Fostering 21st Century Skills Through Autonomy Supportive Science Education Outside the Classroom

Ulrich Dettweiler, Gabriele Lauterbach, Christoph Mall, and Ruth Kermish-Allen

1 Introduction

1.1 21st Century Skills

In the face of economic, environmental, and social challenges, education, or more specifically science education, is even more important today than in the past (National Research Council, 2012), and concepts for the convergence between environmental and science education still need to be implemented (Wals et al., 2014). Public education should provide young people with the knowledge and experiences to become responsible citizens, decision-makers, and problem solvers, capable of addressing serious economic, environmental and social issues. These types of aptitudes and knowledge are termed 21st century skills and have been promoted in several different frameworks by governmental organizations, such as the European Union (2006) and the Organisation for Economic Co-operation and Development (OECD) (2005), as well as (semi-)commercial organizations including Partnership for 21st century skills (P21) (2015), ATC21S™ (Griffin et al., 2012) and EnGauge (Burkhardt et al., 2003). In their meta-review, Voogt and Roblin (2012) have pointed out that all of

U. Dettweiler (✉) · G. Lauterbach
Faculty of Arts and Education, University of Stavanger, 4021 Stavanger, Norway
e-mail: ulrich.dettweiler@uis.no

G. Lauterbach
e-mail: gabriele.lauterbach@uis.no

C. Mall
Department of Sport and Health Sciences, Technical University of Munich, Georg-Brauchle-Ring 62, 80992 Munich, Germany
e-mail: christoph.mall@tum.de

R. Kermish-Allen
Maine Mathematics and Science Alliance (MMSA), Augusta, ME 04,330, USA
e-mail: rkermishallen@mmsa.org

R. Jucker and J. von Au (eds.), *High-Quality Outdoor Learning*,
https://doi.org/10.1007/978-3-031-04108-2_13

the above-mentioned concepts include information- and communication technology (ICT) related competences, collaboration, communication, as well as social and cultural competences. In addition, some of the frameworks encompass outcomes that represent self-regulatory competences with autonomous decision making in real-life scenario learning. All those features are described as enriching classical classroom settings.

It has been argued by a number of authors that societies require citizens, who can independently analyse problems, make choices (even when the choice challenges social norms), and work collaboratively to find solutions (cf. the anthology by Krasny & Dillon, 2012). Therefore, effective education should cultivate autonomous decision-making as well as collective problem solving (Chawla & Derr, 2012). Our children need to become “resilient learners” (Sterling, 2010), capable of collaborating across boundaries, working towards solutions, and thinking critically from multiple perspectives.

In order to address this call to action, science education in the USA, for example, has been undergoing a period of transition from a disconnected fact-based system to a more holistic approach. Scientific practices that span across the scientific disciplines are integrated into real-world scenarios. This transformative vision has been laid out in detail by the National Academy of Sciences in both the Framework for K-12 Science Education (National Research Council, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013). The NGSS challenges educators to do the work of scientists in real-world contexts and paves the way for crafting experiential educational experiences that relate specifically to learners’ interests, lives, and issues they care about. Even if this is not systematically integrated in national curricula, school curricula and classroom activities, many of those 21st century skills are implicitly enacted in teachers’ current conceptions in science class (van de Oudeweetering & Voogt, 2018).

1.2 Education Outside the Classroom (EOtC) and 21st Century Skills

In northern European countries, such 21st century skills are often (implicitly) addressed with educational concepts outside the classroom.[1] To our knowledge, there exist only a few explicit school policies in this respect. In Scotland, we can find governmental support for the role of outdoor education in the delivery of curricular and non-curricular educational themes, such as personal, social, environmental and health education (Nicol et al., 2012). In Norway, formalized and regular EOtC concepts emerged in the 1990es (Jordet, 1998). They are deeply rooted in the Nordic

[1] Originally, the term “Education Outside the Classroom (EOtC)” was coined by Bentsen et al. (2009) in order to refer to the Danish concept of *udeskole*, regular and compulsory outdoor teaching over the whole school year with a frequency of at least three hours at least every two weeks. We will use this term also for short-term curriculum-based science teaching interventions.

version of outdoor sports of the 1920s and many teachers still design EOtC with a physical activity (PA) focus (Helle, 2017). With respect to 21st century skills, the 'Sustainable Backpack' project is a national program using EOtC, which was initiated by the Ministry of Education and Research and the Ministry of Climate and Environment to support Norwegian schools to implement education for sustainable development. To date, more than 550 schools had been enrolled since 2009 (Scheie, 2017). In Sweden, EOtC is seen as an integral part of school culture, however, no reliable data on the prevalence of outdoor teaching is available today (Skoven i Skolen, 2021). In Finland, outdoor teaching is predominantly found in short term residential programs at specific centres, however, as in Sweden, there exists no systematic overview. In Denmark, on the contrary, the extent and dissemination of EOtC is very well documented. Three major surveys from 2007 (Bentsen et al., 2010; Barfod et al., 2016; Barfod et al., 2021) show that at least 19.5% of Danish general schools and 34.0% of Danish special-needs schools practised one or more classes of regular EOtC in 2019. Although the extent of the provision among general schools has been stable since 2014, the number of classes providing regular EOtC in general public schools has increased by 31.8%.

The focus of EOtC research in Denmark lies on pupils' PA, well-being and learning (Nielsen et al., 2016), and very little is known on the use of EOtC for the development of 21st century skills. However, a conceptual paper exploring the similarities and differences between English Forest Schools and Danish *udeskole* ("outdoor school"), found that despite different national educational and cultural contexts, the two concepts share several commonalities within a naturalistic/progressive pedagogical tradition. Differences appear mainly in the degree of integration within national educational systems. Furthermore, global calls for increased connection to nature and recent alignment of results-driven school systems in both countries influence their foundational principles, perhaps leading to greater convergence in the future (Waite et al., 2015). Especially the TEACHOUT research project from 2013 to 2018 on health-related, social, motivational, and academic effects of EOtC has generated evidence based on reasonably large samples in Denmark (Bentsen et al., 2021). With respect to PA and thus health prevention, particularly boys seem to benefit from regular EOtC (Schneller et al., 2017; Schneller et al., 2017). Children's academic achievements in reading skills seem to improve in EOtC compared to normal schooling irrespective of gender (Otte, 2018) and their overall motivation for school seems to increase through regular EOtC (Bølling et al., 2018).

1.3 Autonomous Learning and Practical Relevance Through EOtC in the 21st Century Skills Framework

There is a wealth of empirical studies that have shown the potential benefits of motivation interventions to enhance educational outcomes (Lazowski & Hulleman, 2016). In their meta-analysis, the authors conclude that more intervention research is needed to inform practice and policy about educational settings for the students' benefit. Within self-determination theory (SDT), students' motivation and interest for curriculum related contents are key determinants for their learning and academic success. The more one's behaviour is self-determined, the more it shifts from external to intrinsic motivation (Deci & Ryan, 2000, 2002). Especially intrinsic motivation is of great importance in educational settings. If a student is intrinsically motivated to learn specific contents, she or he is more likely to achieve better academic outcomes (Taylor et al., 2014).

