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Better learning in the outdoors?

**Social, motivational and health-related aspects in
Education Outside the Classroom**

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Summary

There can be no doubt that the childhood and adolescence of recent generations is different from that of earlier generations. A variety of factors are at play, and it seems a valid conclusion that overall challenges are increasing. These can be seen directly, for example, in the increasing deterioration in the mental health situation of children and adolescents and their subjective future prospects. The school, as possibly the central setting for this age group, has a special role to play here. It therefore seems necessary to develop intervention concepts that address these health-related problems and at the same time are suitable for long-term implementation in schools. Accordingly, these concepts should also meet the basic criteria of a suitable future-oriented school concept - e.g. with regard to methodical-didactic principles and the addressing of 21st century skills. A concept that may be able to combine several topics (proper use of methodical-didactic teaching principles, forcing the teaching and experience of future-oriented 21st century skills, providing an appropriate environment regarding a healthy development) is Education Outside the Classroom (EOtC). EOtC is characterized by curriculum-compliant lessons that are regularly moved out of the classroom into the outdoors and has a particularly wide distribution in Scandinavia. In this dissertation, a total of 66 students in four fifth grades (one of which regularly conducts EOtC) at the same school in Germany were assessed for their health-related quality of life (HRQoL), self-determined learning motivation, basic psychological need satisfaction, social interaction, and friendship networks and compared over time. Statistical analysis using linear mixed models and social network analysis revealed on the one hand an improved self-determined motivation to learn, as already evident in previous studies from other countries. At the same time, the results do not confirm the presumptions of positive associations of EOtC and HRQoL and social interaction. Some reasonable explanations can be found, but the results clearly underline the need for additional research in the coming years. The statistical results and their interpretation, suggest that in countries like Germany, where the concept of EOtC has been implemented comparatively rarely so far, numerous steps are still needed to fully exploit the social, motivational and health-related potential of the concept. Primary among these is the investigation of correlations between motivational regulation, cooperative learning and 21st century skills by combining qualitative and quantitative approaches in single analyses. Furthermore, especially in the case of research on such a societal topic, close cooperation with practitioners and politicians seems to be urgently recommended.

List of abbreviations

APEC	Asia-Pacific Economic Cooperation
BPN	Basic Psychological Needs
CL	Cooperative Learning
EOtC	Education Outside the Classroom
ERGM	Exponential Random Graph Model
HRQoL	Health-Related Quality of Life
LPA	Light Physical Activity
MANOVA	Multivariate Analysis of Variance
MVPA	Moderate-to-Vigorous Physical Activity
OECD	Organisation for Economic Cooperation and Development
SAOM	Statistical Actor Oriented Model
SDGs	Sustainable Development Goals
SNA	Social Network Analysis
WHO	World Health Organization

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1 Introduction

In some respects, the lives of children and adolescents may seem easier than those of adults. They bear less responsibility and are less aware of many issues than their adult contemporaries. It is therefore easy to assume that children and adolescents are more carefree and therefore happier. In combination with the economically, politically and educationally privileged situation in Germany, children and adolescents must be optimistic about their own future, according to this assumption. Although just a few years ago such assumptions could be confirmed by representative surveys conducted by opinion research institutes (e.g. Shell Jugendstudie [Shell Youth Study], 2019), the current picture is completely different.

Based on a current survey, only 16% of children and adolescents believe that the overall situation in Germany will be better in three years than it was at the time of the survey (Bertelsmann Stiftung [Bertelsmann Foundation], 2022). In view of the fact that at the time of the survey (March 2022), the outbreak of the Ukraine war was like a shock in everyone's bones, the pandemic only settled slowly, and a new spectre of fear was making its appearance in the form of recession and inflation, this is a truly depressing outlook. Not even half of all respondents between the ages of 12 and 18 describe themselves as generally "very satisfied" with their own lives (Bertelsmann Stiftung [Bertelsmann Foundation], 2022). It is advisable to treat such surveys and subjective feedback with caution. However, the irrevocable impression remains that the majority of children and adolescents in Germany are concerned about the future.

In addition to these subjective, sometimes abstract and future-oriented concerns, some difficulties are already evident today with which children and adolescents are confronted – and such have clearly specifiable medical and developmental-psychological relevance. According to currently available statistics, there is a prevalence of 16.9 % of mental health issue-affected in the group of 3-17 years old in Germany (Klipker et al, 2018) and as many as 48% showed low levels of health-related quality of life (HRQoL) during the COVID-19 pandemic (Ravens-Sieberer et al., 2022). Unfortunately, in line with this only 22.4 % (girls) respectively 29.4 % (boys) of children and adolescents in Germany between 3-17 years meet the World Health Organization (WHO) recommendations for physical activity (Finger et al., 2018). Here, too, it was observed that the level dropped sharply in parts during the pandemic (Ravens-Sieberer et al., 2021). The link between physical activity and mental health is expressed by empirical findings suggesting that sufficient physical activity may also be considered a buffer for mental

health in children and adolescents (Ahn & Fedewa, 2011; Biddle & Asare, 2011; Bell et al., 2019; Booth et al., 2023). Admittedly, this health situation is not directly reflected in the thoughts about the future described above. However, both could be mutually reinforcing, especially with regards to mental health. Despite that, it is foreseeable that such health-related conditions, as well as their possible implications and further developments in adult age (Chaddha et al., 2016) will lead to even greater problems on a physical, psychological and economic level already among the youngest members of our society (Power, Lake & Cole, 1997; Wang et al., 2011; Goodman, Joyce & Smith, 2011).

Particularly with regard to the anxious look into the future and mental health issues among children and adolescents, the question arises as to the causes. Even though, of course, it is almost impossible to make any firm conclusions about what is really causing the mental health issues in this population. At the beginning of this introduction, the thesis was put forward that children and adolescents would live their lives more carefree because they are only affected to a comparatively small extent by the major (positive and negative) developments in the world community. This may be true for younger children in the case of warlike conflicts, for example. But stressors of a psychological nature also exist in the everyday lives of children and adolescents. Related to those, half (48%) of more than 1,000 school principals from all types of schools in Germany consider the current examination practice at schools to be a major psychological burden on students (Robert Bosch Stiftung [Robert Bosch Foundation], 2023), which as well can be confirmed by the assessment of the students themselves (Inchley et al., 2020). Unfortunately, well over half of these school principals (57%) do not see sufficient competence represented at their school to adequately address these and other psychosocial stresses for students. Parallel to this, a steady decline in intrinsic and self-determined learning motivation among students can be observed as students go through secondary school (Gnambs & Hanfstingl, 2016; Scherrer & Preckel, 2019). The impression arises that school or school-based learning under these conditions of significant stress and less intrinsic motivation contributes only to a limited extent to a pleasurable and joyful life for many students. This assumption is supported by a study that identified school as a whole as the No. 1 stressor for students (Anniko, et al., 2019).

From these remarks, the urgent need to make the mental health of children and adolescents the subject of appropriate interventions in schools emerges. This inevitably raises the question

of how appropriate interventions could be integrated into the current school system. What is already clear here is that they must be able to be integrated in the long term in order to have a real impact. In this respect, it is imperative that these interventions meet the criteria of a verifiable teaching concept. In the best case, appropriate concepts as part of interventions also take into account that children and adolescents move in a rapidly changing world. It would be foolhardy to view current standards as still being in place a few decades from now (Clark et al., 2020). The described health-oriented interventions should therefore, in the best case, not only be understood as effective in terms of health, but also meet the requirements of a "modern concept of education" and teach future-oriented skills ("21st century skills") and therefore be real future-oriented school concepts. In order to meet this great and lengthy challenge, science, civic life and politics must work together to develop school concepts that are truly future-proof. In the best case, this should not be driven by actionism or an "innovation mania" (Knights & McCabe, 2003). Rather, the task is to supplement central existing structures with meaningful and practicable elements in order to ensure their future compatibility. The potential of such a complementary element in the school setting is the subject of this dissertation.

2 Background

The introduction to this thesis emphasizes that children and adolescents have to struggle with (mental) health-related problems, which may be in a mutually dependent cycle with subjective and objective future prospects (Sawyer et al., 2012). It seems a big challenge to address a larger part of these complex trends of a changing world at the same time. If this is to succeed, the environment of the school in particular seems to be a promising setting, as on closer inspection, it becomes clear what potential lies in focusing on schools as a starting point for health-related interventions and the teaching of 21st century skills. At the same time, in view of the great challenges, the question inevitably arises as to whether the current school systems, especially in Germany, are capable of remedying the situation.

2.1 Modern childhood and the school setting

Children and adolescents are not considered a particularly vulnerable group for nothing, since they themselves (at least up to a certain age) have little or no control over the conditions of their lives. At the same time, in childhood and adolescence there is a particularly high sensitivity to changes that could potentially have lifelong repercussions (Patton et al., 2016) – both positive and negative, affecting health-related, cognitive, psychological and socio-emotional facets (Welsh & Pennington, 1988; Pluess et al., 2018; Geary & Bjorklund, 2000; Calvin et al., 2011). Consequently, the importance of healthy and appropriate development of children and adolescents cannot be overestimated at all. Early intervention, raising awareness and enabling certain experiences is particularly valuable at this age stage. Automatically, the question arises of where and how to reach as many children and adolescents as possible. In this context, the importance of schools as starting points for interventions is already clear in purely quantitative terms, as children and adolescents spend a large part of their waking hours there (Huber & Köppel, 2017; Leech et al., 2014). In Germany, as of 2026, there is a legal right for children in elementary schools to be cared for at school throughout the whole day (Bundesregierung [German Government], 2018). This is a reasonable adjustment from the perspective of promoting women in the workplace, as well as the general compatibility of family and career. However, this means that the importance of school could increase even further: In hardly any other setting will it be possible in the future to reach all children and adolescents equally. This can be

seen as an opportunity from the perspective of public health. Even now already, the WHO places schools centrally in its overall strategy as perhaps the most powerful resource for comprehensive health promotion (WHO, 2023). Also, on a national level, the special importance of the school setting is pointed out by position papers of the united health insurances (GKV-Spitzenverband [GKV Central association], 2023). Based on these strategy papers from (nearly) all public health insurance companies in Germany, it is already clear that this task is understood to be one that affects society as a whole (Clark et al., 2020). Precisely because of their limited opportunities to influence their own lives, paired with the deficits described in the area of mental health and in view of the future, it would be negligent as a society not to seize the opportunities to enhance the youngest.

As indicated above, however, the implementation of health promotion initiatives cannot be exclusively about achieving the greatest possible effects in a small group with selective interventions. Rather, such interventions should be seen as a long-term complement to the school system (Day et al., 2019; Shaya et al., 2008) and, accordingly, be able to contribute to general school education. In this context, it is important to address the shortcomings of the current system: Although this was already known, the COVID-19 pandemic revealed once again that there are no or only a few alternatives to the traditional teaching especially in Germany (Schneider et al., 2021; Sonnenberg, Buddeburg & Hornberg, 2022). Structural difficulties or peculiarities of the German school system such as the fragmentation of teacher training, the strong focus on the academic training of teachers and federal responsibility in the education system sometimes have the effect of slowing down rather than innovating (Kotthoff & Terhart, 2013).

Of course, at this point, no need for innovation should be conjured up that is not necessary. Therefore, the question arises as to what schools in Germany should be able to teach, despite their lack of health-promoting character.

2.1.1 The 21st century skills set

It does not take scientific research to reliably determine that our world is changing (Clark et al., 2020) and probably faster than ever before. Changes are visible in every aspect: e.g. politics, society and working life (Lambert, 2017). A changing world also requires new skills in order

to be able to move and develop successfully as an individual in this very world. In the meantime, it seems to have become generally accepted that specialist knowledge alone is not enough, but that modern educational programs should also include “higher order thinking skills, attitudinal skills and socio-emotional skills” (Lamb et al., 2017, 7; Mann et al., 2022). In general, 12 skills are defined specifically for students that seem necessary for them to navigate this modern world – so called *21st century skills* (Alismail & McGuire, 2015). These seem to be necessary for students to lead successful and self-determined lives in the modern days (Larson & Miller, 2011). The corresponding assessment was centrally driven by the US Common Core State Standards Initiative and subsequently disseminated by the Organisation for Economic Cooperation and Development (OECD) and Asia-Pacific Economic Cooperation (APEC). In the meantime, however, these skills are being widely rolled out and communicated world-wide. The underlying assumption of a "modern world" is characterized by an ever more rapidly evolving society and world of work, which is increasingly characterized by digital processes, but also according to the ability of an individual to adapt to changing conditions (Voogt & Roblin, 2012). The 21st century skills specifically in the area of schools are considered to be (sometimes communicated in slightly varying form) (Alismail & McGuire, 2015):

- Critical thinking
- Creativity
- Collaboration
- Communication
- Information literacy
- Media literacy
- Technology literacy
- Flexibility
- Leadership
- Initiative
- Productivity
- Social Skills

Especially the skills, which are commonly called "soft skills" (e.g. social skills), are of central importance, which is also underlined by fundamental theories like the systems theory (Luhmann, 2021). The systems theory on the social level can be based on a similar view of the world and the human being as, for example, constructivism, another major sociological theory (Glaserfeld, 1997). Systems theory argues that individual actors should always be recognized in the context of the respective reference system and that dependencies should also be understood as system behavior (Luhmann, 1997). This assumption alone makes it clear how central soft social skills are considered not only in the context of 21st century skills but also in traditional sociological theories.

Obviously, all of those 21st century skills should be thematized explicitly or implicitly in future-oriented schools. Otherwise, schools would miss their mission to form responsible citizens of the future. Accordingly, schools and the quality of teaching today should be measured (at least too) by whether and to what extent they address, teach and promote these 21st century skills (Schleicher, 2011; Saavedra & Opfer, 2012). At least, that is how it seems conclusive from an initial view. But the standards by which education has been judged "good" have not always been the same throughout history and even in current educational concepts, one usually looks in vain for an explicit reference to 21st century skills. The question therefore arises as to what educational concepts practiced today are actually oriented to. The following chapter will trace the development up to today's concepts and ideals of school teaching.

2.1.2 Aspiration of educational and teaching concepts

Historically, it is not easy to date the beginning of "school teaching".¹ What is known for sure is that schooling was already carried out in and by monasteries in the 7th century (Geißler, 2014). A first systematization of this teaching took place with the introduction of the "septem artes liberales" (Latin for "the seven liberal arts"), whereby different subjects and associated with them specific didactic approaches were established for the first time (Geißler, 2014). Until the 13th century, it remained a privilege of the spiritual to teach – only with the introduction of school subjects, which increasingly served practical purposes, could these also be taught by secular persons. This could be understood as the birth of school teaching and education in its basic features as we still know it today (Geißler, 2014).

Even before considering the content and semantics of education, the German-speaking world has a terminological peculiarity that the English language does not feature in this form: In German, a distinction is made between the terms "Erziehung" and "Bildung", both of which

¹ This term describes teaching at an institution that was created specifically for this purpose. In the German-speaking countries, the term is not free of discussion. The corresponding term "Unterricht" is sometimes viewed critically, as it supposedly implies a hierarchy ("unter" means "below") - however, by definition, "Unterricht" describes the interaction of teachers and learners for the purpose of a gain on the part of the learners of knowledge, attitudes or skills (Lüders, 2012).

are translated into English as "education". This may seem trivial at first, but the (mostly) German-speaking authors and pioneers of educational theories partly refer to different terms.² A linguistic tracing of this development does not seem to be useful, but rather a delimitation of what all the authors consider fundamentally desirable in the context of education. Thus, all understandings are united in that the outcome of an educational process should be that the student is or becomes responsible, self-reliant, and self-determined. This fundamentally contradicts the mindset, that education is only characterized by the learning of facts, but rather the empowerment of life-long and self-determined learning should be the focus of education (Böhm & Seichter, 2022; Humboldt, 1920; Klafki, 1964; Meyer & Renartz, 2013; Robinsohn, 1969; Tenorth, 2003). According to this understanding, a highly educated person would not (only) be able to enumerate many facts, but would be able to navigate confidently in different situations and work out solutions self-determined. Consequently, this includes not only measurable skills, but also facets of personality (humanistic education) (Tenorth, 2012). This understanding of education is not only a philosophical ideal, but is also reflected in concrete strategies and guidelines. The United Nations' Sustainable Development Goals (SDGs) explicitly include high-quality education as one of their 17 goals and follow the basic principles of the humanistic understanding of education (United Nations, 2015). At the national level, political guidelines also point out that early childhood and secondary education should be oriented towards the empowerment of life-long learning (BMFSFJ, 2008; Kultusminister Konferenz [Conference of Ministers in Education], 2020). Obviously, this understanding of true education is also in line with the idea of 21st century skills, which turn away from specialist knowledge and instead focus on skills that enable continuous development and navigation through life and the world (Lamb et al., 2017). From today's position, it could therefore be easy to proclaim precisely this as a central goal of school education as well – at least in addition to learning "hard skills" (e.g. basic physical mechanisms or biological cause-effect relationships). Over the decades, specific educational goals in view of this understanding of education have increasingly emerged. In addition to crystalline knowledge, these include, for example, applied skills, abstract key qualifications (e.g., self-management) and social competencies (Weinert, 2001).

² For example, Böhm and Seichter (2022), in their standard work, speak of "Erziehung" when they refer to those constructs which, in turn, Humboldt (1920), Klafki (1964) one of the most significant educationalists in Europe, as well as Meyer and Reinartz (1998), refer to as "Bildung."

Assuming that the activation and empowerment for life-long and self-determined learning is determined as the goal of school, the question then arises as to how these skills can best be taught. In this context, it is worthwhile to delve deeper into the discussion about which criteria constitute supposedly good teaching (in the sense that the students have a great take-away from the teaching through a high level of involvement) – a discussion that is ongoing and can neither be answered conclusively in principle, nor within the framework of this thesis. However, it seems necessary and quite possible to approach a list of basic criteria.

Subject to fluctuation over the years was the assumption about the importance of personality traits on the part of teachers (Bohnsack, 2004; Mayr, 2014). The idea that these characteristics are primarily decisive for the success of teaching has recently been replaced by more complex understandings, which in turn attempt to explain and take into account a whole range of criteria describing supposedly good teaching in addition to teacher characteristics (Helmke, 2015). These criteria, which are sometimes referred to as "teaching principles," "pedagogical principles," or "didactic principles" and whose content is largely congruent, apply in principle to all situations of teaching, learning, and instruction (Glöckel, 2003). In the international context, Hattie's (2011) empirically tested and extensively described criteria are certainly the most prominent. In Germany, those of Meyer (2007), Wiater (2021) and Helmke (2015) are particularly frequently addressed, which seems to be due not least to their formal anchoring in the training of teachers in universities and schools (Nix, 2017). In sum, there is a great deal of overlap between Hattie's, Meyer's, Wiater's and Helmke's thinking, which can best be paraphrased as all assuming a continuum of instruction and construction and thus synchronously emphasizing the great importance of the teacher as well as the need for distinctly student-centered instruction (Hattie, 2011; Helmke, 2015; Meyer, 2007; Wiater, 2021). Here, Hattie takes the position of the one who particularly emphasizes the role of the teacher (Hattie, 2011), while Meyer emphasizes the involvement of the students as the most important criterion (Meyer, 2007) – an understanding that is currently experiencing new momentum in the course of resonance theory (e.g. Rosa, 2019). Both positions are not to be understood as opposites, but as

different accentuations, which can be mutually conditioned. In conclusion, the following methodical-didactic principles³ can be defined, against which successful teaching must be measured, as far as it is based on the understanding of education described above:⁴

- Self-activity of the students
- Differentiation (considering the heterogeneity of the learning group)
- Illustration of the learning content
- Motivation (arousing and maintaining learning and performance needs)
- Holistic approach (multi-perspective view of the contents)
- Goal orientation that is comprehensible for the students
- Structuring (conveying the contents according to an orderly arrangement)
- Appropriate assurance of results

However, it should be emphasized that this list is neither final nor static. However, based on a process of consideration and consolidation between empirical findings and primarily theoretical approaches, the presented list seems to be the essence. Assuming that these methodical-didactic principles are considered as the basis for successful learning in any form, this of course also applies to the acquisition of 21st century skills. One of the few studies that investigated the relationship between learning environments (which are not purely spatial, but also methodical-didactic) and the promotion of 21st century skills underlines the assumed relationship (Lemley et al., 2014). Analogous to Hattie's (2011) conclusion that the person of the teacher in particular is crucial, the importance of the teacher-student relationship is also pointed out here. At the same time, Lemley et al. (2014) point out the existing difficulties in surveying 21st century skills in learning environments.

