our insights are transferable or are at least informative for other courses and forms of instruction at school and university.

At school, outdoor education can complement indoor education. It offers possibilities for learning that are not realizable in other ways, and often it is those ‘special’ lessons that students keep in mind from school. Moreover, for schools implementing high quality outdoor education may become a ‘unique selling point’. As stated by Ayotte-Beaudet et al. (2017), teachers often do not feel well-prepared to organize such activities. We thus urge other universities offering teacher education programmes to reflect on also taking up outdoor project-based courses.

At universities, project-based learning becomes more and more common. Field trips or excursions are also common ingredients of study programs. In section 1, we presented the basic aspects to consider when planning project-based outdoor education: structure and alignment, assessment, situatedness, and equity issues. These aspects are not only relevant for outdoor education. They are foundational for all kinds of project-based learning, for organizing field trips and excursions. We believe that our detailed description and reflection of our course provides informative insights and knowledge not only for outdoor enthusiasts, but for all lecturers who want to complement their traditional in-class teaching.

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Appendix

Titles	Subjects	Description	Impression
To eat or not to eat	Biology	The students learn about edible and poisonous plants at various stations. They have to describe them and pick the edible plants to make a herb soup together. Formative assessment: the teacher shows certain plants and asks whether they should throw them into the cooking pot.	
Flight height of rockets	Physics, Chemistry	At various stations, the pupils test how high a water bottle with air pressure, a tablet tube with vinegar and baking powder and a tablet tube with cola and Mentos fly. First they predict which will fly highest. To measure the height, they receive various objects such as a meter rule and a protractor for triangulation.	
pH value and plants	Chemistry, Biology	Students explore how different conditions such as sunlight, soil and proximity to water affect the pH value, measure the pH value with a measuring device and categorize plants that grow there.	
Solar cooker	Biology, Geography, Chemistry	Students build different solar cookers to recognise the principles of reflection, absorption and heat trapping. All are set up at the same time and the temperature of the water is compared after a certain time.	

Water quality and machine learning	Informatics, Biology	Students look for creatures in the water which indicate the water quality. They identify them using an identification key. Then they send pictures of the identified creatures to the teacher. The teacher feeds the images to a machine learning model (e.g. Google Teachable Machine). After a certain time, they test the quality of the machine learning model for new images of such creatures.	
Navigation	Geography, Informatics	Students receive training at various stations information about navigation using maps, directions, or GPS, and have to find their way to the next station using the knowledge they have acquired. The stations use experiments and enquiry-based learning such as ‘how many satellites do I need to identify the correct car from a row of lined-up cars?’	
Geo-Tagging	Geography, Biology, Informatics	Students divide into groups of 4 and these again into groups of 2. The groups of 2 look for various plants selected by the teacher at very specific locations and describe the plant and their locations as accurately as possible. They pass the descriptions to the other two group members, who have to find the plants. Points are awarded for each plant found.	
Catapult	Physics	Students build a catapult according to a manual. After that they think about optimizing the distance and accuracy of the catapult using physics principles and elaborate on the topic of oblique throw in a practical manner.	

Fire	Chemistry	Students divide into groups of 3 and try to light a fire with various tools as fast as possible without being explicitly instructed on how to do so. The task is structured as a group challenge. In the following various methods of how to light, burn and subsequently extinguish fire are covered in the outdoor unit.	
Micro:bit	Informatics, Biology	Using a micro computer 'micro:bit' students experience informatics in the outdoors: Different components and parts of the micro computer are visualized using materials stemming from the woods. In the following the micro:bit is used to simulate the spreading of a virus (Covid-19) and a metal detector is prepared to look for a lost ring.	
Pyrolysis cooker	Chemistry	Students build a pyrolysis cooker following simple instructions. The idea of the pyrolysis cooker is to burn the gases that are produced during pyrolysis, thereby achieving very high temperatures. To test the functionality of the cooker, it is filled with a minimal amount of wood, which must be sufficient to grill a sausage.	

Table A1: Selection of outdoor projects from our students.