According to self-determination theory, intrinsic motivation is achieved by the satisfaction of basic psychological needs (BPN). Those are autonomy and competence support, as well as experiences of relatedness (Deci & Vansteenkiste, 2004). The more the school environment enables the students' autonomy, their experience of competence, and social relatedness, the more likely they develop intrinsic motivation and become increasingly engaged in school (Reeve et al., 2004). However, teachers tend to apply more controlling instead of autonomy supportive teaching styles (Reeve, 2009). Whereas the importance of BPN-satisfaction for educational success has been widely discussed in the educational literature (Niemiec & Ryan, 2009; Vansteenkiste et al., 2006), only a few studies focus on the perceived relevance of content (Vansteenkiste et al., 2006). Assor et al. (2002) have shown that the main autonomy-enhancing behaviour of teachers in different subjects, e.g. fostering relevance, was positively associated with behavioural and cognitive engagement and positive feelings. Rakoczy et al. (2008) were able to connect the students' perceived relevance of content with self-determined learning in mathematics.

In their multiple-methods survey on learning environments for 21st century students, Lemley et al. (2014) identified the students' autonomy support and perceived relevance of material, presentation, and teacher competence as critical for the students' motivation and learning attitude. The authors connect 21st century skills explicitly to self-determination theory, and define the 21st century classroom as a flexible learning space with multimedia materials, and opportunities for networking and collaboration. Darner (2009) proposes three educational means to effectively create a 21st century classroom. Firstly, one needs to support the students' need for autonomy, for example via curricular activities that include sufficient opportunities for students to actively engage in solving environmental problems of their choosing. This will secondly foster the students' scientific understanding which will satisfy their need for competence. Thirdly, students should get a chance to experience the practical relevance of the teaching content, for example by getting exposed to real-world problems and meeting people in their communities who deal with those problems.

1.4 Research Rationale

Inspired by the above-mentioned research, we wanted to find out how accurately we can estimate the perceived relevance of content (PRC) in science classes from the relative importance of the four basic psychological needs (BPN), autonomy support (A), competence support (C), student-teacher relations (RT), and student-student-relations (RS) in normal and EOtC-learning environments. Our hypothesis is that BPN-satisfaction is a good predictor for perceived practical relevance of content (PRC) in any teaching context.

To address our research question, we combined data from two different EOtC interventions. Study A presents results from a within-subjects design study with n = 281 students studying BPN-satisfaction and PRC in normal science classes and a one-week residential science 'research week' (Dettweiler et al., 2017a, b). We conducted a secondary analysis of this data with a new focus. Study B offers insights into a between-subjects design study in science teaching, using the same instruments as in study A. An intervention group (IG) was taught science classes outdoors one day per week over a school year. The IG was compared to a control group (CG) with normal schooling. Data on students' PA and biological stress responses from study B have been published elsewhere (Dettweiler et al., 2017a, b).

2 Materials and Methods

2.1 Study Design and Intervention

2.1.1 Study A: A Within-Subjects Design Intervention Study

Data was collected from students in relation to learning in two distinct educational settings: (i) the regular science classroom context, and (ii) a curriculum-based residential outdoor science learning course—referred to as 'research week' (Dettweiler et al., 2015).

During the research weeks, specific topics from the curriculum in biology, geography, and mathematics were both taught in the laboratory and during a two-day research expedition into the Berchtesgaden National Park Area for data collection, with an overnight-stay in a secluded mountain hut (cf. Table 1).

The study was conducted from 2012 to 2016 during the months of May to September at the Student Research Centre near Berchtesgaden, Germany. The Student Research Centre is run by the Technical University of Munich. Feasibility of the program was tested in 2012 and program content standardized thereafter (Becker, 2012). Data from 2013 were used as a pilot study (Dettweiler et al., 2015) and to test and validate the measures applied (Dettweiler & Ünlü, 2015). Data from 2014 to 2016 provide the basis of the current study.

The study group consisted of a convenience sample of n = 281 students (168 female: mean age = 12.48 years, SD = 1.76; 113 male: mean age = 12.49 years, SD = 1.71) from ten classes and five different schools, with a bias in the proportion of girls to boys of 3:2. All students attended lower secondary schools in Germany. The socio-cultural backgrounds were considered to be similar; and grades in mathematics

Table 1 Teaching schedules in the two studies

Study A (within-subject design)		
Schedule	**EOtC**[a]	
Sunday	Arrival at the Student Research Centre. Welcome and introductory class, repeating curriculum from science class	
Monday	Introduction to the laboratory work in small groups, identifying and defining research topics, preparing for the expedition	
Tuesday	First day of the expedition. Collecting data along a transect of 1000 m elevation in the individual groups of 3–4, each accompanied by either a teacher, pre-service teacher student, or staff from the Student Research Centre	
Wednesday	Second day of the expedition. Continuing with data collection on the way down in the individual groups	
Thursday	Data analysis in the individual groups, then re-grouping (group puzzle) and cross-group (disciplinary) discussion and documentation of the findings. Poster session Issuing of the questionnaire	
Friday	Meeting with researchers from the National Park Service and presentation and discussion of the findings. Departure	
Study B (between-subject design)		
Schedule	**EOtC**	Normal
07.55–08.40	Meeting at 8.00 and short mini-bus transfer to outdoor 'classroom'; preparing for the day	Regular class according to curriculum
08.45–09.30	Forest class according to curriculum	Regular class according to curriculum
09.30–09.45	Break	Break
09.45–10.30	Continued forest class according to curriculum	Regular class according to curriculum
10.35–11.20	Continued forest class according to curriculum	Regular class according to curriculum
11.20–11.35	Break Issuing of the questionnaire	Break Issuing of the questionnaire
11.35–12.20	Continued forest class according to curriculum	Regular class according to curriculum
12.25–01.05	Continued forest class according to curriculum	Regular class according to curriculum

[a]The normal teaching schedules in biology, geography and mathematics in study A follow the ordinary individual plans in the respective schools, with normally two hours biology, two hours geography, and four-five hours mathematics lessons per week. The questionnaire was issued during one of the science classes about six weeks prior to the research week by a trained researcher

and German suggested a normal distribution of overall academic achievement in our study group.