2.1.3 Implementation of life-long and self-determined learning

It seems that there is a great deal of overlap between the ultimate goal of the traditional understanding of education according to Humboldt (1920), Klafki (1964), Böhm & Seichter (2022) and others and 21st century skills: the empowerment of life-long and self-determined learning.

³ From now on, the term "methodical-didactic principles" will be used consistently when describing those criteria. From the author's point of view, this combination of terms best reflects what the list of those principles represents: a (successful) mixture of convictions about practical implementation, which includes both the choice of appropriate methods (methodical) and the appropriate use of these for teaching (didactic).

⁴ In this context, an intensified implementation of a certain teaching principle is not to be considered "better" in every case. For example, a forced maximum of self-activity of the students would possibly be at the expense of a clear presentation of the contents by the teacher.

This raises the question of whether school as it is practiced today is promising for a promotion of these. In the last few years, as well as in the most recent past, this has unfortunately had to be denied. It turns out that some countries, including Germany, still place a very large focus on learning cognitive skills (Noweski et al., 2012; Rychen, 2003) and in some cases do not even enable the teachers with the skills which would later have to be transferred to the students (Kazu & Demiralp, 2016; Kinshuk et al., 2016). If young teachers, in turn, show the will to implement methods to promote 21st century skills, they often experience obstacles from the historically grown school system (Tican & Deniz, 2019). The COVID-19 pandemic has once again proven that the technical equipment and the qualification of the teachers often do not allow the promotion of specific, technology-oriented skills (Price, 2015). Germany even performs significantly poorly in a European comparison in this regard (Blume, 2020). Student's self-determined motivation to learn can be seen as an indicator of whether the previously described goal of education (life-long self-determined learning) is being achieved. Unfortunately, research suggests that both in Germany and internationally, self-determined motivation to learn steadily decreases in the course of secondary schools (Gnambs & Hanfstingl, 2016; Scherrer & Preckel, 2019). The experiences from the COVID-19 pandemic could act as an additional catalyst for insufficient motivation of the students (Schneider et al., 2021). These results complement the professional assessments of experts on, in European comparison, widespread active and passive truancy among German children and adolescents at the beginning of the 21st century (Schreiber-Kittl, 2011).

The conclusion can be drawn from this that schools (at least in Germany) do not currently implement methods that result in an ability for life-long and self-determined learning, at least not across the board and effectively. Therefore, the school must reinvent itself or be meaningfully intertwined with independent concepts that unite a holistic understanding of the tasks of a modern school in a changing world, such as a) enabling the use of proper methodical-didactic teaching principles in order to b) foster the teaching and experience of future-oriented 21st century skills and c) providing an appropriate environment regarding a healthy development of children and adolescents (Mahmoudi et al., 2012; Ferreira et al., 2020).

The subject of this dissertation is a teaching concept that could be capable of addressing at least some of the needs in social, motivational and health-related regards. This concept is called

Education Outside the Classroom (EOtC) and moves teaching outside of the classroom into natural or cultural places like forests, museums, playgrounds or factories. In the following chapter, the history and definition, the current state of research and the superordinate potential as a future-oriented concept auf teaching of EOtC will be explained in detail.

2.2 The concept of Education Outside the Classroom

The field of concepts dealing with education in the broadest sense outside the classroom is wide and partly confusing. "Outdoor education", "forest schools" and "experiential education" are only a few of the terms that are used and have more or less large overlaps with each other. The necessity of consensus on certain terms and constructs has been recognized in the meantime and sometimes attempted to establish in elaborate procedures regarding outdoor play and teaching (e.g. Lee et al., 2022). Especially for the research of certain concepts, it is not only desirable but even necessary to agree on certain delimitations in order to be able to establish a scientific comparability. The understanding on which this research is based will be discussed in the following chapters, in addition to the historical perspective as well as the state of research on EOtC.

2.2.1 Definition and historical background

It is certainly permissible to claim that the concept of EOtC implemented in Germany is strongly influenced by those from Scandinavia but also those from New Zealand and Scotland (Beames & Ross, 2010; Jordet, 2007; Beames, 2006). In these regions, teaching approaches shifting school teaching outside the classroom have been practiced since the late 1980s or early 1990s. In Scandinavian countries, the spread of EOtC (Denmark: "udeskole"; Norway: "uteskole") in recent years can be understood as a grass-root movement (Bentsen et al., 2009; Jordet, 2007). Accordingly, this stems from the initiative of individual engaged teachers rather than directives from school boards or politicians. As the concept became more widespread, scientific interest in it also increased. With *TEACHOUT*, the largest and most comprehensive research project to date on EOtC was carried out in Denmark from 2016 onwards, supplementing the very scattered individual studies that existed up to that point (Nielsen et al., 2016).

Especially with regard to the development of systematic reviews summarizing research findings (e.g. Becker et al., 2017) and large-scale research projects such as TEACHOUT, it quickly seemed necessary to identify a unified definition for EOtC that would subsequently make it possible to compare the results more reliably with one another. Before, first definitions only considered specific approaches in individual countries (e.g. Mygind, 2009). In lack of whatever binding criteria for EOtC, the international research community has come to agree over the years that in order to be designated as EOtC, a school concept must meet the following key characteristics (those are e.g. the basis for the review of Becker et al., 2017 or the TEACHOUT project in Denmark [Nielsen et al., 2016]):

- The teaching takes place at least bi-weekly in natural, communal or cultural spaces outside the classroom.
- The lessons are designed for the long term, not as a short-term project phase of a few weeks.
- The individual units of lessons must not be less than four school hours.
- The content of the lessons must be clearly based on the regular curriculum of the respective type of school and grade.

In the EOtC pioneer country Denmark, according to current surveys, about one fifth of all schools (public schools: 17.6%; private schools: 24.3%; special schools: 34.0%) implement EOtC in at least one class (Barfod et al., 2021). The numbers of schools offering EOtC in Denmark seem to have been mostly stagnant for several years – but in fact the number of classes implementing EOtC per school is steadily increasing (Barfod et al., 2021). So far, there are no comparable systematic surveys on EOtC in Germany. However, on the basis of rough estimates of experts in this field, it can be assumed that there are hardly more than two dozen schools in Germany that currently apply the concept according to the above-mentioned definition of EOtC (DNDD, 2021). The front-running role of Denmark and the other Scandinavian countries with regard to EOtC is also expressed in their contribution to research on EOtC.

2.2.2 Research on Education Outside the Classroom

Research on EOtC has received a boost, especially since the initiation of TEACHOUT in Denmark. This was followed by research projects in some countries with a few schools, as well as several smaller surveys. In sum, an increasing interest in the research of EOtC is noticeable,

but also measurable. For example, in their 2017 review, Becker et al. were able to include a mere 13 studies (Becker et al., 2017); in a recently update-process to that review, also including publications from the years 2017 - 2022, 27 new studies were added (Mall et al., 2022 [PROSPERO registration]). It should be noted that these reviews are based on exactly the understanding of EOtC presented earlier and only focus on aspects as outcomes on the students.

In principle, many research projects seem to hypothesize the same understanding of and for mechanisms of effects and interrelations between various variables in EOtC, as do the authors of the TEACHOUT study, as shown in Figure 1. Accordingly, changed conditions in the area of social relations and cooperation could lead to an increase in physical activity (because most of children's activities take place in groups [Nielsen, 2011]) and well-being in and motivation for school, which could have a positive effect on learning overall via physiological stimuli on cognition (Nielsen et al., 2016). From this illustration, we simultaneously read the confirmation that EOtC can actually be a meaningful complement to school teaching, but also to school life. In fact, academic learning (learning) could at the same time be directly addressed with aspects of physical (physical activity) and mental health (well-being) and social regards (social relations and cooperation).

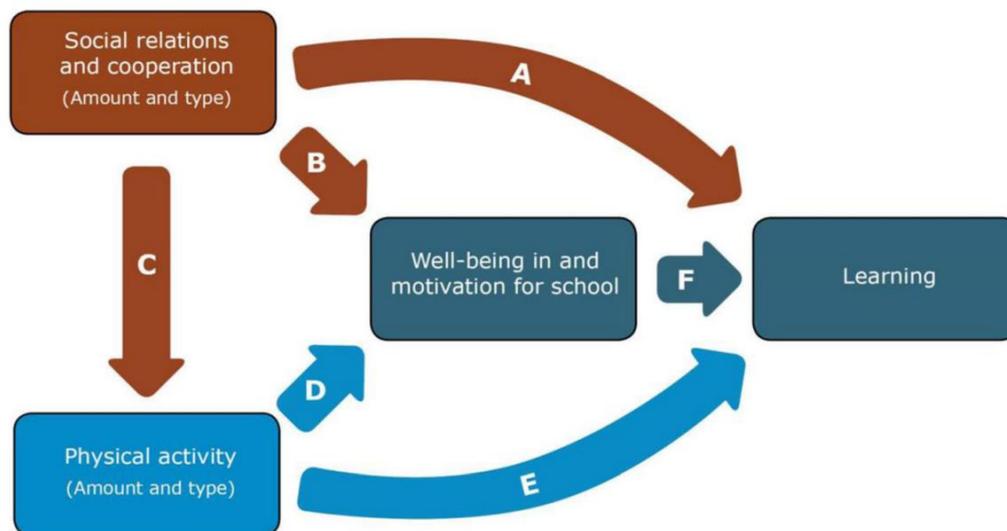


Figure 1. Interrelations of outcomes within the context of EOtC (Nielsen et al., 2016).

In the following, the published research findings on the EOtC are presented in detail. Here, too, a similar structure of the variables as in Figure 1 is taken as a basis, but at the same time expanded and supplemented by the assessment of experiences of the teachers in addition to

the outcomes on the student level. Although this should not be generalized, it tends to show that the methodological quality of the studies increased, especially with the start of TEACHOUT (Mall et al., 2022 [PROSPERO registration]) compared to earlier studies (Becker et al., 2017). Previous studies provided important insights and inspiration for future research projects, but were mostly only transferable to other situations to a very limited extent.

Socio-emotional development

EOTC could address social as well as emotional facets in students in a variety of ways. Within the quantitative as well as qualitative research paradigm, the methods used to collect these data are just as diverse as the effects. In the following, an overview of these methods and results will be given.

The survey of social relations by means of questionnaires did not initially reveal any clear indications of advantages or disadvantages of the EOTC in comparison with indoor settings (Mygind, 2009). Retrospective considerations in the context of interviews, social cognitive mapping, or written statements (self-letters), however, do suggest improvements in social relations, social behavior, and the uptake of new affiliations, which seem to be due in particular to an increased degree of cooperation (Ernst & Stanek, 2006; Hartmeyer & Mygind, 2015; Dettweiler et al., 2015; Bølling et al., 2019b). In addition, initial findings suggest that students' social well-being may improve (Bølling et al., 2019a; Jørring et al., 2019) – although the same research also points to the risk of increasing exclusion of individual students. These initial findings also underscore the intertwining of socio-emotional with health-related ones, as described in the following paragraph. Given the broad spectrum of objective and subjective effects and correlations in this domain, the high diversity of methods seems necessary and should be continued in future research projects in order to obtain a balanced picture of socio-emotional development in and through EOTC.

Physical activity and health

Basically, it is assumed that EOTC enables more and new forms of movement by transferring teaching into open spaces (Armbrüster et al., 2016). Early on, following this impression, physical activity in EOTC was measured using objective accelerometry according to the applicable gold standard (Burchartz et al., 2020). Although initial case studies did not consistently show that children are more active in EOTC than in the classroom, the sum of these smaller surveys

showed an initial trend in this direction (Mygind, 2007; Mygind, 2009). Those findings on physical activity have since been supplemented by others and reinforce this picture. For example, accelerometry-based TEACHOUT surveys, demonstrate increased levels of physical activity (both moderate-to-vigorous [MVPA], and light physical activity [LPA], depending on the survey) (Schneller et al., 2017a; Schneller et al., 2017b). Other studies suggest stronger effects for girls in the MVPA domain (Lacoste et al., 2021). In particular, conducting EOtC in natural spaces (as opposed to cultural or communal spaces) appears to have a positive effect on the physical activity (Mygind, 2016; Bølling et al., 2021).

The assessment and analysis of cortisol secretion in saliva samples over several time points during the day suggests that children in EOtC show a lower level of this stress indicator (Dettweiler et al., 2017; Becker et al., 2019). While there does not appear to be a global correlation of the cortisol level with physical activity, it seems possible that it is at least related to high levels of LPA (Becker et al., 2019). EOtC also seems to be stress-effective with regard to the efficient regulation of biological stress-reactivity, as suggested by recent studies (Dettweiler et al., 2022). The finding that EOtC in natural environments increases tonic vagal tone and thus current stress adaptability (Mygind et al., 2018b) underscores the stress-related relevance of EOtC in some regards. This is an important indication, especially in the context of the stress-related relevance of the school environment for children and adolescents described above. In the broader focus of "health," it is also worth noting that EOtC approaches with a strong focus on gardening may have positive effects on eating behaviors (Ambusaidi et al., 2018; Ambusaidi et al., 2019). Several promising and in part already extensively documented health-relevant mechanisms of action of EOtC have been identified. Currently, in the context of the investigation of "physical activity and health", the clear focus is on physical and objectively measurable parameters. Initially, it remains unclear whether these (mostly physiological) effects are also positively reflected in the students' mental health experience.

Learning and academic achievements

Analogous to physical activity, the potential for a changed and possibly improved learning atmosphere in EOtC lies primarily in the breaking up of the classical teaching space in the classroom. Research in recent years suggests an increased use of cooperative forms of instruction (Ellinger et al., 2022b) and the appropriation of physical space in new patterns (Mall et al., 2021) and activities (Sahrakhiz et al., 2017). In this context, the finding that children in EOtC

do not suffer the frequently observed drop in intrinsic (and thus self-determined) learning motivation is particularly significant (Bølling et al., 2018). This can be further supported by the finding that EOtC is associated with positive experiences and joy from the children's perspective (Scogin et al., 2017). However, these initially quite hopeful findings are not consistently reflected in previous research on academically measurable learning success. The inconsistent results in this area indicate better learning performance in some subjects (Bakioglu, 2018; Otte et al., 2019a), whereas corresponding effects were absent in other areas (Otte et al., 2019b). Accordingly, future research should focus on understanding the mechanisms of a possibly improved motivational regulation and in particular on exploring how this could possibly be transferred into improved learning performance (see also chapter 5.3) and possibly into benefits in the abstract but at least equally important "life skills" and deep learning (Mygind et al., 2018a; Winje et al., 2021).

From the perspective of teachers, EOtC has great potential to improve learning performance and everyday skills (Mygind et al., 2018a). EOtC thus potentially enables inquiry-based teaching and thus student-oriented and -centred teaching with cognitive challenges (Barfod & Daugbjerg, 2018) and promotes school and instructional development processes in terms of interdisciplinary teaching, testing new methods, and enhancing diverse teaching competencies (Sahrakhiz, 2017). However, parallel challenges of EOtC implementation have been identified in the past, with increased teacher workload, weather and clothing, structural conditions, and overall school expectations playing particular roles (Barfod & Bentsen, 2018; Ellinger et al., 2022b).

Environmental aspects

The state of research on the effects and correlations of EOtC in the field of environment is almost surprisingly thin, especially in recent years. After all, it would sound very likely to assume extensive effects on the impact on various environmental and nature-related beliefs, attitudes, and behaviors of students, especially in the case of teaching in natural settings. As one of the most recent studies, a study suggests that the satisfaction of basic psychological needs (BPN) in EOtC in particular is an important prerequisite for motivating environmentally friendly behavior (Christodoulou & Karfiatis, 2018). At the same time, another study suggests that EOtC may as well cause deteriorations (e.g., in the domains of compassion, humility, and acceptance) (Martin et al., 2009). In contrast, EOtC has been observed to increase interest in

natural materials (Fiskum & Jacobsen, 2013), to have a positive long-term impact on environmental-friendly behaviors (Moeed & Averill, 2010), and to increase understanding of the interconnectedness of global systems (Santelmann et al., 2011).

In sum and in at least those domains presented above, it seems quite reasonable that EOtC has the potential to bring about improvements in e.g. social, motivational and health-related aspects. However, it also becomes clear that the findings are sometimes inconsistent or the studies can only be considered as pilot studies for future investigations.

2.3 Education Outside the Classroom: A future-oriented concept?

In chapter 2.1 of this thesis, it was described what modern schools in a changing world should accomplish – enabling the use of proper methodical-didactic teaching principles, forcing the teaching and experience of future-oriented 21st century skills and providing an appropriate environment regarding a healthy development – in order to enable their students to learn skills that may be needed to be valuable, healthy and happy members of society. At the same time, it also became clear that the current concepts and understandings of school and school teaching (at least in Germany) will reach their limits in the attempt to satisfy them.

New concepts such as EOtC could reveal valuable perspectives for further development or additions to the status quo. But which criteria should be used to assess the suitability of a modern school concept? This question undoubtedly holds endless potential for discussion. A saying of Niklas Luhmann, the father of the much-cited systems theory and one of the most distinctive sociologist of the 20th century, sums up his personal opinion, which is in line with Humboldts understanding (1920) of proper education: „[It cannot be enough, in a society where so much time and effort is spent on education, to reflect only on the conditions of success and failure. It cannot be enough to take up and reformulate only the perspectives of professional work]“⁵ (Luhmann, 1997, 9). Consequently, it seems worthwhile to consider the system (in this case the school) as a whole and not to focus exclusively on individual variables of

⁵ Original quote in German: „Es kann in einer Gesellschaft, in der so viel Zeit und Aufwand auf Erziehung verwendet wird, nicht genügen, nur die Bedingungen von Erfolg und Mißerfolg [sic!] zu reflektieren. Es kann nicht genügen, nur die Perspektiven der professionellen Arbeit aufzugreifen und zu reformulieren“ (Luhmann, 1997, S. 9)

academic success in order to test a suitable concept. In the following, it is rather interdisciplinary and practice-relevant questions that provide information about the suitability of a future-oriented school concept.

In the authors opinion, from the described problems, as well as the assumed character and the previous research on EOtC, some constructs can be distilled, whose deeper scientific consideration seems worthwhile to examine the suitability of EOtC as a future-oriented teaching concept. This concerns firstly the preoccupation with the glaring deficits in the area of mental health. Besides direct indicators of mental health, well-being or HRQoL, also those factors should be considered which could have an indirect influence on the population of school-aged children and adolescents. Here the joy of learning, as well as the underlying mechanisms should be mentioned. But this also concerns social skills, whose high relevance is additionally reflected in theoretical or very practical (e.g. 21st century skills) considerations. All these factors are the subject of this dissertation.

2.4 Aims of this dissertation

It appears that EOtC holds several promising opportunities for improvements on student level. These equally include health-related issues and concerns, as well as opportunities to strengthen some of the 21st century skills. However, it is apparent that there is still a research desideratum in the regard of addressing already evident issues, as well as much-needed future skills in the context of EOtC.

Consequently, this dissertation attempts to analyze the innovative concept of EOtC in terms of its suitability as a future-oriented teaching concept with a focus on certain constructs. For this purpose, the procedure and the results of two published papers are presented. In order to address the issue of mental health, this dissertation takes HRQoL into account. In addition to this, a focus is placed on the investigation of learning motivation – possibly an indirect influencing factor of HRQoL. Both learning motivation and HRQoL could in turn be determined by the satisfaction of all or specific BPN, which is why this is also part of the analysis. A detailed description of these assumed relationships can be found in the theory section of the first publication (see Section 4.1). In addition to this, social factors will be explicitly considered. Based on theoretical foundations as well as empirical research (see chapter 4.2), these can also

be said to have a significance for mental health and are of central concerns in 21st century skills. In addition, an analysis of the interrelationship between different social aspects (social interaction, social relatedness, friendships) seems worthwhile, especially in EOtC as research in this area still has extensive gaps.

Related to the findings that are drawn from the empirical studies to be presented later, those considerations that will follow in the general discussion also represent a central part of this dissertation. Thus, it is possible to produce a clear content focus, as well as pointed methodological and practical derivations within the empirical publications, and to merge them within this thesis. In doing so, the aim of this dissertation is not to produce generalizable statements, but rather to provide impulses for theoretical as well as practice-relevant discussions. In the context of this dissertation the following questions were examined:

1. Do students in EOtC show improved scores of HRQoL and motivational regulation compared with students taught exclusively in the traditional way and over time?
2. Do students in EOtC show specific patterns of association between BPN satisfaction, HRQoL, and motivational regulation when compared with students taught exclusively in the traditional way and over time?
3. Do students in EOtC show intensified social interaction compared with students taught exclusively in the traditional way and over time?
4. Do students in EOtC and those in traditional teaching show interrelations between social interaction and social relatedness and friendships over time?

The practical relevance, as well as derivation for school practice, is discussed for all of these issues. In the following, the publications as well as the methodological basis for those will be presented.

3 Theoretical foundations, methods and study designs

As described above, possible effects of EOtC, especially in the areas of social, motivational and health-related issues, can be well justified within the framework of current research findings. However, in order to better understand concrete mechanisms, it is essential to complement this empirical structure with further theoretical approaches that are, in the best case, already sufficiently empirically supported by their own. In the following, the theoretical foundations that are elementary for the publications and its inherent questions will be presented.

3.1 Theoretical foundations

The publications presented later in this thesis contain detailed explanations of how the respective research questions are to be classified in the theoretical foundations and on which concrete empirical findings these assumptions are based. Therefore, the following will only briefly discuss the background of these theories and otherwise refer to the theory chapters of the publications. The basics described in the following should also serve as a basis for the general discussion.

Self-Determination Theory

Without a doubt, SDT, which goes back to Edward Deci and Richard Ryan (1985; 2000), can be said to be an extremely high-profile, much-cited theory for decades, and possibly even the central theory for explaining and researching human motivation at all. It has a wide range of applications in research. Central parameters of SDT are the so-called BPN and motivational regulation. The satisfaction of the BPN, namely autonomy, competence and social relatedness is said to be crucial for well-being (Ryan and Deci, 2017; Ng et al., 2012). In the area of motivational regulation, SDT defines the distinction between self-determined (intrinsic) and externally determined (identified, introjected and external) forms of motivational regulation, as well as amotivation. The extent to which a particular behavior is self-determined cannot only affect the initiation and maintenance of the behavior, but also has an impact on the well-being, general joy of life and mental health of the individual (Milyavskaya & Koestner, 2011). To name current or past research topics in a comprehensive way is beyond the scope of this thesis, but the online presentation of this theory offers an excellent overview and illustrates once more the enormous impact of this theory on science since the 1980s (CSDT, 2023). Empirical research

has often underscored the relationships between inherent constructs of SDT and health-related outcomes (Ng et al., 2012), which is why SDT is central to the concerns of this dissertation in the school setting.

Social and developmental psychology

Unlike SDT, social and developmental psychology does not describe a clearly delineated theory, but rather certain disciplines for the consideration of corresponding phenomena from a psychological perspective. Social psychology can be attributed with the basic question of how a situation (context) influences behavior and experience – both supposedly negatively and positively (Seppala et al., 2012; Hay et al., 2018). The close connection with the core assumptions of systems theory, the BPN (in particular the BPN of social relatedness) as well as the relevance of this for the consideration of EOtC is already clear from this paraphrase. The second publication focuses strongly on the social situation, as a space for social interaction. In this respect, we see this publication as a building block for a progressive elaboration of social psychology. It seems trivial that in a context of education the perspective of child-centered, holistic and healthy development should be a central one (Hartup, 1999). Nevertheless, it is particularly important for us to examine and discuss the developmentally relevant facets of our theoretical assumptions and the results of our data collection.

3.2 Study design and samples

The samples of both publications are based on the same surveys. These were conducted in the 2019/20 school year in a public high school in southwestern Germany in the fifth grade. This school year was the first time EOtC was conducted at this high school. One of the total of four fifth-grade classes spent one full school day per week in a nearby forest (about a 15-minute walk from the school). In the second publication, on page 54 of this document, a table gives detailed information on how this EOtC usually took place. Consequently, the children were taught outside in two subjects per half-year (first half-year: German and biology; second half-year: English and geography). In addition to two fifth grade classes, which received only the usual classroom lessons, there was also a fifth-grade class at the school in question, which was characterized by a so-called "sports profile". The children of this class received one additional hour of physical education per week.

In the 2019/20 school year, a total of four measurement time points was planned at the school, each at the beginning and end of both half-years. Within the framework of these surveys, a large number of variables were to be recorded, not all of which are reflected in this thesis. A general overview of the planned surveys, as well as the underlying research questions, can be found in the study registration (Center for Open Science, 2019), which gives an overlook over the whole project which this dissertation was part of. Unfortunately, it was not possible to implement the planned study design. Due to the nationwide school closures at the onset of the COVID-19 pandemic beginning in March 2020, it was no longer possible to reliably reach children and teachers. Therefore, the surveys were discontinued after the third measurement time point. As a result, some research questions could not be followed up. Others (e.g. those mentioned in chapter 2.4) were only slightly affected by this, so that an analysis and discussion of the results seemed permissible. Figure 2 shows the planned and finally implemented design of the survey implementation.

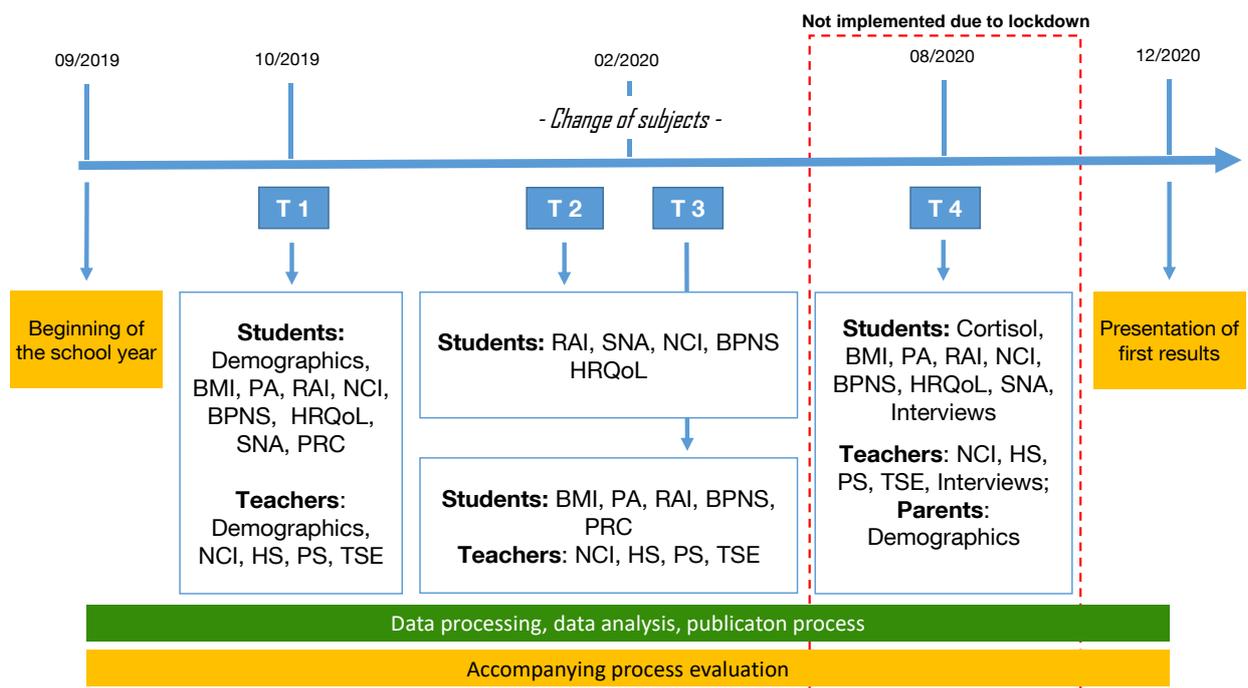


Figure 2. Planned and implemented study design (BMI = Body Mass Index; PA = Physical activity; RAI = Relative Autonomy Index [Motivational regulation]; NCI = Nature Connection Index; BPNS = Basic Psychological Needs Satisfaction; HRQoL = Health-Related Quality of Life; SNA = Social Network Analysis; HS = Health Status; PS = Perceived Stress; TSE = Teacher Self-Efficacy).

Prior to our study, we contacted a total of 100 students from the four classes and their parents. Based on student and parent consent forms, we were able to include 66 students who were

attending school in fifth grade at the time. In the EOtC class, all students ($N = 27$; 44% female) agreed to participate in our study. In the meantime, of the measurement time points, two students had to be excluded from the EOtC class because they changed schools or withdrew their consent. From the other classes, 41 students participated (36.6% female). Due to illness or other absence reasons, we were unable to collect data from every student at every time point. Depending on the intended question and method, not all students were included. The exact sample description and reasons for the exclusion of individuals can be found in the method sections of the publications. The average age of the participants at the beginning of the school year was 10.1 years, with a minimum and maximum age of 9 and 11 years.

3.3 Methodology of mixed models

Mixed models are part of linear regression and thus basically allow to estimate the influence of certain independent variables on dependent variables over time and thus fulfill similar purposes as classical linear or logistic regressions or also multivariate analysis of variance (MANOVA). In contrast to classical linear regression analyses, a linear mixed model allows not only to consider the influence of previously foreseeable, clearly intended dependent ("fixed") variables, but also to analyze so-called "random" effects (Bolker, 2014; Meteyard & Davies, 2020). This is necessary if the primary aim is to investigate the effect of, for example, a behavioral intervention by comparing two groups (experimental group vs. control group), but at the same time these groups are subject to an additional hierarchy or subdivision. This could be the case if the groups are composed of students from different schools and different classes within these schools. Theoretically, it is conceivable that the school and class affiliation in this example holds a much larger share in the variance explanation than the affiliation to the experimental group. This could be due to a certain class climate, for example, which only occurs in this form in this one class in question. With the use of a linear mixed model and the possibility to investigate the variance resolution of random and fixed effects, a more differentiated analysis is therefore possible. As a consequence, experts see the advantages of mixed models, among others, in the improved avoidance of falsely positive results, as well as the greater flexibility in applying strategies to deal with missing values (West et al., 2022; Krueger & Tian, 2004; Yang et al., 2014).

Taking that information into account, for our main analysis in the first publication, we used a linear mixed model design to account for the characteristics of our data (Meteyard & Davies, 2020). In order to obtain information not only on whether the independent variables (in this case: BPN) are positively or negatively associated with the dependent variable, but also on whether the satisfaction of those in one class receiving EOtC differs significantly from that in a control class with only indoor teaching, we additionally conducted a MANOVA for this purpose. In doing so, we defined the four facets of the BPN (autonomy, two facets of social relatedness and competence) as dependent variables and the groups as independent variables. For the linear mixed models, based on the literature, BPN (resp. the relevant subscales) were defined as fixed factors. The explained variance over time of the inherent individual determinants was of particular interest. In addition, please see the methods section of the first publication for further information regarding the application of linear mixed models in this specific context and chapter 4.1 of this thesis for further information about the design and aim of first publication.

3.4 Methodology of Social Network Analysis

The methodology of network analysis enables an insight into and analysis of fairly complex structures with regard to various conceivable questions. At the same time, network analysis is less to be understood as a concrete procedure, but rather as a collection of different approaches, which are unified by the goal of describing the interrelationships and dependencies in networks partially or as comprehensively as possible (Borgatti et al., 2009; Luke, 2015). In this regard, networks are always the sum of nodes and links (edges) between them. Nodes and edges can carry an enormous variety of semantics in network analysis. This allows the versatile use of network analyses, for example in the investigation of cooperation between municipal institutions (Wolbring et al., 2022), tourism management (Valeri & Baggio, 2021) or vaccine patents (Gaviria & Kilic, 2021). A network analysis becomes a Social Network Analysis (SNA) when either the edges convey a social relationship meaning (e.g., frequency of conversations, financial flows, professional collaboration) and/or the nodes represent individual people or a group of people (e.g., political party, sports club, professional group). In recent years, the use of SNA in empirical research increased strongly (Borgatti et al., 2009; Maltseva & Batagelj, 2019). On the one hand, this could be due to the improved technical possibilities (Camacho et

al., 2020) or the large number of potential fields of application of SNA. However, on the other hand, it could also be due to the advantages that this method has in comparison to others. For example, SNA provides a unique overall view of network interrelationships – which can equally mean cross-sectional correlations, longitudinal influences (two-way), the revelation of certain structural features (e.g., in accounting for cliques or triads ⁶), or quality features to be defined depending on the content object of the specific network (e.g., geodesic distance) (Borgatti et al., 2018; Saqr & Alamro, 2019).

A particular strength of SNA is also the inherent possibility to realize mixed-methods approaches. This seems to be of great advantage especially in disciplines with more or less strong characteristics of social sciences or interdisciplinary elements (Froehlich et al., 2019). This is particularly reflected in an element that is very often part of an SNA: the sociogram. Such is very basally referred to as the visualization of a theoretical network so that a truly tangible network structure becomes visible (see Figure 3 for an example of a sociogram). This visualization per se already is a combination of qualitative and quantitative data collection and evaluation. However, when additionally intertwined with inferential statistical methods, it reveals great potential for simultaneously understanding and explaining data structures.

In addition to descriptive approaches such as the sociogram, inferential statistical analyses in the narrowest quantitative tradition are also used to answer the questions posed in this dissertation. The specific models used within the SNA are explained in more detail below.

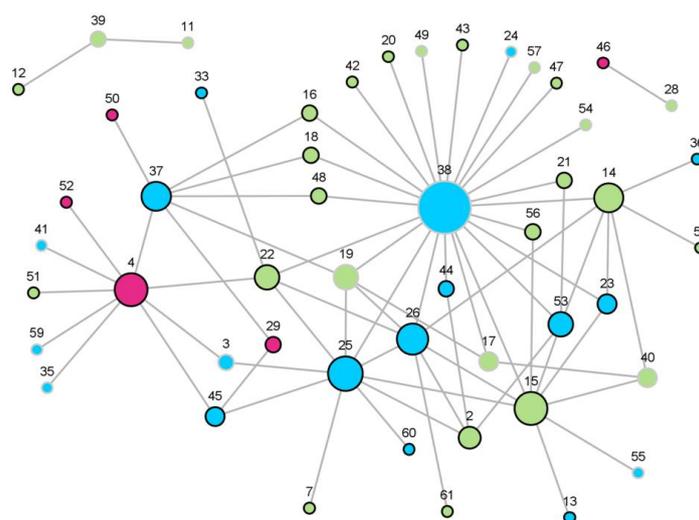


Figure 3. Example of a sociogram (illustrating cooperation on community-level [Wolbring et al., 2022]).

⁶ In the context of the second publication of this dissertation, a table on page 56 of this thesis defines and explains the central concepts and metrics of SNA.

3.4.1 Exponential Random Graph Models

The most commonly used statistical models in SNA are Exponential Random Graph Models (ERGMs) (Hunter et al., 2008), which are based on Monte Carlo Markov Chain maximum-likelihood estimates. Consequently, actually observed/empirically captured networks are compared with a certain number ("exponential") of simulations of comparable networks ("random graph") (Harris, 2013). The result is a check whether the empirical network differs significantly from the simulated ones (Shumate & Palazzolo, 2010). In other words: If the empirical network exhibits statistical significance with respect to certain characteristics, these can be said to be non-random and therefore a significant finding and/or the effect of a certain intervention. In an ERGM it could be checked, for example, whether the cooperation between actors is due to the fact that those share the same characteristic (e.g. category of the number of employees in a company or the gender of the head of the department). However, the original design of ERGMs was to use cross-sectional questions, which is a significant limitation for the analysis of longitudinal data.

3.4.2 Statistical Actor Oriented Models

Statistical Actor Oriented Models (SAOMs) have similar requirements and areas of application as ERGMs. However, they go a decisive step further by already including a longitudinal component. Accordingly, with SAOMs it is possible to examine the influence of certain variables (e.g., a certain behavior of individuals) on the realization of edges (e.g., friendships) and vice versa (Ripley et al., 2012; Snijders et al., 2010). ERGMs have also received a temporal extension mathematically in recent years, allowing networks to be analyzed across multiple measurement time points. However, for the purposes of the questions outlined above, SAOMs were used, reflecting recent recommendations (Block et al., 2019). In particular, SAOMs exhibit better statistical fit when each edge realized reduces the likelihood of including additional edges from and with the same node as a result (even if only slightly or even purely theoretically) (Block et al., 2019). This is especially true when the nodes are real-world individuals. Accordingly, it is impossible for a real person to build up an infinite number of edges – regardless of what they represent in terms of content – since each realized edge requires the contribution of e.g. biological or cognitive resources.

4 Publications

4.1 Publication on health-related quality of life, motivational regulation and Basic Psychological Need satisfaction

Authorship: Jan Ellinger, Filip Mess, Simon Blaschke & Christoph Mall

Title: Health-related quality of life, motivational regulation and Basic Psychological Need Satisfaction in Education Outside the Classroom: an explorative longitudinal pilot study

Journal: *BMC Public Health* (Scimago Journal Rank: Q1 [Public Health, Environmental and Occupational Health])

Date of Publication: January 8th, 2022

<https://doi.org/10.1186/s12889-021-12450-9>

Previous studies have suggested that EOtC may help improve self-determined motivational regulation, as well as BPN satisfaction. Both, in turn, could translate into improved mental health. Especially given the alarming health situation among children and adolescents described earlier, this seems crucial. The first publication of the dissertation was therefore intended to explore precisely these relationships between motivational regulation, BPN satisfaction, and HRQoL as an indicator of mental health. For this purpose, students (N = 66) of a public high school in southern Germany were studied. 25 students were part of an EOtC class, which was taught one full day per week in a near forest throughout the school year. The remaining children functioned as a control group and received only traditional school lessons in the classroom. Questionnaire data on the constructs of motivational regulation, BPN satisfaction, and HRQoL were included alongside sociodemographic data at two time points over the course of a school year. The analysis of linear mixed models was able to confirm the hypotheses posed in some cases, but not in others, which provided profound occasions for discussion. Thus, a significant advantage of the EOtC class regarding self-determined motivational regulation was also shown in the present publication, which underlines previous results. With regard to HRQoL, on the other hand, the EOtC class showed disadvantages compared to the control group, which is expressed in particular by a significant drop in HRQoL over time in the EOtC class which is now apparent in the control group. The authors subsequently discuss

the possible influence of seasons (to be included in analyses in the future), as well as methodological weaknesses of the approach. In any case, facets of HRQoL or well-being should remain one focus of research on EOtC among others to be able address the problem of poor health in children and adolescents in this regard. The results of this publication contribute to answering the questions 1 and 2 of this dissertation as described in chapter 2.4.

Filip Mess and Christoph Mall conceived, conceptualized and designed the overall study, which was the framework for this publication. Jan Ellinger and Christoph Mall conducted the data collection. Jan Ellinger conceptualized the design and assessments for this publication and Jan Ellinger and Simon Blaschke analysed the data with the help of Christoph Mall. Jan Ellinger was the leading author and major contributor in writing the manuscript with substantial contributions from Filip Mess, Simon Blaschke and Christoph Mall. All co-authors read and approved the final manuscript.

The published full version of the paper follows. The corresponding appendix of the publication can be found in the appendix 9.1 of this document starting on page 90.

RESEARCH

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Health-related quality of life, motivational regulation and Basic Psychological Need Satisfaction in Education Outside the Classroom: an explorative longitudinal pilot study

Jan Ellinger*, Filip Mess, Simon Blaschke and Christoph Mall

Abstract

Background: Given a suboptimal state of mental health among children, an urgent need exists to seek approaches related to health promotion in this population's settings, such as in schools. Increased health-related quality of life (HRQoL) and improved school motivation could be crucial for children's mental health. Based on *self-determination theory*, paths can be identified that could lead to such improvements by strengthening the basic psychological needs (BPN). This study aimed to examine the impact on and the relationships among HRQoL, school motivation and BPN within the promising concept of *education outside the classroom* (EOTC).

Methods: In this exploratory study, we employed a between-subjects cohort study design with no blinding or randomisation. We surveyed fifth graders (mean = 10.1 years) attending EOTC (experimental group [EG], n = 25) and normal indoor lessons (control group, [CG], n = 41) at the beginning (T1) and end (T2) of a semester. We used the translations of validated questionnaires and established linear mixed-effects models to evaluate whether the students in EOTC show higher scores of HRQoL and school motivation and, whether the satisfaction of BPN of autonomy (PAut), competence (PCom), social relatedness with classmates (PSRC) and teachers (PSRT) show associations with these outcomes.

Results: Regarding intrinsic and identified motivational regulation, results showed significant increases over time in the overall sample and significant higher scores in the EG than in the CG. For HRQoL, no group differences were found, but a significant decrease over time in the EG. Regarding possible associations between the outcomes and BPN, such could only be found between HRQoL and PSRC, but not for the other BPN and not for motivational regulation and BPN.