Data collection was administered during the week of learning in each educational setting, with the regular classroom context occurring about six weeks prior to the EOtC week. The self-reported questionnaires contained socio-demographic data and two validated constructs. The explanatory variables were comprised of an adapted version of the Basic Psychological Need Satisfaction Scale (BPNS) (Deci & Ryan, 2000). The BPNS consists of four scales, i.e. "autonomy support (A)", "competence support (C)", "student-teacher relatedness (RT)", and "student-student relatedness (RS)". The A-scale consists of eleven items and is divided in three sub-scales, asking for "ascertained respect", "possibilities of choice" and "comprehended reasons". The scale showed excellent internal consistency (Cronbach's alpha = 0.88).[2] The C-scale consists of eight items in two subscales, "perceived support", and "perceived structure" (Cronbach's alpha = 0.78). Each of the relatedness-scales (RT, RS) consists of four items, asking for the quality of social interactions, with good reliability measures of Cronbach's alpha = 0.84 for RS and Cronbach's alpha = 0.87 for RT. As the pedagogical/didactical response variable we chose to operationalize the German construct developed for measuring PRC in mathematics in our target age-group (Rakoczy et al., 2008), since this construct has specifically been developed within self-determination theory (SDT) and the concept of BPN-satisfaction. This scale consists of five items checking on the students' experiences with examples, transfer of knowledge, and practical applications of the learned contents during science class. Cronbach's alpha for the PRC-scale is 0.76.

2.1.2 Study B: A Longitudinal Between-Subjects Design Intervention Study

Study B is a longitudinal control group design using a convenience sample at a private secondary school in Heidelberg, one of the few schools in Germany practicing regular and compulsory outdoor schooling. The compulsory element was important to keep the motivational attitude as constant as possible in the intervention (EOtC) and control (Normal) groups.

Since basic psychological needs (BPNs) are rather constant traits (Deci & Vansteenkiste, 2004), we considered three measurements during the school year sufficient. The first measurement was scheduled four weeks after schools had started (fall), in order to allow the students enough experiences to make their judgements, the second at mid-term (spring), and the third shortly before the summer holidays (summer).

The intervention consisted of one school-day per week in the forest, with 5 × 45 min "science classes" and 1 × 45 min "physical education" (PE) allocated over the school day as specified in Table 1. Looking at the respective schedules, two major

[2] Cronbach's alpha is a measure of scale reliability. It measures how closely related a set of items are as a group. It can take values between 0 and 1, and 0.7 or higher is considered "acceptable".

differences can be seen: (1) the curriculum in EOtC is taught in cross-disciplinary units on the forest days, whereas it is taught in segments, subject by subject, in normal class; and (2) the pedagogical approach of the outdoor-learning program includes opportunities to autonomously use the space in which the teaching is going on, including physical activation such as walks (the rather informal PE part in the intervention design) to reach specific places in the forest. In contrast, the frame for science lessons within the Normal group is connected to traditional indoor teaching concepts with less opportunities and variability with respect to space. With respect to the cognitive load and academic demand, we consider both teaching contexts to be equivalent since the curriculum is not different from the control classes in the EOtC setting.

Participants were recruited from 5 and 6th grades from the above mentioned secondary school in Heidelberg, Germany.

We were able to include 48 students into the study, 37 in the EOtC group, and 11 in normal class. This imbalance was a consequence of last-minute changes to the design after the school had decided to accommodate parents' demands for a third EOtC class rather than sticking to the plan with two. As we will describe in the methods section, this has been accounted for in the statistical analysis. As of normal occurrence, some students were absent from school during data collection, which accordingly lead to missing data. Table 2 summarizes the enrolment data, and we can see a bias in the proportion of girls to boys of 4:6. The socio-economic status can be considered similar. Data were collected at the end of each of the three school days using a paper-based composite questionnaire, containing socio-demographic data and the same constructs as in Study A, the Basic Psychological Need Satisfaction Scale and the Perceived Relevance of Contents Scale. The reliability measures showed

Table 2 Enrolment data for the two studies

Sample Study A (within-subjects, missing cases deleted)				
	Normal	**EOtC**		**Statistics**
	281 total	281 total		
Gender	113 (40%) male	113 (40%) male		$BF_{01} = 0.0$
	168 (60%) female	168 (60%) female		
Age in summer	12.5 years			
Sample Study B (between-subjects, missing cases treated as "missing" in the models)				
	Participants Recruited	**Fall**	**Spring**	**Summer**
Total	48	46	45	46
EOtC	37	35	35	35
Normal	11	11	10	11
	Normal (CG)	**EOtC (IG)**		**Statistics**
Gender	7 (64%) male 4 (36%) female	23 (62%) male 14 (38%) female		$BF_{01} = 0.0$
Age in summer	12.5 years	12.0 years		–

again acceptable values, Cronbach's alpha = 0.89 for autonomy support, 0.84 for competence support, 0.87 for student-teacher relatedness and 0.86 for student-student relatedness. Cronbach's alpha for the PRC-scale was 0.79.

2.2 Data Analysis

Due to the clustered and unbalanced design as well as the theoretical and statistical non-independence of the four BPN variables, the data structure is rather complex. Thus, Bayesian modelling has been applied which is particularly able to handle those problems. The Bayesian approach, named after the rev. Thomas Bayes (1702–1761), has a number of advantages over classical ('frequentist') statistical null-hypothesis testing, which we can use to address our problem. First of all, Bayesian statistics tests the probability of a hypothesis directly on the data, rather than testing the probability of the data given a null-hypothesis which is never true, as in the classical approach. Moreover, Bayes theorem takes into account prior beliefs which are specified as distribution functions for all parameters that are estimated in a given statistical model. This is a critical step in the analysis: Technically, the defining of so-called "*prior* probability functions" (i.e. our beliefs with regard to the outcomes, based on our experience and previous research, expressed in mathematical form) makes it possible to directly quantify the probability distribution of the estimates (the so-called *posterior* distribution function), and the more realistically this distribution is defined, the more accurate are the posterior estimates. In classical statistical analysis, the same probability is assigned over the infinite range of possible values, which does not really make sense and leads to overestimation. Prudently chosen prior distribution functions (or short: "priors") mitigate overfitting (i.e. an overestimation of the results). Another important feature of Bayesian statistics is that the posterior estimates are derived from *simulations* of generated data, based on the distribution parameters of the *observed* data. Those simulations are run several times with a huge number of iterations, often more than 20.000, and the results of the simulations are then cross-validated with the observed data. If the deviation between the two sets of estimates, the observed and the simulated, is small, we have good reason to trust the simulation and the parameter estimates derived and can directly inspect the uncertainty attached to each estimate. Thus, if (a) the simulation worked (which is not a given since misspecified models often collapse) and if (b) the uncertainty associated with an estimate is low, i.e. the posterior distribution function has a low standard deviation and the credibility interval does not include zero), the sign of the parameter estimates indicating a positive or negative effect from unbalanced groups can be trusted.