Conclusions: Without having been able to explain this on the basis of increased BPN values, our results show that EOTC can support improvements in specific regulation types of school motivation. This could contribute to an improvement in the mental health situation in children, as school represents a major stressor for them. Future steps in terms of researching HRQoL in this setting are discussed, as this pilot study does preliminary work for necessary examinations, e.g. in structural equation approaches.

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Keywords: Children, Education outside the Classroom, Basic Psychological Needs, Well-being, Health-related quality of life, School Motivation, Linear mixed-effect models

Background

Today, large proportions of the child and adolescent population exhibit mental health issues. In a recent study, 12.8% of children (aged 6–11 years) showed mental health problems [1]. Looking at the population of children, adolescents and young adults under 25 years of age, 14.3% are officially diagnosed with depression [2]. At the beginning of adolescence, individuals are particularly susceptible to effects on their mental health and well-being because a large number of psychological and physical changes and developments take place during this time [3]. Anniko et al. [4] identified school pressure as the source of mental health problems over all other considered sources (e.g. arguments at home or romantic relationships) in a longitudinal study. Therefore, a suitable entry point for interventions tackling these issues seems to be the school because children and adolescents spend a large part of their waking hours there [5, 6], and there is the tendency to even increase the time per day spent at school, at least in European countries [7, 8]. Subsequently, current studies should, on the one hand, verify the effectiveness of developed interventions on mental health in the school setting (e.g. [9, 10]); however, on the other hand, also explain the effects in detail by using specific theories and models, such as the *health-action-process-approach* in the field of health behaviour change [11] or *achievement goal theory* in the research of intrinsic motivation [12]. Additionally, *self-determination-theory* (SDT) seems suitable for the considerations of health-related issues in general, which is the reason we will focus on this theory in the following chapter. A meta-analysis led to the assumption that a foundation of SDT in particular could possibly promise success regarding physical and mental health because the results suggest a positive association between SDT-based constructs and indicators of mental health [13], such as well-being and health-related quality of life (HRQoL) [14, 15]. According to our understanding, well-being and HRQoL have significant overlaps from a psychological perspective and are not necessarily distinguishable from each other [16, 17]. In this article, we always use the terminology of the original authors when reporting on previous studies. With the increased use of HRQoL in publications and surveys in recent years [18], we use this term when describing our own considerations.

Background on Self-determination Theory

Within SDT, as a first central element, authors Ryan and Deci [19, 20] distinguish different types of motivational regulation: intrinsic, integrated, identified, introjected and external motivation. In addition, explicit amotivation can be seen as a special form in close connection with these types, which expresses the lack of any motivation with regard to a target behaviour. An intrinsic type of motivation here corresponds to maximally self-determined motivation, which is the reason these two terms have a great degree of overlap but must be distinguished at the theoretical level [20]. External motivation as the second extreme of the continuum, on the other hand, is not based on personal value, but rather on external rewards or punishments that are associated with the corresponding behaviour. The types of integrated, identified and introjected motivational regulation each set their own semantic priorities, but all fall between these two extremes [20]. In order to further summarize these types of motivational regulation, they can be hierarchically described in the sense of Ryan and Deci with intrinsic, integrated and identified motivation as self-determined types and introjected and external motivation as controlled motivational regulation types, besides amotivation [19].

As the second central element of SDT, basic psychological needs (BPN) are described as needs that are equal to all persons across gender, culture and time [21]. Three BPN dimensions are distinguished: autonomy, competence and social relatedness, which, in the specific context of school, can be subsequently divided into social relatedness with teachers on the one hand and classmates on the other [19]. In the context of the practical research application of these dimensions, the subscales are often marked as ‘perceived’ (perceived autonomy = PAut; perceived competence = PCom; perceived social relatedness with teachers = PSRT; perceived social relatedness with classmates = PSRC). Regarding BPN, the needs for PAut and PCom are most closely linked [22]. SDT is considered an established theory of motivation in various areas, such as research in work organisations [23] or environmental education [24].

The majority of SDT-informed health-domain interventions focus on BPN in relation to other variables, such as mental health outcomes [25], and it seems quite possible to cause a (positive) change in SDT elements (e.g. level of satisfaction of BPN) through interventions [13].

The reported dimensions of the BPN can also, in essence, be directly applied to the school setting [26, 27].

State of Research on Self-determined Motivation, HRQoL and BPN in schools

SDT holds possible starting points for improving HRQoL and motivational regulation in students. Both could be at least partly explained by the satisfaction of BPN. Those relationships between the degree of satisfaction of specific BPN and these practical relevant outcomes of HRQoL and motivational regulation can be well argued, as described in the following.

Relationship Between HRQoL and BPN

If the satisfaction of the BPN is not sufficient, comprehensive health is difficult to imagine [21], which is why it can be argued that an increase in the satisfaction of BPN can already lead to improvements in HRQoL [28, 29]. Although some studies suggest the great importance of social relatedness in particular for HRQoL it can be assumed that all three BPNs can have a positive effects here as there is no clear trend towards a superior importance of one of the BPNs over the others (e.g. [30–32]). In the past, Tian et al. identified a relationship between BPN and school-related well-being with the BPN as a mediator between school-related social support and well-being [33, 34]. In the context of specific school subjects, the possible impact of BPN-satisfaction on HRQoL was pointed out [35, 36]. A significant decrease in HRQoL is observed with an increase in the age of the students [37].

Relationship Between Motivational Regulation and BPN

Empirical evidence suggests that satisfaction of the BPN correlates with internalisation and intrinsic motivation in adults [38]. In particular, the needs of autonomy and competence could be considered as tenets and predictors of a more self-determined type of motivational regulation [39]. Of course, these relationships are also of particular interest in institutions that are characterised by learning and teaching, such as in universities and schools, as the BPN have already been identified as an essential factor in motivation [40–42]. Studies that carried out a detailed breakdown of both the BPN and different motivational regulation types were able to show on the basis of larger samples within the German and Australian school setting that in particular autonomy and competence show an positive influence on the intrinsic and identified motivational regulation [43, 44]. In analogy to the observations on HRQoL, a steady decline of motivation can be observed during adolescence, which is predicted by a decline in the satisfaction of the BPN [45].

The findings show that satisfaction of the BPN could be crucial to both motivational regulation and the HRQoL of

students. For HRQoL all BPN seem of importance, while for motivation PCom and particularly PAut seem to be crucial factors [21, 39]. Beyond the association of BPN and HRQoL, an increase in self-determined and intrinsic motivation could also have a positive impact on HRQoL on the long run [46], as intrinsic motivation plays a unique role in predicting academic performance [47]. This in turn can be related to subjective well-being based on the results of a large-scale meta analysis [48]. Certain school concepts could start at this point and enable improvements in the corresponding constructs of motivational regulation and HRQoL aside the satisfaction of BPN.

Education Outside the Classroom and the Impact on HRQoL

The concept of *education outside the classroom* (EOTC) could be of great value for improving HRQoL via the described mechanisms in students. EOTC can be defined as regular teaching that takes place in natural, industrial or cultural locations in accordance with the curriculum. Which methods are used and with which aids or agreements the learning contents are conveyed are the responsibility of the school or the teacher [49, 50]. In Scandinavia, the concept is applied in approximately 20% of all public and private schools [51], whereas in Germany, similar to many other countries, only isolated attempts by individual schools have been observed to date; however, there is a lot of rising interest toward this concept [52]. Because EOTC appears promising from the perspectives of health and learning, it has already moved into the extended focus of research. In their review, Becker and colleagues summarised and critically appraised first findings regarding the effects of EOTC on social, learning and health dimensions [53]. Recent publications indicate a connection between EOTC and increased physical activity [54–56], a gain in peer affiliations [57] and inconsistent results on the influence on academic performance in school subjects [58, 59].

The evidence on concrete effects of EOTC on HRQoL is still rather incomplete. So far, initial findings provide evidence that the psychosocial well-being of children in EOTC could particularly be enhanced by an increase in prosocial behaviour [60]. Links to possible effects on HRQoL also arise from findings regarding stress. Thus findings show that the profile of cortisol secretion in students taught outdoors may be closer to what is considered a (stress-related) healthy pattern and thus could contribute to an improvement in the stress-related mental health situations in the student population [61]. Breaks and rest periods in particular could also have a positive effect in this respect [62]. Effects on the learning process and school motivation are also still rare in EOTC, but there are also first tendencies. For example,

the descriptions of students taught outdoors showed that the learning process was not even perceived as learning in the formal sense by the students [63]. Methodologically well-structured studies also show the importance of the EOtC as a possible buffer against a drop in the students' intrinsic motivation over the course of a school year [64].

As previously pointed out, such effects could be at least partly due to the satisfaction of the BPN. Following that, the question arises as to whether EOtC can influence levels of satisfaction of BPN in students. Regarding PAut, the possibility of choices within an environment of structure is considered particularly beneficial [65, 66]. EOtC offers a wide range of potential choices capable of influencing PAut (cf. [Supplementary Material](#)), such as when choosing a partner for tasks, the place where the students want to learn, which writing underground they use (e.g. forest soil, tree trunk, clipboard) or in which order they work themselves through working stations. The balance of a controlled structure plays a decisive role in patterns of autonomy-supportive teaching [67], which is a particular challenge but also an opportunity for the teachers, particularly in initially unstructured natural environments [68]. Therefore, it seems quite reasonable to assume that autonomy is particularly promoted by EOtC. Additionally, a promotion of the PCom seems promising through EOtC. The introduction of EOtC is disruptive in the extreme, which is the reason why all elements of instruction are bound to be questioned. Because teachers in EOtC rely heavily on the engagement, cooperation and discipline of their students, it is quite conceivable that competence-supporting strategies, such as incorporating students' opinions, will be increasingly applied in EOtC. Additionally, a learning environment in nature offers competence-supportive characteristics to a special degree [69], such as the necessity of pointing out concrete plans of learning locations and contents because in EOtC, unlike in classical indoor settings, these are not to be considered as set. In addition, the will to acquire competences could be increased among the students because of the high relevance to everyday life [70]. When considering the BPN of social relatedness, the EOtC also reveals a wide range of possibilities for positive effects. Already the intensive engagement with and in nature in couple constellations or groups seems to lead to positive effects in social interaction [71, 72]. Compared with a classroom setting, the EOtC offers very obvious opportunities for social interaction at least in natural environments. Because spatial limitations are almost completely eliminated, one can speak of a new form of movement in space, from which new social interactions can also arise [73], which could in turn be reflected in increased social relatedness.

Taken together, there are indications suggesting that EOtC may improve HRQoL, in parallel with or conditioned by improvements in self-determined motivational regulation and satisfaction of the BPN. However, the corresponding findings come from different studies and cannot be directly linked to each other or were not gained from studies with regularly conducted EOtC. Therefore our pilot study aims to gain a deeper understanding of individual processes of these in EOtC. For this purpose we set up the following hypotheses to explore this in a step-by-step manner: (a) EOtC-class and control group differ in terms of their scores of HRQoL over time; (b) EOtC-class and control group differ in terms of their scores of motivational regulation types over time; (c) EOtC-class and control group differ in terms of the association of HRQoL and BPN; (d) EOtC-class and control group differ in terms of the association of motivational regulation types and BPN.

Methods

Intervention

Our study began in the summer of 2019 in co-operation with a secondary school located in southwest Germany. The co-operating school incorporated EOtC in the school year 2019–2020 into their curriculum for the first time. The underlying teaching concept was based on practical knowledge of EOtC gained by teachers from Germany and was elaborated before the beginning of the school year. The EOtC-class was curriculum compliant and was implemented every Thursday from 08:30 a.m. to 12:55 p.m. in a nearby forest. After an initial lesson in the school facilities, which was used for tasks, such as to check attendance and prepare important contents, students and teachers walked to the forest (estimated 15 min of walking). Onsite, various locations were used for teaching. During the following lessons, two teachers held two different outdoor classes selecting from the school subjects of German and Biology. At the end of each school day, teachers and students made their way back to the school together. Additional details about the teaching situation in the EOtC in general and within our study are presented in the [supplementary material](#).

Study Design

In addition to the EOtC-receiving experimental group (EG), the secondary school contained three other fifth-grade classes, which received regular indoor teaching in the corresponding subjects and served as the control group (CG). In this pilot study, we used a between-subjects, prospective cohort study design with no blinding or randomisation. Initially, we planned four measurement points spread over the entire school year. With the outbreak of the COVID-19 pandemic and the resulting

school closures throughout Germany, this plan could not be fully implemented. Therefore, only two measurement points (T1, T2) were conducted at the start (October) and end (February) of the first semester. This represents four weeks of EoTC until T1 and 17 weeks until T2 for the EG.

Participants

We contacted a total of 100 students and their parents from all four fifth-grade classes of the school year 2019–2020 in the run-up of our study. Based on the declarations of consent of the students and parents, we were able to enrol 70 students who attended the school at that time in the fifth grade. In the EG, all students agreed to participate in our study. During the two enquiries, two students each had to be removed from the EG and the CG because of a change of school or withdrawal of consent. Our analysis therefore contained 66 students. Our EG comprised 25 students (female, $n = 11$; male, $n = 14$), and the CG comprised of 41 students (female, $n = 15$; male, $n = 26$). With illness or other reasons of absence, we were not able to collect data from every student at every time point. The participants had a mean age of 10.1 years at T1, with the minimum and maximum ages of 9 and 11 years. Enrolment data and descriptive statistics are presented in the chapter ‘Results’ and the [Supplementary Material](#).

Data Collection

Using a combined questionnaire, the measures necessary to test the hypotheses and demographic information were collected. The *Basic Psychological Needs Scale (BPNS)* was used for the purpose of assessing BPN. The BPNS was originally developed by La Guardia, Ryan, Couchman and Deci [74], and for application in our study, we used the German translation by Hanfstingl et al. [75]. The BPNS comprises 24 items on a 5-point Likert scale and contains the subscales of PAut, PCom, PSRT and PSRC. Higher scores indicate better satisfaction of BPN. For our data, all subscales showed acceptable to good values for Cronbach’s alpha (PAut: $\alpha = 0.82$; PCom: $\alpha = 0.80$; PSRT: $\alpha = 0.75$; PSRC: $\alpha = 0.62$).

The *KIDSCREEN-27* Questionnaire [76] was of choice to determine the HRQoL and is suitable for assessing the subjective health and well-being of children aged 8–18 years [77]. The *KIDSCREEN-27* is a validated short form of the *KIDSCREEN-52* and has already been used in numerous studies in similar age groups [78, 79]. The sum score of the items ($\alpha = 0.83$) was transformed to Rasch person parameters by using an algorithm according to the manual [76]. This results in a mean score of 50 with $SD = 10$ for the children in the reference group [80]. Higher total scores indicate a better HRQoL.

The *Academic Self-Regulation-Questionnaire (SRQ-A)* was used to assess motivational regulation in school [81]. The SRQ-A is a 32-item questionnaire (4-point Likert scale) that measures students’ attitudes towards schoolwork. Particularly in the field of EoTC research, the SRQ-A seems to be a common and reliable tool as shown by its use in the studies of Bølling et al. [64] and Dettweiler et al. [69]. In our study, the German validated version of the SRQ-A by Kröner et al. [82] was used. The SRQ-A provides results for the individual subscales of intrinsic ($\alpha = 0.80$), identified ($\alpha = 0.82$), introjected ($\alpha = 0.75$) and external motivational regulation ($\alpha = 0.75$), whereas higher scores indicate a higher degree in the corresponding motivational regulation type.

In addition to the aforementioned measures, within this project, other parameters were collected from the students. These parameters will be addressed in publications with a different thematic focus. More details on the entire project design can be found on the Center for Open Science: <https://osf.io/f32kg/>.

Statistical Analysis

For our main analysis, we used a linear mixed-effects model (LMM) design to account for the characteristics of our data [83]. In order to obtain information not only on whether the BPN are positively or negatively associated with the outcomes, but also on whether the satisfaction of the BPN in the EG differs significantly from that in the CG, we additionally conducted a multivariate analysis of variance (MANOVA) for this purpose. In doing so, we defined the four facets of the BPN as dependent variables and the groups as independent variables. For the LMMs, based on the literature, BPN (resp. the relevant subscales) were defined as fixed factors. The explained variance over time of the inherent individual determinants was of particular interest. Consequently, we defined the individual as a random factor. The metrics of the dependent variables were left on their T-scores in the case of HRQoL, as recommended by the authors [76]. In the case of motivational regulation, we used the raw average values of the motivational regulation types. We screened for multivariate outliers by using Mahalanobis distance [84] but found none. Subsequently, we decided to keep the few univariate outliers in our data because we have no evidence that the values were skewed by measurement errors or the inclusion of someone not in the target group. Because our outcome scores do not have meaningful zero values in their initial form, centring was performed for them in advance of the analysis. We report estimates (regression coefficients), their confidence intervals (CI 95%) and Cohen’s d (d) as indicators for the effect sizes as well as standard deviations. We also consulted R-squared (R^2) [85] to determine the proportion of variability explained

by fixed and random factors in the different models. The initial general model of our analysis can be represented as follows for the enquiry i of person j of gender k in group l :

$$y_{ijkl} = \beta_0 + (\beta_1 + r_{1k}) * x_{ijkl} + \beta_i + \beta_{ij} + \beta_{ijk} + \beta_{ijkl} + \epsilon_{ijk}$$

β_0 is the intercept, and β_1 represents the slopes. x represents the fixed factors of BPN. The residuals r and ϵ are also zero mean normally distributed random variables with covariance matrix dependent on the situation as described on the corresponding levels. This approach allowed us to determine the general influence of the satisfaction of the BPN while considering groups, gender and time point of enquiry and random effects because of the repeated measurement of the same individuals. The model fit was evaluated using the AIC criterion and restricted maximum likelihood ratio tests. Based on the presented previous findings, we constructed five models to account for our hypotheses. Four models recorded the motivational regulation types as a dependent variable based on the BPN (Intrinsic: Model 1; Identified: Model 2, Introjected: Model 3; External: Model 4). In the last model (Model 5), HRQoL was implemented as a dependent variable, and the BPN were again implemented as independent variables. For all models the corresponding variant of the model without interaction effects of Group and Gender alongside all other variables showed better model fits (cf. Supplementary Table 1). Heteroskedasticity was rejected by visual inspection for all of the five models and confirmed by Levene's test [86]. Multicollinearity could be rejected by calculating the variance inflation factor for our respective independent variables and their subscales and following the recommendations by Wooldridge [87]. This was particularly necessary in view of possible content overlaps in KIDSCREENs subscale "Social Support and Peers" with PSRC. The software *RStudio* (Version 1.3, RStudio Inc., Boston, USA) was used for data analysis [88]. The imputation of missing values was performed by predictive mean matching based on predicted values, which also take care of the random effects, by using the method '2l.lmer' of the package 'MICE' [89–91]. In the analysis of the five mixed models, we used the software package 'nlme' [92], as well as for our MANOVA.

Results

Data reflecting the first time point at the beginning of the school year could be used from 66 participants (EG: 25; CG: 41) and at the second time point from 64 participants (EG: 23; CG: 41). In total, the data of 25 girls and 41 boys were included. The discrepancy in the EG is due to absence from school because of illness or other reasons. Table 1 provides an overview of the average values,

standard deviations and confidence intervals achieved for the outcomes of HRQoL and the four motivational regulation types collected at the corresponding enquiry in the individual groups. The descriptive data already indicate that the EG could have advantages in intrinsic and identified motivational regulation (cf. Fig. 1 and Supplementary Fig. 2). For HRQoL, EG shows higher scores at T1. For the facets of BPN, at first glance, we see comparable values between the groups and no apparent trends over time (cf. Supplementary Table 3).

The first inferential result of our MANOVA is that there are group differences in the level of satisfaction of the BPN (cf. Supplementary Table 2). Thus, the EG shows an advantage in PAut ($p < 0.05$) and PCom ($p < 0.01$), while the CG reveals significantly higher values in PSRC ($p < 0.001$). These results will later serve as a basis for the interpretation of the main analysis.

Our LMM analysis revealed the following results. An overview of the results of all of our models is given in Table 2. As per our first hypothesis, we expected group differences in HRQoL over time, possibly in favour of EG. However, our analysis of the corresponding model ($r^2 = 0.61$) could not find any group differences ($p = 0.215$, $\eta^2 = 0.31$, $\beta = 2.49$). What was noticeable, however, was a significant decrease in the HRQoL values of the EG at T2 ($p = 0.016$, $\eta^2 = -0.71$, $\beta = -5.57$). With regard to our second hypothesis, some significant results were obtained: The EG shows significantly higher values than the CG in intrinsic ($p = 0.003$, $\eta^2 = 0.79$, $\beta = 0.51$) and identified ($p = 0.040$, $\eta^2 = 0.54$, $\beta = 0.33$) motivational regulation, while no differences were evident in the external ($p = 0.220$, $\eta^2 = -0.31$, $\beta = -0.22$) and introjected ($p = 0.957$, $\eta^2 = 0.01$, $\beta = 0.01$) types.

Across both groups, there was also a significantly positive development over time for the intrinsic ($p = 0.007$, $\eta^2 = 0.81$, $\beta = 2.49$) and the identified ($p = 0.034$, $\eta^2 = 0.63$, $\beta = 1.84$) type. Especially boys showed a significant drop over time in the external ($p = 0.031$, $\eta^2 = -0.07$, $\beta = -0.47$) and introjected ($p = 0.042$, $\eta^2 = -0.60$, $\beta = -0.50$) types. Measured with the values of R-squared, the models which included intrinsic ($r^2 = 0.46$) and identified motivational regulation ($r^2 = 0.37$) as outcomes showed the comparatively best fit within motivation (Introjected: $r^2 = 0.19$; External: $r^2 = 0.21$). With regard to our third hypothesis, a significantly positive relationship between HRQoL and PSRC ($p = 0.007$, $\eta^2 = 0.79$, $\beta = 4.78$) could be stated (cf. Fig. 2), but not for the other BPN (PAut: $p = 0.300$, $\eta^2 = 0.64$, $\beta = 4.78$; PCom: $p = 0.175$, $\eta^2 = 0.39$, $\beta = 2.85$; PSRT: $p = 0.074$, $\eta^2 = -0.52$, $\beta = -3.07$) or in interaction with affiliation to EG (PAut: $p = 0.291$, $\eta^2 = -0.44$, $\beta = -8.02$; PCom: $p = 0.449$, $\eta^2 = 0.31$, $\beta = 5.49$; PSRC: $p = 0.994$, $\eta^2 = -0.01$, $\beta = -0.05$; PSRT: $p = 0.901$, $\eta^2 = 0.05$, $\beta = 1.02$).

Table 1 Statistical characteristics for the outcomes of HRQoL and motivational regulation types between groups, genders and enquiries

		T 1					T 2					
		HRQoL	Intr.	Ident.	Intro.	Ext.	HRQoL	Intr.	Ident.	Intro.	Ext.	
EG	Girls	M	54.18	3.00	3.33	2.58	2.57	56.53	3.39	3.45	2.91	2.61
		SD	9.84	0.56	0.31	0.70	0.69	7.79	0.22	0.44	0.63	0.62
		CI ^a	48.36 / 60.0	2.44 / 3.56	3.02 / 3.64	1.88 / 3.28	1.89 / 3.26	51.92 / 61.14	3.17 / 3.61	3.01 / 3.90	2.28 / 3.53	1.99 / 3.24
	Boys	M	59.51	3.44	3.54	3.26	2.88	57.14	3.39	3.27	2.79	2.57
		SD	7.70	0.41	0.38	0.50	0.48	8.35	0.34	0.52	0.67	0.53
		CI ^a	55.48 / 63.54	3.03 / 3.85	3.15 / 3.92	2.76 / 3.76	2.39 / 3.36	52.76 / 61.52	2.85 / 3.53	2.76 / 3.79	2.12 / 3.46	2.04 / 3.11
	All	M	59.58	3.23	3.44	2.93	2.73	56.85	3.29	3.46	2.85	2.59
		SD	9.31	0.53	0.37	0.69	0.61	8.10	0.30	0.49	0.65	0.58
		CI ^a	52.93 / 60.23	2.69 / 3.76	3.07 / 3.81	2.24 / 3.62	2.12 / 3.34	53.68 / 60.02	2.98 / 3.59	2.87 / 3.85	2.19 / 3.50	2.01 / 3.17
CG	Girls	M	57.03	2.84	3.16	2.93	2.83	54.25	2.37	2.91	2.73	2.83
		SD	8.48	0.69	0.64	0.60	0.49	9.23	0.56	0.56	0.76	0.71
		CI ^a	52.74 / 61.32	2.15 / 3.53	2.52 / 3.81	2.33 / 3.53	2.34 / 3.33	49.58 / 58.92	1.82 / 2.94	2.35 / 3.47	1.97 / 3.48	2.11 / 3.54
	Boys	M	55.65	2.52	3.01	2.79	2.88	55.44	2.54	2.97	2.91	2.83
		SD	5.32	0.59	0.67	0.51	0.48	8.78	0.58	0.57	0.62	0.58
		CI ^a	53.61 / 57.69	1.94 / 3.11	2.34 / 3.67	2.27 / 3.30	2.40 / 3.35	52.06 / 58.82	1.96 / 3.12	2.39 / 3.54	2.29 / 3.53	3.25 / 3.41
	All	M	56.15	2.64	3.06	2.84	2.86	55.01	2.58	2.95	2.84	2.83
		SD	6.69	0.64	0.66	0.55	0.49	8.96	0.58	0.57	0.68	0.63
		CI ^a	54.1 / 58.2	1.99 / 3.28	2.40 / 3.72	2.29 / 3.39	2.37 / 3.35	52.27 / 57.75	1.90 / 3.05	2.37 / 3.52	2.16 / 3.52	2.20 / 3.47
All	M	56.32	2.88	3.24	2.86	2.78	55.67	2.82	3.15	2.89	2.79	
	SD	7.79	0.67	0.56	0.61	0.52	8.71	0.63	0.58	0.67	0.62	
	CI ^a	54.44 / 58.2	2.21 / 3.55	2.68 / 3.80	2.25 / 3.47	2.26 / 3.30	53.57 / 57.77	2.19 / 3.45	2.57 / 3.73	2.22 / 3.56	2.16 / 3.41	

HRQoL. Health-related quality of life; Intr. Intrinsic motivational regulation (MR); Ident Identified MR; Intro. Introjected MR; Ext. External MR; M Mean; SD Standard deviation; CI Confidence interval; ^a 95% Lower / Upper CI

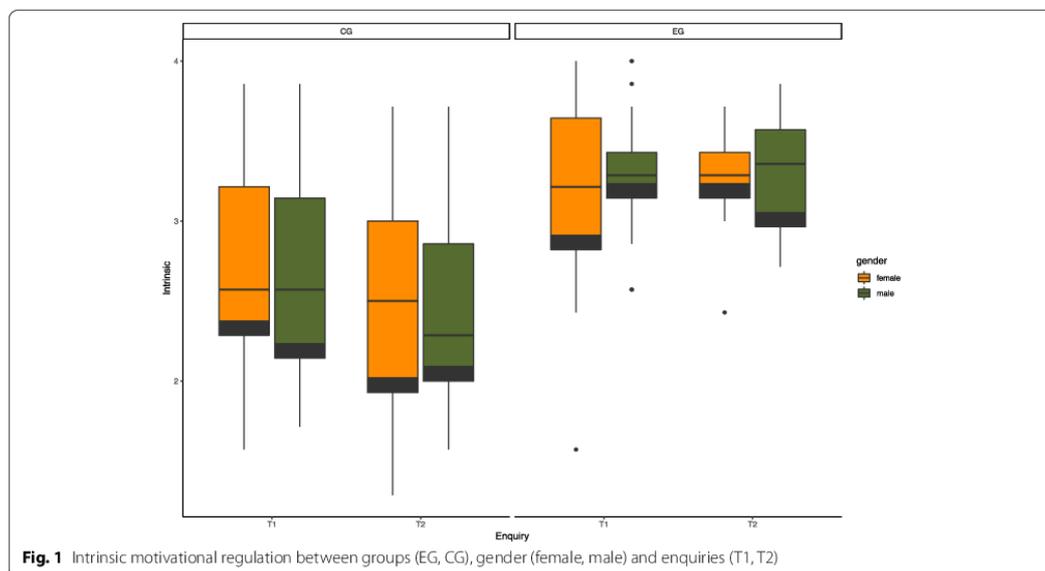


Table 2 Results of the analysis of the five different models regarding p-values (p), effect sizes (η^2), regression coefficients (β) and confidence intervals (CI)

	p	η^2	β	CI ^a	p	η^2	β	CI ^a
	Model 1^b				Model 2^b			
PAut	0.357	0.27	0.17	-0.19 / 0.53	0.229	0.35	0.21	-0.14 / 0.56
PCom	0.155	0.42	0.26	-0.10 / 0.61	0.940	0.02	0.01	-0.33 / 0.35
PSRC	0.449	0.22	0.11	-0.18 / 0.40	0.730	0.10	0.05	-0.23 / 0.33
PSRT	0.559	-0.17	-0.08	-0.37 / 0.20	0.710	0.11	0.05	-0.22 / 0.33
Male	0.887	-0.04	-0.02	-0.33 / 0.28	0.800	0.03	0.02	-0.27 / 0.31
EG	0.003	0.79	0.51	0.18 / 0.83	0.040	0.54	0.33	0.02 / 0.64
T2	0.007	0.81	2.49	0.71 / 4.28	0.034	0.63	1.84	0.14 / 3.54
PAut:EG	0.548	0.25	0.46	-1.09 / 2.00	0.738	0.14	0.23	-1.22 / 1.70
PCom:EG	0.419	0.34	0.59	-0.89 / 2.08	0.706	0.16	0.26	-1.14 / 1.67
PSRC:EG	0.285	-0.46	-0.71	-2.04 / 0.63	0.519	0.27	0.40	-0.86 / 1.66
PSRT:EG	0.560	0.25	0.47	-1.18 / 2.13	0.819	-0.09	-0.18	-1.74 / 1.39
Male:EG	0.476	0.28	2.71	4.86 / 10.28	0.558	0.15	2.11	-5.04 / 9.26
T2:EG	0.116	0.46	0.34	-0.09 / 0.76	0.301	0.30	0.21	-0.19 / 0.61
PAut:T2	0.505	-0.19	-0.18	-0.70 / 0.35	0.460	-0.26	-0.23	-0.74 / 0.27
PCom:T2	0.161	-0.41	-0.39	-0.94 / 0.16	0.459	-0.22	-0.20	-0.73 / 0.33
PSRC:T2	0.421	-0.23	-0.14	-0.49 / 0.21	0.807	-0.07	-0.04	-0.38 / 0.29
PSRT:T2	0.799	0.07	0.05	-0.34 / 0.44	0.785	-0.08	-0.05	-0.43 / 0.32
Male:T2	0.116	-0.10	-0.07	-0.47 / 0.33	0.645	0.13	0.09	-0.29 / 0.47
	Model 3^b				Model 4^b			
PAut	0.390	0.25	0.18	-0.24 / 0.60	0.731	0.09	0.06	-0.24 / 0.60
PCom	0.304	0.30	0.21	-0.20 / 0.62	0.297	0.30	0.18	-0.20 / 0.60
PSRC	0.463	-0.21	-0.12	-0.45 / 0.21	0.487	-0.20	-0.10	-0.46 / 0.21
PSRT	0.771	-0.08	-0.05	-0.38 / 0.28	0.794	-0.07	-0.03	-0.38 / 0.28
Male	0.126	0.39	0.27	-0.07 / 0.61	0.131	0.39	0.23	-0.08 / 0.61
EG	0.957	0.01	0.01	-0.35 / 0.37	0.220	-0.31	-0.20	-0.35 / 0.37
T2	0.185	0.39	1.42	-0.70 / 3.55	0.963	-0.01	-0.04	-0.70 / 3.55
PAut:EG	0.105	0.70	1.31	-0.29 / 2.89	0.448	0.32	0.52	-0.87 / 1.91
PCom:EG	0.977	-0.01	-0.02	-1.55 / 1.51	0.716	0.15	0.24	-1.11 / 1.59
PSRC:EG	0.985	-0.01	-0.01	-1.39 / 1.36	0.250	0.49	0.69	-0.52 / 1.87
PSRT:EG	0.656	-0.19	-0.37	-2.08 / 1.34	0.154	-0.61	-1.06	-2.56 / 0.43
Male:EG	0.111	0.41	6.33	-1.49 / 14.14	0.717	0.09	1.24	-5.59 / 8.07
T2:EG	0.970	-0.01	-0.01	-0.52 / 0.01	0.799	0.07	-0.06	-0.52 / 0.50
PAut:T2	0.714	-0.10	-0.11	-0.73 / 0.50	0.240	0.34	0.32	-0.73 / 0.50
PCom:T2	0.318	-0.29	-0.32	-0.97 / 0.32	0.067	-0.54	-0.53	-0.97 / 0.32
PSRC:T2	0.706	0.11	0.08	-0.34 / 0.50	0.202	0.37	0.24	-0.34 / 0.50
PSRT:T2	0.762	0.09	0.07	-0.39 / 0.53	0.840	0.06	0.04	-0.39 / 0.53
Male:T2	0.042	-0.60	-0.50	-0.98 / -0.02	0.031	-0.07	-0.47	-0.98 / -0.01
	Model 5^b							
PAut	0.300	0.64	4.77	0.46 / 9.08				
PCom	0.175	0.39	2.85	-1.31 / 7.02				
PSRC	0.007	0.79	4.78	1.35 / 8.22				
PSRT	0.074	-0.52	-3.07	-6.44 / 0.31				
Male	0.321	-0.25	-1.88	-5.65 / 1.88				
EG	0.215	0.31	2.49	-1.48 / 6.46				
T2	0.749	0.09	3.14	-16.46 / 22.74				
PAut:EG	0.291	-0.44	-8.02	-23.35 / 7.31				
PCom:EG	0.449	0.31	5.49	-9.24 / 20.21				

Table 2 (continued)

	p	η^2	β	CI ^a	p	η^2	β	CI ^a
PSRC:EG	0.994	-0.01	-0.05	-13.43 / 13.34				
PSRT:EG	0.901	0.05	1.02	-15.70 / 17.76				
Male:EG	0.578	0.14	21.47	-55.27 / 98.22				
T2:EG	0.016	-0.71	-5.57	-10.38 / -1.12				
PAut:T2	0.314	-0.29	-2.92	-8.69 / 2.85				
PCom:T2	0.904	-0.03	-0.37	-6.52 / 5.77				
PSRC:T2	0.385	-0.25	-1.69	-5.58 / 2.19				
PSRT:T2	0.062	0.54	4.18	-0.22 / 8.59				
Male:T2	0.108	0.47	3.53	-0.80 / 7.86				

^a 95% Lower / Upper confidence interval; ^b Dependent variable (DV) in Model 1: Intrinsic motivational regulation; DV Model 2: Identified motivational regulation; DV Model 3: Introjected motivational regulation; DV Model 4: External motivational regulation; DV Model 5: HRQoL

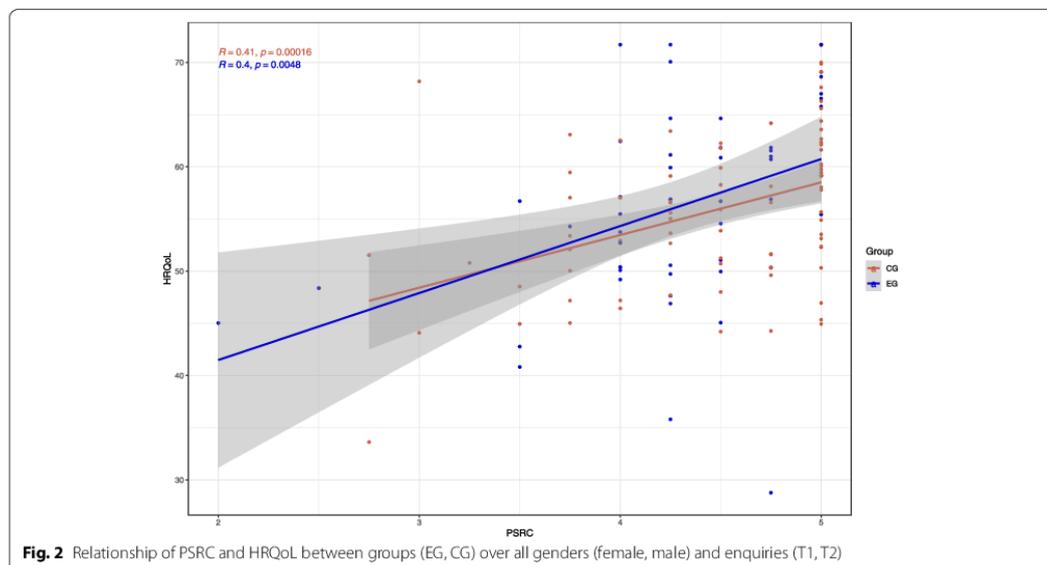


Fig. 2 Relationship of PSRC and HRQoL between groups (EG, CG) over all genders (female, male) and enquiries (T1, T2)

With regard to the motivational regulation in the context of our last hypotheses, no significant relationships could be determined, neither for the individual BPN itself (e.g. in relation with intrinsic motivational regulation: PAut: $p = 0.357$, $\eta^2 = 0.27$, $\beta = 0.17$; PCom: $p = 0.155$, $\eta^2 = 0.42$, $\beta = 0.26$; PSRC: $p = 0.449$, $\eta^2 = 0.22$, $\beta = 0.11$; PSRT: $p = 0.559$, $\eta^2 = -0.17$, $\beta = -0.08$), nor for interaction with EG (PAut: $p = 0.548$, $\eta^2 = 0.25$, $\beta = 0.46$; PCom: $p = 0.419$, $\eta^2 = 0.34$, $\beta = 0.59$; PSRC: $p = 0.285$, $\eta^2 = -0.46$, $\beta = -0.71$; PSRT: $p = 0.560$, $\eta^2 = 0.25$, $\beta = 0.47$). Please see Table 2 for the results regarding the others motivation regulation types

Discussion

HRQoL Between the Groups

With the results presented, our analysis could not demonstrate any general differences in the level of HRQoL between EG and CG, which contradicts our initial hypothesis. It can be seen that the values in all groups are above the mean values of the validation of the used instrument and corresponding Europe-wide studies [80]. Simultaneously, the results are in the same range as those of a large German study in a population of children and adolescents of the same age also using the KID-SCREEN questionnaire [93]. The only significant result

in our models was that the EG shows a significant drop in HRQoL over time (cf. Supplementary Fig. 1). Both the absence of group differences and the decrease in the EG contradict our preliminary assumptions, which were developed on the basis of several empirical and theoretical publications. They also contradict the few previous studies that have suggested that psychosocial well-being improves in EOtC [60]. A comparison of the results of these studies and our own is obvious due to the similar setting. Despite large overlaps in content, a different instrument was used in this studies which is why a comparison is not unrestrictedly valid. However, alignment with these studies suggests that within well-being and HRQoL, a focus on social and psychosocial aspects may be worthwhile in the future [60]. Furthermore, one possible explanation for the observed drop in HRQoL in the EG could be due to the seasons, as several empirical studies have already pointed out that winter time can have a negative impact on mental complaints and behavioural problems of younger people [94, 95]. As our T2 took place in (German) February, this effect may have been at play and the EG may have been even more influenced by this than the CG due to their increased exposure to nature. In contrast, Bølling et al. [60] were better able to account for that seasonal influence than ourselves, as our study had to be shortened due to the COVID-19 pandemic. It furthermore seems conceivable that an additional positive influence on HRQoL via school-relevant aspects such as motivation and academic achievement could not be mapped in our forced limited time frame [46, 47].

Motivational Regulation Between the Groups

With regard to motivational regulation, our statistical analysis revealed two key results that only partly confirm our hypotheses. First, the EG shows significant advantages over the CG in intrinsic and identified motivation - i.e. those forms of motivational regulation that can be referred to as self-determined (cf. Fig. 1 and Supplementary Fig. 2). The observed significant positive development of intrinsic motivational regulation over time thus seems to be mainly due to the EG, given the descriptive data. This is a very important finding because a steady decline in self-determined school motivation in students has already been documented in a large number of studies [96], even in studies comprising only one school year [64]. Here, the study results are consistent with previous research, which identified EOtC as a possible buffer against the drop of intrinsic motivation in regular classes [64, 97]. The results show even slightly higher intrinsic motivational regulation scores in the EG compared with Bølling et al. [64]. The moderate effect sizes

are comparable between the two studies, despite different sample sizes and grouping strategies. We suspected in advance that possible changes in motivational regulation might be related to BPN. However, this could not be confirmed by our analysis. Possible explanations for the alternative source of the EG's comparatively higher intrinsic and identified motivation are discussed in the following chapter.