In study A, data have been treated on class-level, accounting for the different settings of those ten courses that have been run over three summers. In study B,

Table 3 Descriptive results summary table for outcome variable PRC in the two models

Gender	Context	Enquiry	Mean	SD	N[a]
PRC Study A (within-subjects design)					
Female	Normal	–	3.222	0.792	164
	EOtC	–	4.019	0.647	167
Male	Normal	–	3.163	0.832	107
	EOtC	–	4.045	0.592	112
PRC Study B (between-subjects design)					
Female	Normal	Fall	3.050	1.237	4
		Spring	2.850	0.915	4
		Summer	2.700	0.503	4
	EOtC	Fall	4.042	0.517	12
		Spring	4.135	0.786	10
		Summer	3.923	0.815	13
Male	Normal	Fall	3.093	0.563	7
		Spring	3.700	0.533	6
		Summer	3.240	1.135	5
	EOtC	Fall	3.755	0.582	22
		Spring	4.168	0.616	19
		Summer	3.741	0.696	17

[a] In study A, two cases needed to be deleted for incomplete data for the calculation of the centred predictor variables

data have been modelled on the individual subject level, i.e. taking the individual children's learning experiences into consideration.[3]

3 Results

3.1 Descriptive Results and Correlation Analysis

Table 3 summarizes the descriptive results for the outcome variable PRC, factored on gender, group and enquiry in the respective studies.

It can be seen that in both studies (the within-subjects design A and the between-subjects design B) the relevance of the teaching content was perceived higher in the EOtC context. In study B, the effect is constant over the school year, with a moderate

[3] A more detailed description of the analytical approach and technical information for the model can be obtained from the corresponding author.

Table 4 Pearson correlation matrix of the four compositional explanatory variables A, C, RT, RS for the two models

Study A, within-subject design, n = 281								
		A		**C**		**RT**		**RS**
A	Pearson's r	–	–	–	–	–	–	–
	$\log(BF_{10})$	–	–	–	–	–	–	–
C	Pearson's r	0.749	***	–	–	–	–	–
	$\log(BF_{10})$	221.19	–	–	–	–	–	–
RT	Pearson's r	0.693	***	0.595	***	–	–	–
	$\log(BF_{10})$	175.51	–	115.545	–	–	–	–
RS	Pearson's r	0.217	***	0.168	***	0.242	***	–
	$\log(BF_{10})$	10.18	–	4.872	–	13.57	–	–
Study B, between-subject design, n = 48								
		A		**C**		**RT**		**RS**
A	Pearson's r	–	–	–	–	–	–	–
	$\log(BF_{10})$	–	–	–	–	–	–	–
C	Pearson's r	0.729	***	–	–	–	–	–
	$\log(BF_{10})$	137.73	–	–	–	–	–	–
RT	Pearson's r	0.596	***	0.576	***	–	–	–
	$\log(BF_{10})$	78.95	–	71.867	–	–	–	–
RS	Pearson's r	0.323	***	0.232	***	0.248	***	–
	$\log(BF_{10})$	17.7	–	7.383	–	9.075	–	–

* $\log(BF_{10}) > \log(10)$, **$\log(BF_{10}) > \log(30)$, ***$\log(BF_{10}) > \log(100)$. The Bayes Factor ($BF_{10}$) quantifies the amount by which we should prefer the hypothesis that there is a correlation (H_1) over the Null-Hypothesis (that there is no correlation) H_0 (thus the direction 1–0 in the subscript). We log-transformed the values just for cosmetic reasons to avoid huge numbers. The cut-off points marked with the asterisk can be interpreted analogously to the classical p-value in the Pearson correlation matrix despite its different meaning

peak at mid-term (spring) and a slight decline towards the end of the school year for the boys in the Normal group.

Table 4 displays the correlation matrix of the four explanatory BPN-variables. It can be seen that the Pearson's r is rather constant across the two studies.

3.2 *Main Effects*

The simulation worked just fine for all parameters in both studies. Figure 1 displays the 95% credible intervals for the respective parameters in the above specified models.

In study A, of the main effects "gender" and "context", only "context" is credible. The students' estimated score for the EOtC is about 0.3 units higher on the 5-point

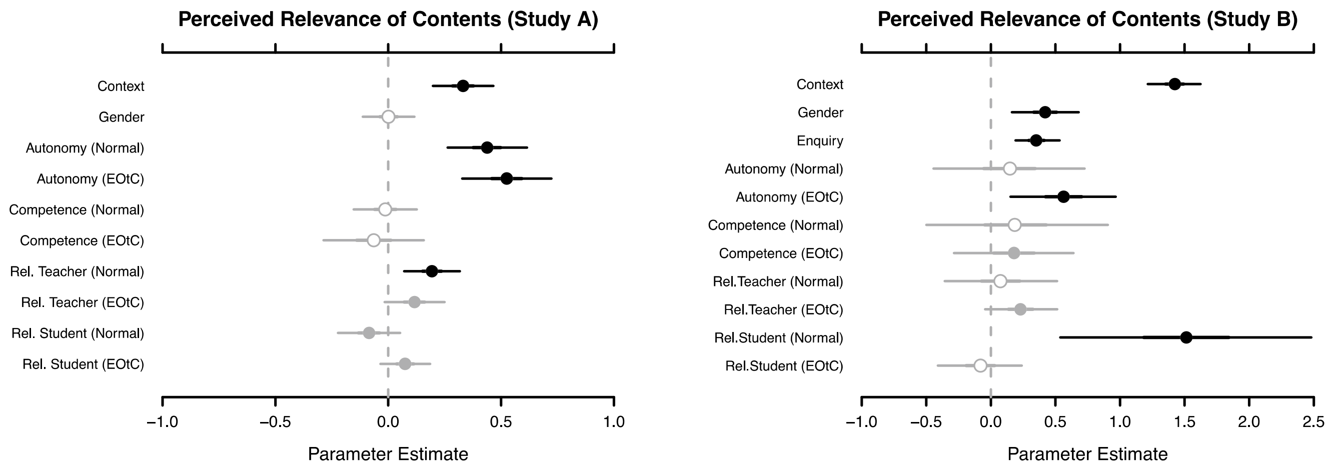

Fig. 1 The two panels display the highest probability densities for main effects context, gender and time-point of enquiry (study B only), and interaction effects of the four explanatory basic psychological needs variables with context (Normal/EOtC) in the two studies. Shading, whether 50% of credible interval (CRI; grey with open circle), 95% CRI (grey with closed circle), or neither (black) do overlap 0. Black dots indicate of a strong association between the outcome and explanatory variable

PRC Likert scale than in the normal school setting, adding statistical credibility to the above-mentioned descriptive results. The relative effect size (for an explanation cf. footnote † in Table 5) of 4.9 is medium, and there is no risk of a wrong sign (type-S error, Gelman & Carlin, 2014). In study B, the students in the EOtC group have on average 1.4 higher unit values on the five unit PRC-scale than their peers in the normal school setting, with a particularly high relative effect size of 13.7, with virtually zero probability of a type S error. Different from the short-term within-subject design, a relatively moderate gender effect (3.2) can be determined in the between-subject study B, with boys benefiting on average 0.4 units more from the EOtC setting. Moreover, the time point of enquiry seems to be of some importance. As Table 3 indicates, the midterm measures in spring for PRC tend to be higher compared to the baseline in fall and the measure at the end of the school year in summer, with one exception: the girls' values in the control group seem to decline in PRC from fall to spring.