The second central result of our analysis suggests that boys experience a negative development of external and introjected motivational regulation (cf. Supplementary Figs. 3 and 4). In principle, a decline in motivational values over time is no surprise considering previous research [45]. Additionally, differences between the genders in academic motivation (tending in favour of girls) have already been identified in the past. These differences in comparable aged populations on different academic motivation constructs in school may have been related to specific school subjects [98, 99] or focused on school routine as a whole [100]. Previous studies have also already pointed to gender differences in connection with these two types of controlled motivational regulation (e.g. [101]). In this case, the observed development, especially in external regulation, seems to be mainly due to the EG. In connection with the lack of a drop in intrinsic motivational regulation in the EG, one possible explanation could be that the boys' motivational profile in this case shifts on the continuum in the direction of self-determined motivational regulation (cf. [102]). In principle, this mechanism of a displacement of external motivational regulation through a strong intrinsic motivational regulation could be valued as a positive finding, but it would have to be examined again in the future.

Relationships Between Motivational Regulation, HRQoL and BPN

Looking at group differences in the associations of BPN and HRQoL or motivational regulation, our hypotheses could not be confirmed on a significant level. This applies to all models considered. On the verge of this, however, the results confirm the assumption of certain correlations over all groups. Following that, HRQoL is significantly positively associated with PSRC (cf. Fig. 2). However, such significant correlations could not be confirmed for the other BPN (cf. Supplementary Figs. 5-7). Although previous findings do not explicitly point to the enhanced importance of social relatedness for HRQoL over the other BPN, the fundamental connection between social factors and HRQoL has been researched and confirmed many times, especially in relation to the setting of school and peers of children and adolescents [30, 32]. Social interaction with classmates typically exceeds that with

teachers, even in purely quantitative terms. This could be the reason why these correlations are only revealed for PSRC, but not for PSRT. From our point of view, it was conceivable that this effect could become even more apparent in the EOtC, but this was not confirmed by the analysis of our models. In contrast to this assumption, our MANOVA even indicates, that the CG shows significantly higher scores of PSRC.

Contrary to our preliminary assumption, our models could also neither confirm group differences in the correlations of the BPN with the different motivational regulation types nor confirm any correlations regarding this constructs over all groups. According to our MANOVA, the EG shows significantly higher levels of PAut and PCom and, as described above, higher levels of intrinsic motivational regulation. However, these two observations cannot be directly linked to each other on the basis of our models. Thus, our original hypothesis of an (positive) association of these constructs cannot be confirmed. However, we still see our results partly in the tradition of previous studies that suggest a positive relationship between autonomy and competence in particular and motivational regulation. Thus, when looking at intrinsic and identified motivation, these two BPN show a higher correlation coefficient than the facets of social relatedness. At least for the EG, also on a descriptive level, a tendential relationship cannot be completely discarded, even if not on a significant level (cf. Supplementary Figs. 8–11).

A possible, but at this stage speculative, alternative explanation for the increased levels of intrinsic and identified motivation in EG could be the teacher's organisation of the lesson, which would not necessarily have to involve the promotion of PAut or PCom. Thus, it is known from school practice that particularly those curricular contents are used for EOtC that allow for designing a particularly vivid, exciting and experimental lesson. This could automatically increase students' self-determined motivational regulation types of school motivation. Teachers who show a particularly high level of enthusiasm and enjoyment and who point out daily life relevance may opt for EOtC more frequently. These characteristics have been associated positively with school motivation of the respective students in previous studies [103–105] and could also exist independently of the EOtC and without the explicit support and satisfaction of PAut or PCom.

Limitations and Future Directions

This study has some general methodological limitations. With our small sample size, the presented findings must be considered exploratory. Given this impression, we do not claim to generalise our findings. Rather, our study might provide information on how to better design future studies in the field of EOtC: Accordingly, the expansion

to more enquiries and seasons would offer the chance to capture and reliably classify the effects of these via implementation as random effects on a statistical level [106]. Second, no random assignment of the participants to the groups could be realised in this study because we were dependent on the assignment by the parents. Future considerations should also pay attention to an even distribution in the sample, especially if gender effects are conceivable or expected as shown in our analyses regarding HRQoL. Furthermore, existing difficulties and challenges in capturing HRQoL - possibly but not necessarily related to social factors - in this population should be considered in future research [107–109]. In this respect, an even more elaborate selection of instruments and survey methods could possibly contribute to a breakthrough in this context and generate consistent results.

Overall, the basic relationships presented by the SDT between HRQoL, motivational regulation and BPN seem clear at the theoretical level and increasingly more empirical evidence supports them. This pilot study provided evidence for application in EOtC. Subsequent studies should test these relationships by enriching them with further variables (e.g. previous experience through forest kindergarten or socio-economic status) in elaborated statistical procedures, e.g. structural equation approaches. Especially the inclusion of academic achievements as a covariate seems unavoidable if the relationship between motivational regulation and HRQoL is to be examined in detail. Furthermore, when considering an influence of the BPN on HRQoL, a potentially negative effect due to an explicit non-satisfaction of the BPN should also be considered in the future.

Conclusions

For the first time, we measured HRQoL in the EOtC and compared different groups over a longer period of time in a setting that is crucial for child development. As a curricular concept, EOtC could evolve its impact via long-term effects. The example of EOtC shows how the implementation of innovative concepts in schools could contribute to improving the rather poor situation in terms of mental health. Based on SDT multiple approaches exist, that could contribute to HRQoL of students by strengthening the satisfaction of BPN and motivational regulation, as shown by our study. Thus far, schools have only activated very limited capacities to support this [41]. To obtain well-founded results in mental health-related outcomes, such as HRQoL or BPN in the coming years, it is also necessary to constantly adapt the methodological approach in conducting studies to difficulties that arise. Only if it is possible to investigate relevant topics with suitable methods in significant settings in the future, the health of children and adolescents will be influenced positively on the long run.

Abbreviations

WHO: World Health Organisation; PA: Physical activity; SDT: Self-determination theory; HRQoL: Health-related quality of life; BPN: Basic Psychological Needs; PCom: Perceived competence; PAut: Perceived autonomy; PSRC: Perceived social relatedness with classmates; PSRT: Perceived social relatedness with teachers; EOTC: Education Outside the Classroom; SB: Sedentary behaviour; CG: Control group; EG: Experimental group; BPNs: Basic Psychological Needs Scale; LMM: Linear mixed-effects model.

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-021-12450-9>.

Additional file 1.**Acknowledgements**

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Authors' contributions

F.M. and C.M. conceived, conceptualised and designed the study. J.E. and C.M. conducted the data collection and S.B. and J.E. analysed the data with the help of C.M. J.E. was the major contributor in writing the manuscript with substantial contributions from F.M., S.B. and C.M. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations**Ethics approval and consent to participate**

This study was approved by the ethics committee of the Technical University of Munich (Institute of Medicine), Germany (Approval code 336/19 S-SR). The study was conducted according to the guidelines of the Declaration of Helsinki. All subjects and their parents gave written informed consent in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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References

- Kovess-Masfety V, Husky MM, Keyes K, Hamilton A, Pez O, Bitfoi A, et al. Comparing the prevalence of mental health problems in children 6–11 across Europe. *Soc Psychiatry Psychiatr Epidemiol*. 2016;51(8):1093–103. <https://doi.org/10.1007/s00127-016-1253-0>.
- Barker MM, Beresford B, Bland M, Fraser LK. Prevalence and incidence of anxiety and depression among children, adolescents, and young adults with life-limiting conditions: a systematic review and meta-analysis. *JAMA Pediatr*. 2019;173(9):835–44. doi:<https://doi.org/10.1001/jamapediatrics.2019.1712>.
- Eccles JS, Midgley C, Wigfield A, Buchanan CM, Reuman D, Flanagan C, et al. Development during adolescence: The impact of stage–environment fit on young adolescents' experiences in schools and in families. *1993;48(2):90–101*. <https://doi.org/10.1037/0003-066X.48.2.90>.
- Anniko M, Boersma K, Tillfors M. Sources of stress and worry in the development of stress-related mental health problems: A longitudinal investigation from early- to mid-adolescence. *Anxiety Stress Coping*. 2019;32(2):155–67. <background-color:#CFBFB1;vertical-align:super;><https://doi.org/10.1080/10615806.2018.1549657></background-color:#CFBFB1;vertical-align:super;><uvertical-align:super;></uvertical-align:super;>
- Huber G, Köppel M. Analyse der Sitzzeiten von Kindern und Jugendlichen zwischen 4 und 20 Jahren [Analysis of Sedentary Times of Children and Adolescents between 4 and 20 Years]. *Dtsch Z Sportmed*. 2017;68(4):101–6. Available from: <https://www.germanjournalsportsmedicine.com/archive/archive-2017/issue-4/analyse-der-sitzzeiten-von-kindern-und-jugendlichen-zwischen-4-und-20-jahren/>.
- Leech RM, McNaughton SA, Timperio A. The clustering of diet, physical activity and sedentary behavior in children and adolescents: a review. *Int J Behav Nutr Phys Act*. 2014;11(1):1–9. <https://doi.org/10.1186/1479-5868-11-4>.
- Imsen G, Blossing U, Moos L. Reshaping the Nordic education model in an era of efficiency. Changes in the comprehensive school project in Denmark, Norway, and Sweden since the millennium. *Scand J Educ Res*. 2017;61(5):568–83. <background-color:#CFBFB1;vertical-align:super;><https://doi.org/10.1080/00313831.2016.1172502></background-color:#CFBFB1;vertical-align:super;><uvertical-align:super;></uvertical-align:super;>
- Bundesregierung [German Government]. Ein neuer Aufbruch für Europa. Eine neue Dynamik für Deutschland. Ein neuer Zusammenhalt für unser Land. Koalitionsvertrag zwischen CDU, CSU und SPD [A new dawn for Europe. A new dynamic for Germany. A new cohesion for our country. Coalition agreement between CDU, CSU and SPD]. Berlin: Bundesregierung; 2018. Available from: <https://www.bundesregierung.de/breg-de/themen/koalitionsvertrag-zwischen-cdu-csu-und-spd-195906>.
- Dray J, Bowman J, Campbell E, Freund M, Wolfenden L, Hodder RK, et al. Systematic review of universal resilience-focused interventions targeting child and adolescent mental health in the school setting. *J Am Acad Child Adolesc Psychiatry*. 2017;56(10):813–24. <https://doi.org/10.1016/j.jaac.2017.07.780>.
- Dunning DL, Griffiths K, Kuyken W, Crane C, Foulkes L, Parker J, et al. Research Review: The effects of mindfulness-based interventions on cognition and mental health in children and adolescents—a meta-analysis of randomized controlled trials. *J Child Psychol Psychiatry*. 2019;60(3):244–58. <https://doi.org/10.1111/jcpp.12980>.
- Schwarzer R. Self-efficacy in the adoption and maintenance of health behaviors: Theoretical approaches and a new model. In: Schwarzer R (ed). *Self-efficacy: Thought control of action*. Washington, D.C.: Hemisphere; 1992. Available from: <https://psycnet.apa.org/record/1992-97719-010>.
- Dweck, C. Motivational processes affecting learning. *Am Psychol*. 1986;41(10):1040–1048. <https://doi.org/10.1037/0003-066X.41.10.1040>.
- Ntoumanis N, Ng JY, Prestwich A, Quested E, Hancox JE, Thøgersen-Ntoumani C, et al. A meta-analysis of self-determination theory-informed intervention studies in the health domain: effects on motivation, health behavior, physical, and psychological health. *Health Psychol Rev*. 2020;3:1–31. <background-color:#CFBFB1;vertical-align:super;><https://doi.org/10.1080/17437199.2020.1718529></background-color:#CFBFB1;vertical-align:super;><uvertical-align:super;></uvertical-align:super;>
- Warr P. The measurement of well-being and other aspects of mental health. *J Occup Health Psychol*. 1990;63(3):193–210. <https://doi.org/10.1111/j.2044-8325.1990.tb00521.x>.
- Lin X-J, Lin I-M, Fan S-Y. Methodological issues in measuring health-related quality of life. *Tzu Chi Med*. 2013;25(1):8–12. <https://doi.org/10.1016/j.tcmj.2012.09.002>.
- Cella D. Quality of Life: Concepts and Definition. *J Pain Symptom Manag*. 1994;9(3):186–192. [https://doi.org/10.1016/0885-3924\(94\)90129-5](https://doi.org/10.1016/0885-3924(94)90129-5).

17. Cummins R, Lau A, Stokes M. HRQOL and subjective well-being: noncomplementary forms of outcome measurement. *Expert Rev. Pharmacoeconomics Outcomes Res.* 2004;4(4): 413–420. <https://doi.org/10.1586/14737167.4.4.413>.
18. Karimi M, Brazier J. Health, health-related quality of life, and quality of life: what is the difference? *Pharmacoeconomics.* 2016;34(7):645–9. <https://doi.org/10.1007/s40273-016-0389-9>.
19. Ryan RM, Deci EL. *Self-determination theory: Basic psychological needs in motivation, development, and wellness.* New York City: Guilford Publications; 2017.
20. Deci EL, Ryan RM. The “what” and “why” of goal pursuits: human needs and the self-determination of behavior. *Psychol Inq.* 2000;11(4):227–268. https://doi.org/10.1207/S15327965PLI1104_01.
21. Deci EL, Vansteenkiste M. Self-determination theory and basic need satisfaction: Understanding human development in positive psychology. *Ricerche di psicologia.* 2004;27(1):23–40.
22. Durksen TL, Chu M-W, Ahmad ZF, Radil AI, Daniels LM. Motivation in a MOOC: a probabilistic analysis of online learners' basic psychological needs. *Soc Psychol Educ.* 2016;19(2):241–60. <https://doi.org/10.1007/s11218-015-9331-9>.
23. Deci E, Olafsen A, Ryan E. Self-Determination Theory in Work Organizations: The State of a Science. *Annu. Rev. Organ. Psychol. Organ. Behav.* 2017;4:19–43. <https://doi.org/10.1146/annurev-orgpsych-032516-113108>.
24. Darner R. Self-Determination Theory as a Guide to Fostering Environmental Motivation. *J Environ Educ.* 2010;40(2):39–49. <https://doi.org/10.3200/JOEE.40.2.39-49>.
25. Ng J, Ntoumanis N, Thøgersen-Ntoumani C, Deci E, Ryan R, Duda J, Williams G. Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. *Perspect Psychol Sci.* 2012;4(7). <https://doi.org/10.1177/1745691612447309>.
26. Tian L, Zhang X, Huebner ES. The effects of satisfaction of basic psychological needs at school on children's prosocial behavior and antisocial behavior: the mediating role of school satisfaction. *Front. Psychol.* 2018;9:548. <https://doi.org/10.3389/fpsyg.2018.00548>.
27. Standage M, Gillison FB, Ntoumanis N, Treasure DC. Predicting students' physical activity and health-related well-being: A prospective cross-domain investigation of motivation across school physical education and exercise settings. *JSEP.* 2012;34(1):37–60. <https://doi.org/10.1123/jsep.34.1.37>.
28. Moeijes J, van Busschbach JT, Bosscher RJ, Twisk JW. Sports participation and health-related quality of life: a longitudinal observational study in children. *Qual Life Res.* 2019;28(9):2453–69. <https://doi.org/10.1007/s11136-019-02219-4>.
29. Breslin G, Shannon S, Fitzpatrick B, Hanna D, Belton S, Brennan D. Physical activity, well-being and needs satisfaction in eight and nine-year-old children from areas of socio-economic disadvantage. *Child Care Pract.* 2017;23(3):275–91. <https://doi.org/10.1080/13575279.2017.1299108>.
30. Demir M, Leyendecker B. School-related social support is associated with school engagement, self-competence and health-related quality of life (HRQoL) in Turkish immigrant students. *Front Educ.* 2018;3:83. <https://doi.org/10.3389/educ.2018.00083>.
31. Su T, Lili T, Hueber S. The reciprocal relations among prosocial behavior, satisfaction of relatedness needs at school, and subjective well-being in school: A three-wave cross-lagged study among Chinese elementary school students. *Curr Psychol.* 2021;40(8):3734–3746. <https://doi.org/10.1007/s12144-019-00323-9>.
32. Liu W, Tian S, Lili T, Huebner S. Prosocial behavior and subjective well-being in school among elementary school students: the mediating roles of the satisfaction of relatedness needs at school and self-esteem. *Appl Res Qual Life.* 2021;16(4):1439–1459. <https://doi.org/10.1007/s11482-020-09826-1>.
33. Tian L, Chen H, Huebner ES. The longitudinal relationships between basic psychological needs satisfaction at school and school-related subjective well-being in adolescents. *Soc Indic Res.* 2014;119(1):353–72. <https://doi.org/10.1007/s11205-013-0495-4>.
34. Tian L, Tian Q, Huebner ES. School-related social support and adolescents' school-related subjective well-being: The mediating role of basic psychological needs satisfaction at school. *Soc Indic Res.* 2016;128(1):105–29. <https://doi.org/10.1007/s11205-015-1021-7>.
35. Evans P, Liu MY. Psychological needs and motivational outcomes in a high school orchestra program. *J. Res. Music Educ.* 2019;67(1):83–105. <https://doi.org/10.1177/0022429418812769>.
36. Tilga H, Hein V, Koka A, Hagger M. How Physical Education Teachers' Interpersonal Behaviour is Related to Students' Health-Related Quality of Life. *Scand. J. Educ. Res.* 2019. <https://doi.org/10.1080/00313831.2019.1595718>.
37. Langeland IO, Sollesnes R, Nilsen RM, Almenning G, Langeland E. Examining boys' and girls' health-related quality of life from the first to the third year of upper secondary school: A prospective longitudinal study. *Nurs Open.* 2019;6(4):1606–14. <https://doi.org/10.1002/nop2.366>.
38. Soenens B, Deci EL, Vansteenkiste M. How parents contribute to children's psychological health: The critical role of psychological need support. In: Wehmeyer M, Shogren K, Little T, Lopez S (eds). *Development of Self-Determination Through the Life-Course.* Berlin: Springer; 2017. https://doi.org/10.1007/978-94-024-1042-6_13.
39. White RW. Motivation reconsidered: The concept of competence. *Psychol Rev.* 1959;66(5):297. <https://doi.org/10.1037/h0040934>.
40. Erturan-Ilker G, Quested E, Appleton P, Duda JL. A cross-cultural study testing the universality of basic psychological needs theory across different academic subjects. *Psychol Sch.* 2018;55(4):350–65. <https://doi.org/10.1002/pits.22113>.
41. Ryan RM, Deci EL. Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions. *Contemp Educ Psychol.* 2020;101860. <https://doi.org/10.1016/j.cedpsych.2020.101860>.
42. Thuneberg H. Is a majority enough? Psychological well-being and its relation to academic and prosocial motivation, self-regulation and achievement at school. Helsinki: Helda; 2007.
43. Garr AC, Morin AJ, Lonsdale C. Basic psychological need satisfaction toward learning: A longitudinal test of mediation using bifactor exploratory structural equation modeling. *J Educ Psychol.* 2019;111(2):354. <https://doi.org/10.1037/edu0000283>.
44. Kaiser L-M, Großmann N, Wilde M. The relationship between students' motivation and their perceived amount of basic psychological need satisfaction—a differentiated investigation of students' quality of motivation regarding biology. *Int J Sci Educ.* 2020;1–18. <https://doi.org/10.1080/09500693.2020.1836690>.
45. Gnambs T, Hanfstingl B. The decline of academic motivation during adolescence: An accelerated longitudinal cohort analysis on the effect of psychological need satisfaction. *Educ Psychol.* 2016;36(9):1691–705. <https://doi.org/10.1080/01443410.2015.1113236>.
46. Milyavskaya M, Koestner R. Psychological needs, motivation, and well-being: A test of self-determination theory across multiple domains. *Pers Individ Differ.* 2011;50(3):387–91. <https://doi.org/10.1016/j.paid.2010.10.029>.
47. Taylor G, Jungert T, Mageau G, Schattke K, Dedic H, Rosenfeld S, Koestner R. A self-determination theory approach to predicting school achievement over time: the unique role of intrinsic motivation. *Contemp Educ Psychol.* 2014;39(4): 342–358. <https://doi.org/10.1016/j.cedpsych.2014.08.002>.
48. Bucker S, Nuraydin S, Simonsmeier B, Schneider M, Luhmann M. Subjective well-being and academic achievement: A meta-analysis. *J Res Pers.* 2018;74:83–94. <https://doi.org/10.1016/j.jrp.2018.02.007>.
49. Beames S, Higgins P, Nicol R. *Learning outside the classroom: Theory and guidelines for practice.* London: Routledge; 2012.
50. Bentsen P, Mygind L, Elsberg B, Nielsen G, Mygind E. Education outside the classroom as upstream school health promotion: 'adding-in' physical activity into children's everyday life and settings. *Scand J Public Health.* 2021;1(9). <https://doi.org/10.1177/1403494821993715>.
51. Barfod K, Bølling M, Mygind L, Elsberg P, Ejbye-Ernst N, Bentsen P. Reaping fruits of labour: Revisiting Education Outside the Classroom provision in Denmark upon policy and research interventions. *Urban For Urban Green.* 2021;60:127044. <https://doi.org/10.1016/j.ufug.2021.127044>.
52. Passy R, Bentsen P, Gray T, Ho S. Integrating outdoor learning into the curriculum: an exploration in four nations. *Curric Perspect.* 2019;39(1):73–8. <https://doi.org/10.1007/s41297-019-00070-8>.
53. Becker C, Lauterbach G, Spengler S, Dettweiler U, Mess F. Effects of regular classes in outdoor education settings: A systematic review on

- students' learning, social and health dimensions. *Int J Environ Res Public Health*. 2017;14(5):485. <https://doi.org/10.3390/ijerph14050485>.
54. Schneller MB, Schipperijn J, Nielsen G, Bentsen P. Children's physical activity during a segmented school week: results from a quasi-experimental education outside the classroom intervention. *Int J Behav Nutr Phys Act*. 2017;14(1):80. <https://doi.org/10.1186/s12966-017-0534-7>.
 55. Schneller MB, Duncan S, Schipperijn J, Nielsen G, Mygind E, Bentsen P. Are children participating in a quasi-experimental education outside the classroom intervention more physically active? *BMC Public Health*. 2017;17(1):523. <https://doi.org/10.1186/s12889-017-4430-5>.
 56. Bølling M, Mygind E, Mygind L, Bentsen P, Elsborg P. The Association between Education Outside the Classroom and Physical Activity: Differences Attributable to the Type of Space? *Children*. 2021; 6(8). <https://doi.org/10.3390/children8060486>.
 57. Bølling M, Pfister GU, Mygind E, Nielsen G. Education outside the classroom and pupils' social relations? A one-year quasi-experiment. *Int J Educ Res*. 2019;94:29–41. <https://doi.org/10.1016/j.ijer.2019.02.014>.
 58. Otte CR, Bølling M, Stevenson MP, Ejbye-Ernst N, Nielsen G, Bentsen P. Education outside the classroom increases children's reading performance: Results from a one-year quasi-experimental study. *Int J Educ Res*. 2019;94:42–51. <https://doi.org/10.1016/j.ijer.2019.01.009>.
 59. Otte CR, Bølling M, Elsborg P, Nielsen G, Bentsen P. Teaching maths outside the classroom: does it make a difference? *Education*. 2019;61(1):38–52. <https://doi.org/10.1080/00131881.2019.1567270>.
 60. Bølling M, Niclasen J, Bentsen P, Nielsen G. Association of Education Outside the Classroom and Pupils' Psychosocial Well-Being: Results From a School Year Implementation. *J Sch Health*. 2019;89(3):210–8. <https://doi.org/10.1111/josh.12730>.
 61. Becker C, Schmidt S, Neuberger E, Kirsch P, Simon P, Dettweiler U. Children's Cortisol and Cell-Free DNA Trajectories in Relation to Sedentary Behavior and Physical Activity in School: A Pilot Study. *Front Public Health*. 2019;7:26. <https://doi.org/10.3389/fpubh.2019.00026>.
 62. Mygind L, Stevenson M, Liebst L, Konvalinka I, Bentsen P. Stress Response and Cognitive Performance: Modulation in Classroom versus Natural Environments: A Quasi-Experimental Pilot Study with Children. *Int J Environ Res Public Health*. 2018;15(6). <https://doi.org/10.3390/ijerph15061098>.
 63. Sahrakiz S, Harring M, Witte MD. Learning opportunities in the outdoor school—empirical findings on outdoor school in Germany from the children's perspective. *JAEOL*. 2018;18(3):214–26. <https://doi.org/10.1080/14729679.2017.1413404>.
 64. Bølling M, Otte CR, Elsborg P, Nielsen G, Bentsen P. The association between education outside the classroom and students' school motivation: Results from a one-school-year quasi-experiment. *Int J Educ Res*. 2018;89:22–35. <https://doi.org/10.1016/j.ijer.2018.03.004>.
 65. Burt TD, Young-Jones AD, Yador CA, Carr MT. The advisor and instructor as a dynamic duo: Academic motivation and basic psychological needs. *NACADA*. 2013;33(2):44–54. <https://doi.org/10.12930/NACADA-13-006>.
 66. Curran T, Standage M. Psychological needs and the quality of student engagement in physical education: Teachers as key facilitators. *J Teach Phys Educ*. 2017;36(3):262–76. <https://doi.org/10.1123/jtpe.2017-0065>.
 67. Reeve J, Jang H. What teachers say and do to support students' autonomy during a learning activity. *J Educ Psychol*. 2006;98(1):209. <https://doi.org/10.1037/0022-0663.98.1.209>.
 68. Aelterman N, Vansteenkiste M, Haerens L, Soenens B, Fontaine JR, Reeve J. Toward an integrative and fine-grained insight in motivating and demotivating teaching styles: The merits of a circumplex approach. *J Educ Psychol*. 2019;111(3):497. <https://doi.org/10.1037/edu0000293>.
 69. Dettweiler U, Lauterbach G, Becker C, Simon P. A Bayesian mixed-methods analysis of basic psychological needs satisfaction through outdoor learning and its influence on motivational behavior in science class. *Front Psychol*. 2017;8:2235. <https://doi.org/10.3389/fpsyg.2017.02235>.
 70. von Au J, Jucker R. „Neues Lernen - neue Räume“: Lernen im Freien (LIF) als Antwort auf neue Lernhausforderungen [“New Learning - New Spaces“]. *Outdoor learning (LIF) as a response to new learning house demands*. *Lehren & Lernen*. 2018;44(12):7.
 71. Mygind L, Kjeldsted E, Hartmeyer R, Mygind E, Bølling M, Bentsen P. Mental, physical and social health benefits of immersive nature-experience for children and adolescents: A systematic review and quality assessment of the evidence. *Health Place*. 2019;58:102136. <https://doi.org/10.1016/j.healthplace.2019.05.014>.
 72. Roberts A, Hinds J, Camic PM. Nature activities and well-being in children and young people: a systematic literature review. *JAEOL*. 2019;1–21. <https://doi.org/10.1080/14729679.2019.1660195>.
 73. Mall C, von Au J, Dettweiler U. Students' Appropriation of Space in Education Outside the Classroom. Some Aspects on Physical Activity and Health from a Pilot Study with 5th-Graders in Germany. In: Brymer E, Rogerson M, Barton J (ed). *Nature and Health. Physical Activity in Nature*. London: Routledge; 2021. <https://doi.org/10.4324/9781003154419>.
 74. La Guardia J, Ryan R, Couchman C, Deci E. Basic Psychological Needs Scales. *J Pers Soc Psychol*. 2000;79:367–84. Available from: <https://selfdeterminationtheory.org/basic-psychological-needs-scale/>.
 75. Hanfstingl B, Andreitz I, Müller FH, Thomas A. Are self-regulation and self-control mediators between psychological basic needs and intrinsic teacher motivation? *JERO*. 2010;2(2):55–71. Available from: <https://www.waxmann.com/artikelART102666>.
 76. Ravens-Sieberer U, Auquier P, Erhart M, Gosch A, Rajmil L, Bruil J, et al. The KIDSCREEN-27 quality of life measure for children and adolescents: psychometric results from a cross-cultural survey in 13 European countries. *Qual Life Res*. 2007;16(8):1347–56. <https://doi.org/10.1007/s11136-007-9240-2>.
 77. Ravens-Sieberer U, Gosch A, Rajmil L, Erhart M, Bruil J, Duer W, et al. KIDSCREEN-52 quality-of-life measure for children and adolescents. *Expert Rev Pharmacoecon Outcomes Res*. 2005;5(3):353–64. <https://doi.org/10.1111/j.1524-4733.2007.00291.x>.
 78. Andersen JR, Natvig GK, Aadland E, Moe VF, Kolotkin RL, Anderssen SA, et al. Associations between health-related quality of life, cardiorespiratory fitness, muscle strength, physical activity and waist circumference in 10-year-old children: the ASK study. *Qual Life Res*. 2017;26(12):3421–8. <https://doi.org/10.1007/s11136-017-1634-1>.
 79. Parkinson KN, Adamson AJ, Basterfield L, Reilly JK, Le Couteur A, Reilly JJ. Influence of adiposity on health-related quality of life in the Gateshead Millennium Study cohort: longitudinal study at 12 years. *Arch Dis Child*. 2015;100(8):779–83. <https://doi.org/10.1136/archdischild-2014-307498>.
 80. Ravens-Sieberer U, Erhart M, Gosch A, Wille N, Group EK. Mental health of children and adolescents in 12 European countries—results from the European KIDSCREEN study. *Clin Psychol Psychother*. 2008;15(3):154–63. <https://doi.org/10.1002/cpp.574>.
 81. Ryan RM, Connell JP. Perceived locus of causality and internalization: Examining reasons for acting in two domains. *J Pers Soc Psychol*. 1989;57(5):749. <https://doi.org/10.1037/0022-3514.57.5.749>.
 82. Kröner J, Goussios C, Schaitz C, Streib J, Sosic-Vasic Z. The construct validity of the German Academic Self-Regulation Questionnaire (SRQ-A) within primary and secondary school children. *Front Psychol*. 2017;8:1032. <https://doi.org/10.3389/fpsyg.2017.01032>.
 83. Meteyard L, Davies RA. Best practice guidance for linear mixed-effects models in psychological science. *J Mem Lang*. 2020;112:104092. <https://doi.org/10.1016/j.jml.2020.104092>.
 84. Leys C, Klein O, Dominicy Y, Ley C. Detecting multivariate outliers: Use a robust variant of the Mahalanobis distance. *J Exp Soc Psychol*. 2018;74:150–6. <https://doi.org/10.1016/j.jesp.2017.09.011>.
 85. Zhang D. Coefficients of Determination for Mixed-Effects Models. Available from: <https://arxiv.org/pdf/2007.08675.pdf>.
 86. Fox J, Friendly GG, Graves S, Heiberger R, Monette G, Nilsson H, et al. *The car package*. Vienna: R Foundation for Statistical Computing; 2007.
 87. Wooldridge JM. *Introductory econometrics: A modern approach*. Mason: Nelson Education; 2016.
 88. RStudio Team. *RStudio: Integrated Development for R*. RStudio; 2020. Available from: <http://www.rstudio.com/>.
 89. Huque MH, Carlin JB, Simpson JA, Lee KJ. A comparison of multiple imputation methods for missing data in longitudinal studies. *BMC Med Res Methodol*. 2018;18(1):168. <https://doi.org/10.1186/s12874-018-0615-6>.
 90. Huque MH, Moreno-Betancur M, Quartagno M, Simpson JA, Carlin JB, Lee KJ. Multiple imputation methods for handling incomplete longitudinal and clustered data where the target analysis is a linear mixed effects model. *Biom J*. 2020;62(2):444–66. <https://doi.org/10.1002/bimj.201900051>.
 91. Buuren Sv, Groothuis-Oudshoorn K. mice: Multivariate imputation by chained equations in R. *J Stat Softw*. 2010;1:68. Available from: <https://www.jstatsoft.org/article/view/v04i03>.

92. Pinheiro J, Bates D, DebRoy S, Sarkar D, Heisterkamp S, Van Willigen B, et al. Package 'nlme'. Linear and nonlinear mixed effects models. 2017;3(1). Available from: <https://cran.r-project.org/web/packages/nlme/nlme.pdf>.
93. Ellert U, Brettschneider A-K, Ravens-Sieberer U, Group KS. Gesundheitsbezogene Lebensqualität bei Kindern und Jugendlichen in Deutschland [Health-related quality of life among children and adolescents in Germany]. *Bundesgesundheitsbl.* 2014;57(7):798–806. <https://doi.org/10.1007/s00103-007-0244-4>.
94. Kovalenko P, Hoven C, Wicks J, Moore R, Mandell D, Liu H. Seasonal variations in internalizing, externalizing, and substance use disorders in youth. *Psychiatry Res.* 2000;94(2):103–119. [https://doi.org/10.1016/S0165-1781\(00\)00140-2](https://doi.org/10.1016/S0165-1781(00)00140-2).
95. Carskadon M, Acebo C. Parental Reports of Seasonal Mood and Behavior Changes in Children. *J Am Acad Child Adolesc Psychiatry.* 1993;32(2):264–269. <https://doi.org/10.1097/00004583-199303000-00005>.
96. Scherrer V, Preckel F. Development of motivational variables and self-esteem during the school career: A meta-analysis of longitudinal studies. *Rev Educ Res.* 2019;89(2):211–58. <https://doi.org/10.3102/0034654318819127>.
97. Fägerstam E, Samuelsson. Learning arithmetic outdoors in junior high school—influence on performance and self-regulating skills. *Educ* 3 13. 2014; 42(4):419–431. <https://doi.org/10.1080/03004279.2012.713374>.
98. Guay F, Chanal J, Ratelle CF, Marsh HW, Larose S, Boivin M. Intrinsic, identified, and controlled types of motivation for school subjects in young elementary school children. *Br J Educ Psychol.* 2010;80(4):711–35. <https://doi.org/10.1348/000709910X499084>.
99. Yeung AS, Lau S, Nie Y. Primary and secondary students' motivation in learning English: Grade and gender differences. *Contemp Educ Psychol.* 2011;36(3):246–56. <https://doi.org/10.1016/j.cedpsych.2011.03.001>.
100. Bugler M, McGeown SP, St Clair-Thompson H. Gender differences in adolescents' academic motivation and classroom behaviour. *Educ Psychol.* 2015;35(5):541–56. <https://doi.org/10.1080/014434102013849325>.
101. Liu Y, Hou S. Potential reciprocal relationship between motivation and achievement: A longitudinal study. *Sch. Psychol. Int.* 2018;39(1):38–55. <https://doi.org/10.1177/0143034317710574>.
102. Howard J, Gagné M, Morin A, Forest J. Using Bifactor Exploratory Structural Equation Modeling to Test for a Continuum Structure of Motivation. *J Manag.* 2018;44(7):2638–2664. <https://doi.org/10.1177/0149206316645653>.
103. Korur F, Eryilmaz A. Interaction between Students' Motivation and Physics Teachers' Characteristics: Multiple Case Study. *Qual. Rep.* 2018;23(12):3054. Available from: <https://hsuworks.nova.edu/tqr/vol23/iss12/13>.
104. Martin AJ. The relationship between teachers' perceptions of student motivation and engagement and teachers' enjoyment of and confidence in teaching. *Asia-Pac J Teach Edu.* 2006;34(1):73–93. <https://doi.org/10.1080/13598660500480100>.
105. Thoonen EE, Slegers PJ, Peetsma TT, Oort FJ. Can teachers motivate students to learn? *Educ stud.* 2011;37(3):345–60. <https://doi.org/10.1080/03055698.2010.507008>.
106. Konu A, Joronen K, Lintonen T. Seasonality in School Well-being: The Case of Finland. *Child Ind Res.* 2015;8:265–277. <https://doi.org/10.1007/s12187-014-9243-3>.
107. Frisen A. Measuring health-related quality of life in adolescence. *Acta Paediatr Int J Paediatr.* 2007;96(7):963–8. <https://doi.org/10.1111/j.1651-2227.2007.00333.x>.
108. Largo-Wight E, Guardino C, Wludyka PS, Hall KW, Wight JT, Merten JW. Nature contact at school: The impact of an outdoor classroom on children's well-being. *Int J Environ Health Res.* 2018;28(6):653–66. <https://doi.org/10.1080/09603123.2018.1502415>.
109. Rafferty R, Breslin G, Brennan D, Hassan D. A systematic review of school-based physical activity interventions on children's wellbeing. *Int Rev Sport Exerc Psychol.* 2016;9(1):215–30. <https://doi.org/10.1080/1750984X.2016.1164228>.

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4.2 Publication on social interaction, social relatedness and friendships using Social Network Analysis

Authorship: Jan Ellinger, Filip Mess, Joachim Bachner, Jakob von Au & Christoph Mall

Title: Changes in social interaction, social relatedness, and friendships in Education Outside the Classroom: A social network analysis

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Social interaction is undoubtedly of great importance in the healthy development of children and adolescents. The effects of insufficient social interaction span a wide range of mental health problems and disorders. Previous research suggests that spending time and engaging with natural spaces can lead to increased social interaction. The concept of EOtC, due to its character (e. g. increased cooperative forms of learning, elimination of spatial limitations), also makes it possible to facilitate forms of social interaction. The second publication of this dissertation therefore examines the question of whether a restructuring and intensification of social interaction during lessons and breaks can be observed over time in an EOtC class (N = 24) compared to a comparison class that does not receive EOtC (N = 26). Furthermore, the publication addresses the question of whether there is a relationship between social interaction and social relatedness (facet of BPN) and friendships. Lastly, the Publication addresses the question of whether certain structures in social networks can be explained by gender or place of residence. For the purpose of the statistical analysis of the social networks, SAOM and ERGM methods were applied in this publication. The results show no consistent and significant differences between both classes in terms of social interaction. Also, there are no correlations between the changes in social interaction, social relatedness, and friendships. In the EOtC class, however, a trend toward group formation is evident. In both groups a strong dependence of gender for the initiation of social interaction is evident. In the case of the EOtC class, this even

leads to a fragmentation of the overall network of social interaction along the gender boundary. In particular, the results regarding the trend towards group formation and the strongly pronounced separation of the genders initially contradict the assumption that the stay in natural areas in general and the implementation of EOtC in particular would lead to a general intensification of social interaction. Explanations for this take into account the fact that EOtC in Germany is often still carried out as an "educational experiment". In the wake of this, the successful teaching of the subject matter is primarily in the foreground in order to justify the continuation of the concept. Supposedly secondary goals, such as mixing up the class, sometimes seem to take a back seat. Thus, it is often left up to the children themselves to decide with whom they work or play. This freedom of choice, which can be seen as positive at first, can contribute to the consolidation of existing contacts and groups. Consequently, it seems necessary, on the one hand, to consider the implemented didactic concepts when looking at results in EOtC, and on the other hand, to develop corresponding concepts in the first place. Only in this way is it possible to transform the favorable conditions of the EOtC into actual effects. The results of this publication contribute to answering the questions 3 and 4 of this dissertation as described in chapter 2.4.

Filip Mess and Christoph Mall conceived, conceptualized and designed the overall study, which was the framework for this publication. Data collection was performed by Jan Ellinger and Christoph Mall. Jan Ellinger and Filip Mess conceptualized the design and assessments for this publication and statistical analysis was performed by Jan Ellinger with the assistance of Joachim Bachner and Christoph Mall. Jan Ellinger prepared the draft of the manuscript; Jakob von Au, Filip Mess, Joachim Bachner, and Christoph Mall made essential comments and substantial revisions to it.

The published full version of the paper follows.



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Changes in social interaction, social relatedness, and friendships in Education Outside the Classroom: A social network analysis

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Introduction: Social interaction is associated with many effects on the psychological level of children such as mental health, self-esteem, and executive functions. Education Outside the Classroom (EOtC) describes regular curricular classes/lessons outside the school building, often in natural green and blue environments. Applied as a long-term school concept, EOtC has the potential to enable and promote social interaction. However, empirical studies on this topic have been somewhat scant.

Methods: One class in EOtC ($N = 24$) and one comparison class ($N = 26$) were examined in this study to explore those effects. *Statistical Actor-Oriented Models* and *Exponential Random Graph Models* were used to investigate whether there are differences between EOtC and comparison class regarding changes over time in social interaction parameters; whether a co-evolution between social interaction during lessons and breaks and attendant social relatedness and friendships exists; whether students of the same gender or place of residence interact particularly often (homophily).

Results: Besides inconsistent changes in social interaction parameters, no co-evolutional associations between social interaction and social relatedness and friendships could be determined, but grouping was evident in EOtC. Both classes showed pronounced gender homophily, which in the case of EOtC class contributes to a fragmentation of the network over time.

Discussion: The observed effects in EOtC could be due to previously observed tendencies of social exclusion as a result of a high degree of freedom of choices. It therefore seems essential that in future studies not only the quality of the study design and instruments should be included in the interpretation – rather, the underlying methodological-didactic concept should also be evaluated in detail. At least in Germany, it seems that there is still potential for developing holistic concepts with regards to EOtC in order to maximize the return on the primarily organizational investment of implementing EOtC in natural environments.