3.3 Interaction Effects

The interaction effects for group differences with respect to the four basic psychological needs values (autonomy and competence support, relatedness with respect to peers and teachers) are interesting: In both studies, autonomy support has by far the greatest relative importance on perceived practical relevance of the content PRC.

In study A, autonomy support shows moderate relative importance on how relevant the students perceive the taught content, which holds true in both teaching settings, however on a slightly higher level in the EOtC group. In study B, autonomy support shows a moderate effect on PRC in the EOtC group (rel. effect size 2.7, type-S error 0.4%). Most interestingly, the relative importance of perceived competence support does not show any effect on PRC in neither study.

In study A, the students' relatedness with the teachers (RT) seem to matter in the normal school setting but not in EOtC. We can deem a moderate relative effect (3.1) with essentially no risk of type-S error for the within-subjects study. In study B, no effect can be attributed to RT in neither context.

The reverse seems to hold true for relatedness with peers (RS). In Study A, RS appears to have no relative importance in neither teaching context. However, in study B, a moderate relative effect (3.1) can be observed for the students in the normal classes.

Table 5 Parameter estimates of main and interaction effects

Parameter	d	s	2.5%	97.5%	Type S error (%)[a]	Rel. effect size[b] $\left\|\frac{d}{s}\right\|$
Study A, within-subject design, n = 281, Bayesian *P* = 0.52						
Main effects:						
Gender	0.002	0.058	−0.112	0.116	49.2	0.0
Context	**0.332**	**0.068**	**0.198**	**0.466**	**0.0**	**4.9**
Interaction effects:						
Autonomy (Normal)	**0.438**	**0.09**	**0.263**	**0.615**	**0.0**	**4.9**
Autonomy (EOtC)	**0.525**	**0.1**	**0.328**	**0.723**	**0.0**	**5.2**
Competence (Normal)	−0.013	0.071	−0.153	0.127	42.6	-0.2
Competence (EOtC)	−0.064	0.113	−0.287	0.157	28.4	-0.6
Rel. teacher (Normal)	**0.194**	**0.063**	**0.071**	**0.317**	**0.1**	**3.1**
Rel. teacher (EOtC)	0.116	0.067	−0.016	0.25	4.1	1.7
Rel. student (Normal)	−0.085	0.07	−0.222	0.052	11.3	-1.2
Rel. student (EOtC)	0.075	0.056	−0.035	0.185	8.9	1.3
Random effects:						
mu_alpha	0.144	0.349	−0.545	0.829	–	–
Residuals						
sigma_alpha	3.206	0.774	2.094	5.066	–	–
sigma	0.599	0.019	0.564	0.638	–	–
Study B, between-subject design, n = 48, Bayesian *P* = 0.62						
Main effects:						
Gender	**0.421**	**0.132**	**0.164**	**0.68**	**0.1**	**3.2**
Context	**1.422**	**0.104**	**1.215**	**1.623**	**0.0**	**13.7**
Enquiry	**0.355**	**0.088**	**0.191**	**0.532**	**0.0**	**4.0**
Interaction effects:						
Autonomy (Normal)	0.144	0.299	−0.443	0.725	31.3	0.5
Autonomy (EOtC)	**0.563**	**0.209**	**0.153**	**0.967**	**0.4**	**2.7**

(continued)

Table 5 (continued)

Parameter	**d**	**s**	**2.5%**	**97.5%**	**Type S error (%)[a]**	**Rel. effect size[b] $\left\|\frac{d}{s}\right\|$**
Competence (Normal)	0.192	0.355	−0.499	0.905	29.5	0.5
Competence (EOtC)	0.18	0.236	−0.285	0.639	22.1	0.8
Rel. teacher (Normal)	0.075	0.221	−0.357	0.512	36.7	0.3
Rel. teacher (EOtC)	0.232	0.142	−0.044	0.514	4.8	1.6
Rel. student (Normal)	**1.512**	**0.494**	**0.538**	**2.481**	**0.1**	**3.1**
Rel. student (EOtC)	−0.081	0.165	−0.41	0.239	31.1	-0.5
Random effects:						
mu_alpha	0.341	0.357	−0.353	1.049	–	–
Residuals:						
sigma_alpha	0.416	0.14	0.078	0.684	–	–
sigma	0.61	0.078	0.475	0.775	–	–

[a] The probability that the estimate has the incorrect sign

[b] A ratio of $\left|\frac{d}{s}\right| > 2$ is considered a noteworthy relative and thus context-specific statistical effect and displayed in bold letters (Gelman & Carlin, 2014). A ratio > 4 indicates very trustworthy and big effects

4 Discussion

4.1 Practical Relevance of Science Teaching and Basic Psychological Needs Satisfaction

The considerably strong main effect of teaching context in favour of EOtC in both, the within-subject design and the between-subject design on the PRC adds another consistent piece to the puzzle of positive effects of EOtC compared to 'normal' schooling reported in a review by Becker et al. (2017), and empirical results published since (Barfod & Bentsen, 2018; Bølling et al., 2018; Kuo et al., 2018a, b; Schneller et al., 2017; Schneller et al., 2017). In line with the above referenced studies, we did not find any sizeable gender effects with respect to how relevant the students did perceive the teaching in science class in the within-subjects design. However, gender matters in study B, as does the time-point of enquiry due to the nature of the longitudinal design in study B. To our knowledge, the gender effect with boys benefiting more than girls in the longitudinal design but not in the short-term intervention, cannot be sensibly explained with reference to existing research from a theoretical perspective. But given the unbalanced data and the small number of observations in the gender-split groups in study B (4 girls and 7 boys in the control group), the main effect for gender cannot be deemed practically significant despite the stable statistical effect.

The analysis of the relative importance of the basic psychological needs-satisfaction variables ("autonomy support (A)", "competence support (C)", "student-teacher relatedness (RT)", and "student-student relatedness (RS)") in each respective context in the two studies yields interesting results: Here, we can see consistent patterns across the studies.

Most obviously, competence support does not seem to substantially contribute to how relevant the students perceived the teaching, in neither study. This is surprising, since perceived competence support and perceived autonomy support are highly correlated (cf. Table 3), and it could well be argued that the perceived support for the mastery of a taught subject (competence) should make it appear more practically relevant. Yet, the results show that the teacher-centred competence-approach is not the driving force for perceived practical relevance of the teaching contents, and the data suggest furthermore, that teacher-student relations do not substantially contribute to the perceived relevance of the teaching contents, and if so, then only in the normal school setting in the within-subjects design.

It is, however, more in line with our expectations that peer relations (RS) have little influence on how relevant students perceive the teaching in science classes, and if so, then only in the normal school context. There, RS can be deemed more important than in the EOtC context, where the educational setting is enriched with other values. In her analysis of 334 EOtC settings in England, Waite (2011) associates personal values with the outdoors including "freedom and fun; ownership and autonomy; authenticity; love of rich sensory environment and physicality in pedagogical practice". Those personal values make outdoor learning less dependent on social relations, be it with peers, or with teachers.

What is driving basic psychological needs for perceived practical relevance of content overall is clearly perceived autonomy support. Our data strongly suggest that the level of perceived A support can explain the practical relevance of the teaching especially in the EOtC context, in both the within-subjects design and the between-subjects design. The fact that this effect does not show in the between-subjects design in study B might again be partially explained by the nature of the research design rather than by a substantial or theoretical difference between within- or between-subjects design or the type of intervention, i.e. short term (within) or long-term (between). A qualitative analysis of the perceived science teaching in study A shows that the students' positive experiences in the 'normal' science classes can be attributed to teaching forms that use experiential, hands-on learning methods, often in the near outdoor environments of the schools (Dettweiler et al., 2017a, b). This additionally hints at a potential selection bias in the data of study A: the teachers, who are willing to go the extra mile to enrol their students in this program, are certainly more likely to apply alternative teaching methods, i.e. deliver science classes in more enriched classroom settings than the average teacher is prone to. This can be shown in the piloting of study A with a sample of n = 84, where we focused on the analysis of the motivational behaviour of students enrolled in the intervention. The students' self-determination index (Müller et al., 2007) in normal science classes with enriched classroom settings was considerably higher than the empirical baseline of the validation study (Dettweiler et al., 2015). The normal group in study B did not experience such enriched classroom settings, which might explain the missing effect of perceived A support in the normal school setting in the between-subjects design.

We can conclude that this is the first study in EOtC that applies the same BPN-measures in a cross-sectional short-term within-subjects intervention and a longitudinal between-subject intervention. That the relative importance of BPN-satisfaction for the PRC is virtually identical in both studies, i.e. cross-sectional and longitudinal, is an important finding for EOtC practice and research and adds to closing a gap in conceptual understanding of short-term and long-term EOtC interventions.

4.2 EOtC and 21st Century Skills

Our data confirm findings by Lemley et al. (2014), who identified the students' autonomy support and perceived relevance of material as critical for the students' motivation and learning attitude in 21st century classrooms. The criteria that create such enriched classrooms, i.e. offering the students a flexible learning space with multimedia materials, and opportunities for networking and collaboration, can also be identified in the two EOtC contexts described above (cf. Table 1). We might thus conclude that EOtC can well be understood within the theoretical frame of 21st century skills and that future research and practice should in fact extend the scope and explicitly include the outdoors as a viable teaching arena in the transformation of K-12 science education.

It appears that teaching science outdoors is less dependent on the students' perceived competence support, i.e. naturally less teacher-centred, and less vulnerable to the students' distraction through (bad) peer relations. The flexibility—and maybe also the complexity—of the outdoor learning space certainly adds into the equation that lets science education in EOtC appear to be of more practical relevant to the students. They are learning in the real world with obviously real examples.

4.3 Limitations

There are a number of limitations to the results of this study.

On the design-level, both studies rely on an imbalanced sample with respect to gender, and a too small sample in study B to meaningfully interpret gender effects. Moreover, study B has an overall too small sample with yet another imbalance in the control- and intervention-groups. The particularly high relative context-effect reported above should thus be seen critically.

Due to different hierarchical data- and time-structures in the two studies, we were not able to directly test the effect of the design itself—within-subjects or between-subjects—as a factor in one model. This might have been beneficial for the subsequent research question if there is a substantial difference between the two designs, i.e. ways to approach EOtC in practice.

With respect to the statistical analyses, a hierarchical/multilevel Bayesian structural equations model (SEM) would have been favourable to account for the latent variable structures in the psychological constructs and the hierarchical clusters. However, this was not possible because of high correlations and non-independence of the explanatory variables, since the demand for independence of the predictors in SEM would have been violated. But more importantly, the rather sparse data in study B did not allow SEM.

Next steps are clearly to collect balanced data for comparison of within-subject and between-subject designs for normal and EOtC science teaching, to perform follow-up design studies for measuring the 'sustainability' of EOtC over time, compared to other 21st century classroom settings, and to include controlled academic achievement measures in the design.

5 Conclusion

We can conclude that the practical relevance of science teaching in EOtC contexts is perceived higher than in normal classroom settings, both in the short-term, cross-sectional within-subjects design as well as in the long-term, longitudinal between-subjects design. This can be best explained by the degree of the students perceived autonomy support. Thus, science teaching in EOtC fosters 21st century skills through less teacher-centration and more flexible and collaborative settings.

Recommended Further Reading

1. Beames, S., & Brown, M. (2016). *Adventurous learning: a pedagogy for a changing world*. London; New York: Routledge.
2. Brymer, E., Rogerson, M. & Barton. J. (2021): *Nature and Health. Physical Activity in Nature*, London; New York: Routledge.
3. Humberstone, B., Prince, H., & Henderson, K. (2016). *Routledge International Handbook of Outdoor Studies*. London; New York: Routledge.

Acknowledgements UD conceived and planned studies A and B, was the principal investigator and raised the funds for study A. He also analysed the data in both studies and wrote most of the manuscript. GL and CM conceived and optimized the intervention of study A, RKA contributed with respect to its theoretical frame. CM collected data in both studies, GL collected the data in study A. All authors interpreted the results. All authors contributed to the writing of different sections of the manuscript and approved its final version.

References

Assor, A., Kaplan, H., & Roth, G. (2002). Choice is good, but relevance is excellent: Autonomy-enhancing and suppressing teacher behaviours predicting students' engagement in schoolwork. *British Journal of Educational Psychology, 72*(2), 261–278. https://doi.org/10.1348/000709902158883.

Barfod, K., & Bentsen, P. (2018). Don't ask how outdoor education can be integrated into the school curriculum; ask how the school curriculum can be taught outside the classroom. *Curriculum Perspectives, 38*(2), 151–156. https://doi.org/10.1007/s41297-018-0055-9.

Barfod, K., Bølling, M., Mygind, L., Elsborg, P., Ejbye-Ernst, N., & Bentsen, P. (2021). Reaping fruits of labour: Revisiting Education Outside the Classroom provision in Denmark upon policy and research interventions. *Urban Forestry and Urban Greening, 60*, 127044. https://doi.org/10.1016/j.ufug.2021.127044.

Barfod, K., Ejbye-Ernst, N., Mygind, L., & Bentsen, P. (2016). Increased provision of udeskole in Danish schools: An updated national population survey. *Urban Forestry and Urban Greening, 20*, 277–281. https://doi.org/10.1016/j.ufug.2016.09.012.

Becker, C. (2012). *MINT in Bewegung: Eine Fallstudie zur möglichen Integrierung von Expeditionary Learning Alpine (ELPIN) in den fächerübergreifenden gymnasialen Unterricht unter besonderer Berücksichtigung lernmotivationler und gesund-heitsrelevanter Parameter für das Fach Natur und Technik.* (Diploma), Technische Universität München, München.

Becker, C., Lauterbach, G., Spengler, S., Dettweiler, U., & Mess, F. (2017). Effects of regular classes in outdoor education settings: A systematic review on students' learning, social and health dimensions. *International Journal of Environmental Research and Public Health, 14*(5), 485. https://doi.org/10.3390/ijerph14050485.

Bentsen, P., Jensen, F. S., Mygind, E., & Randrup, T. B. (2010). The extent and dissemination of udeskole in Danish schools. *Urban Forestry and Urban Greening, 9*(3), 235–243. https://doi.org/10.1016/j.ufug.2010.02.001.

Bentsen, P., Mygind, L., Elsborg, P., Nielsen, G., & Mygind, E. (2021). Education outside the classroom as upstream school health promotion: 'Adding-in' physical activity into children's everyday life and settings. *Scandinavian Journal of Public Health.* https://doi.org/10.1177/14034948211993715.

Bentsen, P., Mygind, E., & Randrup, T. B. (2009). Towards an understanding of udeskole: Education outside the classroom in a Danish context. *Education 3–13, 3*(37), 29–44.

Burkhardt, G., Monsour, M., Valdez, G., Gunn, C., Dawson, M., Lemke, C., Martin, C. (2003). *Literacy in the digital age: EnGauge 21st century skills for 21st century learners report.* Naperville, IL: North Central Regional Educational Laboratory (NCREL) and the Metiri Group https://firstnationspedagogy.com/engauge21st.pdf.

Bølling, M., Otte, C. R., Elsborg, P., Nielsen, G., & Bentsen, P. (2018). The association between education outside the classroom and students' school motivation: Results from a one-school-year quasi-experiment. *International Journal of Educational Research, 89*, 22–35. https://doi.org/10.1016/j.ijer.2018.03.004.

Chawla, L., & Derr, V. (2012). The development of conservation behaviors in childhood and youth. In S. D. Clayton (Ed.), *The Oxford handbook of environmental and conservation psychology* (pp. 527–555). Oxford University Press.

Darner, R. (2009). Self-determination theory as a guide to fostering environmental motivation. *Journal of Environmental Education, 40*(2), 39–49.

Deci, E. L., & Ryan, R. M. (2000). The 'what' and 'why' of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*, 227–268.

Deci, E. L., & Ryan, R. M. (2002). Overview of self-determination theory: An organismic dialectical perspective. In E. L. Deci & R. M. Ryan (Eds.), *Handbook of self-determination research* (pp. 3–33). University of Rochester Press.

Deci, E. L., & Vansteenkiste, M. (2004). Self-determination theory and basic need satisfaction: Understanding human development in positive psychology. *Ricerche Di Psichologia, 27*, 17–34.
Dettweiler, U., Becker, C., Auestad, B. H., Simon, P., & Kirsch, P. (2017a). Stress in school. Some Empirical hints on the circadian cortisol rhythm of children in outdoor and indoor classes. *International Journal of Environmental Research and Public Health, 14*(5), 475. https://doi.org/10.3390/ijerph14050475.
Dettweiler, U., Lauterbach, G., Becker, C., & Simon, P. (2017b). A bayesian mixed-methods analysis of basic psychological needs satisfaction through outdoor learning and its influence on motivational behavior in science class. *Frontiers in Psychology, 8*(2235). https://doi.org/10.3389/fpsyg.2017.02235.
Dettweiler, U., & Ünlü, A. (2015). *Testing the reliability and validity of a reduced Academic Self-Regulation Questionnaire (SRQ-A) in a mixed-methods approach.* Paper presented at the eighth SELF Biennial international conference, Kiel.
Dettweiler, U., Ünlü, A., Lauterbach, G., Becker, C., & Gschrey, B. (2015). Investigating the motivational behaviour of pupils during outdoor science teaching within self-determination theory. *Frontiers in Psychology, 6*(125). https://doi.org/10.3389/fpsyg.2015.00125.
European Union (EU). (2006). *Recommendations of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning (2006/962/EC).* Brussels. http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32006H0962.
Gelman, A., & Carlin, J. (2014). Beyond power calculations. Assessing Type S (Sign) and Type M (Magnitude) errors. *Perspectives on Psychological Science, 9*(6), 641–651. https://doi.org/10.1177/1745691614551642.
Griffin, P., McGaw, B., & Care, E. (2012). *Assessment and teaching of 21st century skills.* Springer.
Helle, M. K. (2017). *Friluftsliv i skolen. En kvalitativ studie av elevers erfaringer med friluftsliv på idrettslinjen.* (Master Thesis), Universitetet i Tromsø. http://hdl.handle.net/10037/11928.
Jordet, A. N. (1998). *Nærmiljøet som klasserom. Uteskole i teori og praksis [The local neighbourhood as classroom. 'Uteskole' in theory and praxis].* Oslo: Cappelen Akademisk Forlag.
Krasny, M. E., & Dillon, J. (2012). *Trading zones in environmental education: Creating transdisciplinary dialogue.* Peter Lang.
Kuo, M., Browning, M., Sachdeva, S., Lee, K., & Westphal, L. (2018a). Might school performance grow on trees? Examining the link between 'greenness' and academic achievement in urban high-poverty schools. *Frontiers in Psychology, 9*, 1669. https://doi.org/10.3389/fpsyg.2018.01669.
Kuo, M., Browning, M. H. E. M., & Penner, M. L. (2018b). Do lessons in nature boost subsequent classroom engagement? Refueling students in flight. *Frontiers in Psychology, 8*. https://doi.org/10.3389/fpsyg.2017.02253.
Lazowski, R. A., & Hulleman, C. S. (2016). Motivation interventions in education: A meta-analytic review. *Review of Educational Research, 86*(2), 602–640. https://doi.org/10.3102/0034654315617832.
Lemley, J. B., Schumacher, G., & Vesey, W. (2014). What learning environments best address 21st-century students' perceived needs at the secondary level of instruction? *NASSP Bulletin, 98*(2), 101–125. https://doi.org/10.1177/0192636514528748.
Müller, F., Hanfstingl, B., & Andreitz, I. (2007). *Skalen zur motivationalen Regulation beim Lernen von Schülerinnen und Schülern. Adaptierte und ergänzte Version des Academic Self-Regulation Questionnaire (SRQ-A) nach Ryan & Connell [Scales of motivational learning regulation of pupils. Adapted and extended version of the Academic Self-Regulation Questionnarie (SRQ-A) of Ryan & Connell].* Klagenfurt. http://ius.uni-klu.ac.at/inhalte/publikationen/486_IUS_Forschungsbericht_1_Motivationsskalen.pdf.
National Research Council. (2012). *Education for life and work: Developing transferable knowledge and skills in the 21st century.* The National Academies Press.
NGSS Lead States. (2013). *Next generation science standards: For states, by states.* The National Academies Press.

Nicol, R., Higgins, P., Rossi, H., & Mannion, G. (2012). *Outdoor education in Scotland: A summary of recent research.* Edinburgh. http://www.education.ed.ac.uk/outdoored/research/nicol_et_al_oe_scotland_research.pdf.

Nielsen, G., Mygind, E., Bølling, M., Otte, C. R., Schneller, M. B., Schipperijn, J., Ejbye-Ernst, N. & Bentsen, P. (2016). A quasi-experimental cross-disciplinary evaluation of the impacts of education outside the classroom on pupils' physical activity, well-being and learning: the TEACHOUT study protocol. *BMC Public Health, 16*(1), 1117. https://doi.org/10.1186/s12889-016-3780-8.

Niemiec, C. P., & Ryan, R. M. (2009). Autonomy, competence, and relatedness in the classroom. *School Field, 7*(2), 133–144. https://doi.org/10.1177/1477878509104318.

OECD. (2005). *The definition and selection of key competencies. [Executive summary].* https://www.oecd.org/pisa/35070367.pdf.

Otte, C. R. (2018). *Perspektiver på udeskole i relation til læsning, matematik og motivation for læring.* (Ph.D), University of Copenhagen, Copenhagen.

Partnership for 21st century skills (P21). (2015). *Framework for 21st century learning*. http://www.p21.org/storage/documents/P21_framework_0515.pdf.

Rakoczy, K., Klieme, E., & Pauli, C. (2008). Die Bedeutung der wahrgenommenen Unterstützung motivationsrelevanter Bedürfnisse und des Alltagsbezugs im Mathematikunterricht für die selbstbestimmte Motivation [The meaning of perceived support for motivational needs and the practice orientation in maths teaching for self-determined motivation]. *Zeitschrift Für Pädagogische Psychologie, 22*(1), 25–35.

Reeve, J. (2009). Why teachers adopt a controlling motivating style toward students and how they can become more autonomy supportive. *Educational Psychologist, 44*(3), 159–175. https://doi.org/10.1080/00461520903028990.

Reeve, J., Jang, H., Carrell, D., Jeon, S., & Barch, J. (2004). Enhancing students' engagement by increasing teachers' autonomy support. *Motivation and Emotion, 28*(2), 147–169. https://doi.org/10.1023/B:MOEM.0000032312.95499.6f.

Scheie, E. (2017). *Den naturlige skolesekken, Årsrapport*. Oslo: natursekken. https://www.natursekken.no/c1187995/binfil/download2.php?tid=2192651.

Schneller, M. B., Bentsen, P., Nielsen, G., Brønd, J. C., Ried-Larsen, M., Mygind, E., & Schipperijn, J. (2017a). Measuring Children's Physical Activity: Compliance Using Skin-Taped Accelerometers. *Medicine and Science in Sports and Exercise, 49*(6), 1261–1269. https://doi.org/10.1249/mss.0000000000001222.

Schneller, M. B., Duncan, S., Schipperijn, J., Nielsen, G., Mygind, E., & Bentsen, P. (2017). Are children participating in a quasi-experimental education outside the classroom intervention more physically active? *BMC Public Health, 17*(1), 523. https://doi.org/10.1186/s12889-017-4430-5.

Skoven i Skolen. (2021). Udeskole i Norden. http://www.skoven-i-skolen.dk/internationalt.

Sterling, S. (2010). Learning for resilience, or the resilient learner? Towards a necessary reconciliation in a paradigm of sustainable education. *Environmental Education Research, 16*(5–6), 511–528. https://doi.org/10.1080/13504622.2010.505427.

Taylor, G., Jungert, T., Mageau, G. A., Schattke, K., Dedic, H., Rosenfield, S., & Koestner, R. (2014). A self-determination theory approach to predicting school achievement over time: the unique role of intrinsic motivation. *Contemporary Educational Psychology, 39*(4), 342–358. https://doi.org/10.1016/j.cedpsych.2014.08.002.

van de Oudeweetering, K., & Voogt, J. (2018). Teachers' conceptualization and enactment of twenty-first century competences: Exploring dimensions for new curricula. *The Curriculum Journal, 29*(1), 116–133. https://doi.org/10.1080/09585176.2017.1369136.

Vansteenkiste, M., Lens, W., & Deci, E. L. (2006). Intrinsic versus extrinsic goal contents in self-determination theory: Another look at the quality of academic motivation. *Educational Psychologist, 41*(1), 19–31. https://doi.org/10.1207/s15326985ep4101_4.

Voogt, J., & Roblin, N. P. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *Journal of Curriculum Studies*, 44, 299–321. https://doi.org/10.1080/00220272.2012.668938.

Waite, S. (2011). Teaching and learning outside the classroom: personal values, alternative pedagogies and standards. *Education 3–13, 39*(1), 65–82. https://doi.org/10.1080/03004270903206141.

Waite, S., Bølling, M., & Bentsen, P. (2015). Comparing apples and pears?: A conceptual framework for understanding forms of outdoor learning through comparison of English Forest Schools and Danish udeskole. *Environmental Education Research,* 1–25. https://doi.org/10.1080/13504622.2015.1075193.

Wals, A. E., Brody, M., Dillon, J., & Stevenson, R. B. (2014). Convergence between science and environmental education. *Science, 344*(6184), 583–584.

Ulrich Dettweiler is professor of pedagogy at the University of Stavanger, Norway. His research focuses on the effects of Education Outside the Classroom on children's learning and he is especially interested in the psychological and bio-physiological mechanisms associated with learning processes in nature.

Gabriele Lauterbach holds a PhD-stipend in Educational Science at the University of Stavanger, Norway. In her project, she tries to map *uteskole* in Norway, both with respect to its dissemination and its pedagogy, and is especially interested in the inclusive potential of Education Outside the Classroom.

Christoph Mall has a doctoral degree in sports science and works as a lecturer at the Technical University in Munich. He is doing research on physical activity, health and learning motivation with a special focus on students' physical activity levels, their stress response and learning motivation during Education Outside the Classroom.

Ruth Kermish-Allen began her career as a forest ecologist and serves now as Executive Director at the Maine Mathematics and Science Alliance. She has extensive experience in STEM education research, project development, implementation, and evaluation.