KEYWORDS

Education Outside the Classroom, social interaction, social relatedness, natural environments, social network analysis, children

1. Introduction

Social interaction and peer relations have been a central topic in social and developmental psychology for years (Hartup, 1999; Hay et al., 2018). From this perspective, the crucial role played by social factors in children's development should not be underestimated (Seppala et al., 2013). If the

social needs of children, such as having a sense of connection and building trust in relations with significant others, remain unsatisfied in the long term, this could lead to the development of mental disorders (Pachucki et al., 2015; McNamara et al., 2017). The importance of such skills is also emphasized with regard to 21st century skills (Chalkiadaki, 2018; Hirsh-Pasek et al., 2020; van Laar et al., 2020). Experiencing social situations that contain the potential to develop social skills in children's lives, is therefore of tremendous relevance (Hartup, 1989). School life can be seen as a social situation on both a macro (whole school community) and micro (situation in class) level (Sarason and Klaber, 1985; Ma, 2018). Social psychology pursues the task of looking at and analyzing the connections between social situations shaped by social interaction and individual characteristics, behavior or experiences (Baron et al., 2000). In this context, we understand social interactions to be an active process between individuals on an interpersonal level (Simmel, 2013). From this, according to Ryan and Deci (2017), the passive state of social relatedness (as one of the basic psychological needs assumed to be central for the individual), which alludes to a feeling of belonging, can result. Following this, social relatedness also expresses the perceived connection to other people and, thus, inclusion in a particular group. With that being largely based on a particular individual and non-standardized feeling, other aspects like the number of friends cover solely quantitative impressions of embeddedness in a certain group (Fullerton and Ursano, 1994). Both can be the result of previous social interaction as the core of a social situation, such as school life (Baron et al., 2000).

1.1. Research on social interaction in children

Social interaction is important to various aspects of children's life, such as well-being (Lee et al., 2020) and mental health (Li et al., 2020), self-esteem (Harris and Orth, 2020), learning outcomes (Hurst et al., 2013), and executive functions (Moriguchi, 2014). The school setting provides an extremely valuable platform for observing, analyzing, and affecting social interaction since it represents the most important place for social interaction among young people (McNamara et al., 2017; García-Carrión et al., 2019). Children and adolescents spend a great deal of time here. Additionally, the majority of children can be reached and have the opportunity to participate in certain programs regardless of their background. Furthermore, childhood seems to be particularly suitable for forming social bonds between peers (Gifford-Smith and Brownell, 2003). However, there continues to be a paucity of intervention studies that address all students equally, with the explicit goal of improving social interaction between the students with possible effects on social relatedness and friendships.

In childhood, one's own gender and the gender of peers in particular prove to be significant for socialization and friendships (Maccoby, 1988; Block and Grund, 2014). Confrontation with members of the same gender fulfills various important functions in the development of one's own (gender) identity [as does later confrontation with the other biological gender (depending on sexual orientation); Ridgeway and Smith-Lovin, 1999; Powlishta, 2004; Perry et al., 2019]. During late childhood and early adolescence, a strong tendency for girls to interact more with girls and for boys to interact more with boys is evident (Maccoby, 1988; Shrum et al., 1988). Apart from these tendencies, which are typical in the course of development, the school setting also provides additional opportunities to influence social interaction between students. This could include the creation of special meeting and social

spaces in school, or the implementation of specific social activities. Also, entire teaching concepts could be used in order to influence social interaction. One of those is "Education Outside the Classroom" (EOTC).

1.2. Social interaction in Education Outside the Classroom

EOTC is a teaching concept that is – in line with the curriculum – regularly carried out in a natural or cultural environment. EOTC is often practiced for a duration of several consecutive months and up to whole years or more. In most studies, explicitly investigating EOTC, this concept has to be applied at least bi-weekly for four or more lessons. If EOTC is sustainably established at a school, it can enrich the daily school routine as an applicable long-term concept with manageable extra costs (Bentsen et al., 2009, 2021). EOTC lessons are said to be experimental, student-centered, and there is an increased use of group and partner work (Bentsen et al., 2021; Ellinger et al., 2022b). They lead to higher levels of physical activity (Schneller et al., 2017), especially if they are conducted in natural environments (Bølling et al., 2021), which is in part associated with a healthy pattern of cortisol secretion that indicates less stress over the course of the day (Becker et al., 2019). In addition, it can be assumed, that EOTC promotes intrinsic school motivation (Bølling et al., 2018; Ellinger et al., 2022a) and well-being of the students (Jørring et al., 2019).

Moreover, EOTC offers numerous ways of affecting students' social interaction. Even with regard to natural spaces in themselves, it is worthwhile to consider facets of social interaction from different perspectives (Waite et al., 2016; Torkos, 2017; Roberts et al., 2020). Independently of school lessons, it has occasionally been demonstrated that children's intensive engagement in and with nature in groups (e.g., free outdoor play, adventure therapy, seated relaxation, and orienteering) can improve several social aspects such as mutual trust, social cohesion, social functioning, relationship to peers, and cooperation (Doucette, 2004; Roe and Aspinall, 2011; McArdle et al., 2013; Mygind et al., 2019). The availability of natural spaces in the immediate living environment also seems to be able to influence social factors and consequently health (Faber Taylor et al., 1998; Sugiyama et al., 2008). These different and partly specific outcomes limit the comparability, but in sum, there is a clear tendency that both adults, but also children can benefit from group activities in and with nature with regard to their social skills (Mygind et al., 2019; Fyfe-Johnson et al., 2021). As EOTC often takes place in natural environments, these possible benefits of natural environments are combined with a special teaching situation, enabling substantial restructuring, simplification, and promoting cooperative group work, because rigid structures of traditional school teaching such as a fixed seating and desk arrangement are eliminated. Therefore, EOTC offers specific conditions that may help to improve social relations (e.g., play, interaction, student-centered tasks, and cooperation; Hartmeyer and Mygind, 2016; Glackin, 2018). This produces the result that the lessons often differ significantly from traditional indoor school lessons. Regarding social aspects, previous research has shown that EOTC could lead to more positive peer relations than traditional teaching concepts (Mygind, 2009) and to the development of new positive peer affiliations (Bølling et al., 2019), which could be explained by the character of EOTC (Fägerstam, 2014): In the indoor setting of the classroom, social contacts are often limited to the students sitting near to each other. Since the usual spatial forms of organization are largely absent in EOTC, it can be assumed that other ways of teaching and new social constellations are facilitated, as already shown in surveys regarding social forms in EOTC (Ellinger et al., 2022b), as well as opportunities for informal interaction are

created (Jørring et al., 2019). This could lead to intensified movement in space and its appropriation by the students, especially in group constellations – while teaching the same subject matter as during traditional indoor teaching (Mall et al., 2021). Additionally, it has been shown that curriculum-compliant teaching in natural settings can lead to comparatively increased (facets of) social relatedness (Dettweiler et al., 2017), which could be a result of those new or intensified opportunities for social interaction. Undoubtedly, however, there is still a great demand for further studies on this promising topic (Becker et al., 2017).

The central assumption of this study is that EOTC, due to its integration into natural environments, as well as the utterly changed teaching situation, enables not only the implementation of new forms of social interaction, but also more social interaction. This could be captured by the numerical number of classmates with whom a particular child interacts in the context of school or class. Change in social interaction in turn could have an impact on the experience of social relatedness and friendships. In the present study, we therefore aim to map social relatedness and the structure of friendships in addition to assessing social interaction in the class, which represents a novelty in EOTC. We pursue the approach of viewing these social constructs not as factors or mediators for other behaviors but as the main outcomes, which in this context is still rare. In summary, we hypothesize that the introduction of EOTC in natural environments could lead to intensification and restructuring of the network of social interaction in a school class, which is the main focus in this article. With that, also changes over time in social relatedness, as well as friendships seem reasonable. Furthermore, it seems possible that, due to the preference of same-gender interactions in children and adolescents (Maccoby, 1988; Shrum et al., 1988), gender can also influence their social interaction. This, in turn, is of scientific interest given the relevance of engagement with other genders for child development (Ridgeway and Smith-Lovin, 1999; Perry et al., 2019). Additionally, place of residence could also be relevant. This assumption is partly due to the special situation regarding many secondary schools in Germany: When children move from primary to secondary school, this often involves a change of location, as secondary schools are often located only in (larger) cities, so that children from rural areas have to be transported here. This means that children from different cities and villages come together in secondary school. We assume that children who, for example, move from the same village to the same secondary school at the same time have a closer connection because they share their way to school or they may have already been to elementary school together.

This study aims to investigate the following central hypothesis: (a) The students within a EOTC class show increases in social interaction over time, which go beyond those changes in a comparison class without EOTC. Additionally, this study explores the interrelations of those changes with other social factors. Therefore, two sub-hypotheses are set up: (b) There is a co-evolution of the changes of social interaction and social relatedness and friendships over time in both classes; (c) Gender and place of residence partly explain the positions of actors in the network in both classes.

2. Materials and methods

2.1. Intervention

In this study, a class with EOTC is compared to a class without EOTC. In the following, it is described how EOTC was implemented at the cooperating school and how the environment the EOTC took place at can be characterized. Please see also Table 1 for a detailed schedule of an exemplary EOTC-day.

Although the forest used for the EOTC is accessible from the city and the school within approximately 15–20 min walking distance, it can clearly be classified as a natural space or natural environment following consolidated definitions within the field of outdoor play, learn, and teach (Lee et al., 2022). On the fixed EOTC day during our study, the students and two teachers first met in the school building. There, attendance was checked and, if necessary, important instructions for the day were given. Then, the class set off on foot into the forest. Often the students talked among themselves or with the teachers or played little games on the way there. However, there were no organized activities along the way. After a few meters in the residential area, the path the class used was characterized by agricultural land and open meadows. Once in the forest, the class was divided to be taught initially for two school hours (90 min) in one subject and, after a change of groups, in a second subject (90 min) by the two accompanying teachers. In the case of this investigation, the subjects were German and Biology. The learning site visited in the case of this study is a forest with old trees and unstructured vegetation that, apart from the usual forest management, is left in its natural state. The lessons did not take place in a clearly defined outdoor classroom. Accordingly, there were no benches or a blackboard. The

TABLE 1 Schedule of an exemplary EOTC-day.

Schedule	Content	Environment
7.55–8.15 am	EOTC class and two teachers meet at school; check for attendance; important announcements	School building or grounds
8.15–8.30 am	Walking from school to the natural environments nearby the city	Residential area, agri-cultural land and meadows
8.30–8.35 am	Arrival at forest; class splitting up (half of the class with one teacher each); arrangement of a meeting point	Natural environments like forest, clearings and meadows
8.35–8.45 am	Groups walking to the specific places of teaching; preparation of the teaching materials	
8.45–10.15 am	Teaching in the subject of German or Biology; shorter breaks	
10.15–10.45 am	Walking back to the meeting point; longer break	
10.45–10.55 am	Walking to the specific places of teaching; preparation of the teaching materials	
10.55 am–12.25 pm	Teaching in the subject of German or Biology; shorter breaks	
12.25–12.35 pm	Walking back to the meeting point; check for attendance	Natural environments like forest, clearings and meadows
12.35–12.50 pm	Walking back to school together (whole class with both teachers)	Residential area, agri-cultural land and meadows
Approx. 12.55 pm	Official closing of the school day	School grounds

lessons were realized in different places where the children sat or stood on tree trunks or on the ground and it was the responsibility of the respective teacher how he or she organizes the lesson – e.g., whether movement breaks were specifically built in or special social forms were used. After those two different lessons, the group walked back to the school building together, where the school day ends.

2.2. Participants and procedure

Two fifth-grade classes of a German public school participated in this study ($N=50$). The school cooperating in this study has one fifth-grade class that received at least 4 h of curriculum-compliant schooling in the nearby forest [EOtC class; $n=24$ (female = 45.8%)] for the whole school year at one fixed day of the week (first year of conducting EOtC at that school). The comparison class [$n=26$ (female = 46.2%)] received only indoor teaching. Students of the EOtC class came from five different places of residence in and around the city where the school is located. In the comparison class, there were six different places of residence. Since the class assignment depends on the registration of the parents of their children in the respective class, no randomization could be carried out. We conducted our surveys at this school at two time points during the 2019/2020 school year: One month after the beginning of the school year (to wait for a certain period of acclimatization in the new class at the beginning) (T1) and after 5 months (T2). Due to the pandemic-related school closures, the planned third time point at the end of the school year could not take place. This article is part of a larger research project.¹ First results concerning school motivation, health-related quality of life, and the satisfaction of basic psychological needs are published elsewhere (Ellinger et al., 2022a). The differences in the sample size of the two studies result from different methods applied in both studies. The partial secondary analysis of basic psychological needs (social relatedness) is based on the different research questions of the articles.

2.3. Instrumentation

2.3.1. Social interaction

We developed our own questionnaire to collect data on social networks, following common practices (Borgatti et al., 2018). The questionnaire contained two different initial questions and a class list for each question. The students were asked to tick all the students on the lists to whom the initial questions applied. The questions asked were: (a) *With whom do you regularly learn and work during the lessons?* (b) *With whom do you regularly play during the school breaks?* For the EOtC class, the questions were phrased to refer explicitly to EOtC, the comparison class answered the questions in terms of normal indoor lessons. We understand these questions to represent social interaction and act as the basis for our network data (network questions).

2.3.2. Social relatedness

We used a German translation of the *Basic Psychological Needs Scale* (BPNS; La Guardia et al., 2000; Hanfstingl et al., 2010) to assess social relatedness using a 5-point Likert scale (e.g., *I have a good relationship*

with my classmates). Social relatedness (Cronbach's $\alpha=0.77$) is one of the subscales of the BPNS; the results of the other subscales were not of interest for the present analysis and were therefore not included in the analysis. The factorial validity of the BPNS and its subscales has been frequently addressed in the past and is in general well-supported both theoretically and statistically [CFI (comparative fit index), TLI (Tucker-Lewis index) >0.95 ; Deci and Ryan, 2000; Wang et al., 2019]. Following the recommendations by the authors of the statistical method used (cf. the following chapter *Statistical data analysis*), the raw values of social relatedness were divided into seven even categories (Nynke et al., 2019).

2.3.3. Friendships

We also asked the students which of their classmates they would describe as a friend. With this information, we calculated the total number of friends (friendships) and the proportion of mutually declared friendships (mutual friendships). We divided those into three categories (1 = one is nominated as a friend by more than 20% more classmates than the other way around [meaning, the corresponding person is perceived as a friend by more classmates, as he or she would refer to as a friend], 2 = one is nominated as a friend by about as many [+/- 20%] classmates as the other way around, 3 = one is nominated as a friend by more than 20% less classmates as the other way around). With that, we managed to receive three groups about the same size. This categorization is not intended to indicate a qualitative classification but to facilitate the interpretation of the results.

We consider, that social relatedness and (mutual) friendships complement each other to capture an overall impression of perceived embeddedness in the social structure of the class: One representing more the feeling of inclusion, independent of the number of personal contacts (social relatedness) and one the quantitative measurement of the number of a certain type of social reference persons (friendships). In addition, we assessed the age, gender, and place of residence of the participants in a demographic questionnaire.

2.4. Statistical data analysis

In our analysis, the relationship structures generated from the answers to the network questions represent the networks themselves. This means that if person A has indicated that he or she works together with person B during lessons, there is a connection (edge) between person A and B (nodes) in the logic of a network. Thus, a network for the whole class results from the totality of the answers of all students. We treat social relatedness and (mutual) friendships as dynamic attributive variables of the students while defining gender and place of residence as static attributes and covariates. We set up four models, two models each for the EOtC and comparison class representing the two network questions regarding interaction during lessons and breaks.

There are currently two different main approaches for the purpose of statistical network analysis. "Random Exponential Graph Models" (ERGMs) are well-suited to test for the randomness of realized connections in a cross-sectional network analysis (Shumate and Palazzolo, 2010). This means that ERGMs check whether connections in the overall network occur particularly frequently between persons who have the same characteristic of interest (e.g., gender). "Stochastic Actor-Oriented Models" (SAOMs) are feasible for longitudinal network data combined with additional dynamic variables (Ripley et al., 2012). SAOMs therefore combine ERGMs with a temporal component that can also determine randomness (or over-randomness) of connections over

¹ <https://osf.io/6unbf>

a certain period of time. Compared to ERGMs with temporal extension, SAOMs have certain advantages and disadvantages, the relevance of which depends on the type of data collected (Block et al., 2019).

For our analysis of hypotheses (a) and (b), we used the R-package *RSiena* for constructing SAOMs. As key-figures in order to address hypothesis (a), we calculated density, diameter, clustering coefficients, and similarity index. Those are central metrics for gaining an impression of the overall constitution of a network. Since the two classes are almost identical in size and also largely homogeneous in terms of age and gender composition, these parameters can subsequently also be used to compare the results of the EOtC class with the comparison class. We assume that the inclusion of different parameters allows a deeper understanding of the network structures in comparison if only a single metric would be included. To address hypothesis (b), co-evolutional associations (degree and dense triads) were tested. We checked whether the number of the realized edges of a person (degree) correlates with the calculated value of social relatedness and the number of friendships over time. Please see Table 2 or respective basic literature (e.g., Luke, 2015) to clarify these key terms in interpreting social networks. In network analysis, hypotheses like hypothesis (c) are referred to as “homophily” hypotheses, as they test whether nodes that share the same characteristics in relevant aspects (in our case: characteristics of gender and/or place of residence) tend to interact more closely or more often. To address hypothesis (c), we constructed ERGMs using the R-package *ergm* (Hunter et al., 2008). We conducted separate analyses for T1 and T2.

3. Results

In terms of density, a strong decrease in social interaction during lessons from T1 (0.26) to T2 (0.22) can be observed in the EOtC class (cf. Table 3), which runs contrary to hypothesis (a) and the trends in the comparison class (T1: 0.2; T2: 0.22). However, a strong increase in density is observed concerning social interaction during breaks from T1 (0.3) to T2 (0.36) in the EOtC class, whose relevance is also underlined by statistical significant results of the SAOM analysis regarding associations over time [cf. Table 4 ($\beta = -1.02$; $SE = 0.53$; $p < 0.05$)]. The values in the comparison class regarding social interaction during breaks drop slightly (T1: 0.33; T2: 0.31). Measured by the Jaccard similarity index (Snijders et al., 2010), both groups show moderate stability over time in the respective forms of interaction. There is an apparent network fragmentation in social interaction both during lessons and during breaks, which complicates the interpretation of the diameter and the clustering coefficients (Luke, 2015). Please see the up-coming section regarding gender homophily for more information on those fragmentations.

In calculating the models concerning hypothesis (b), excellent t-ratios as an indicator for convergence of the models were found in 72.2% of the calculated effects, 27.8% have to be described as reasonable based on established recommendations with no specific pattern occurring (Ripley et al., 2012). In our analysis, we found initial evidence that in EOtC, measured by transitivity, there is a structural tendency to form groups concerning social interaction during lessons ($\beta = 0.27$; $SE = 0.13$; $p < 0.05$) and breaks ($\beta = 0.54$; $SE = 0.23$; $p < 0.05$) over time, as

TABLE 2 Central terms in the interpretation of a social network and their meaning.

Term	Meaning
Degree	The degree indicates how many connections a node/actor in total has to others in the network. In most networks, a higher degree is considered better because it increases integration in the network. This has to be assessed differently if the recorded interaction is classified as negative (e.g., bullying). Whether, in our case, higher degree is also associated with higher social relatedness (and thus would be considered clearly positive) is to be tested in our study.
Density	The density of a network indicates the proportion of how many of the maximum possible connections are realized between the nodes/actors. As a result, possible values range from 0 to 1. These are not standardized values, so a difference of 0.2 should be interpreted differently in a particularly dense network (e.g., insults between siblings) than in less dense networks (e.g., insults between work colleagues). Similar to the degree, a higher density is desired in most cases and can, therefore, be classified as better. In our case, the classification as “good” for a higher density depends, analogously to degree, on its associations with further parameters.
Diameter	For a network, it is important how many intermediate steps (other nodes/actors) connect each node/actor to every other node/actor, whereby a small number is considered as better. In order to determine the diameter of a network, a two-step procedure is followed. For every actor, the minimal distances (via the existing edges) to reach each of the other actors are identified. The longest of these minimal distances then represents the diameter. Since this is about absolute and not relative numbers, a comparison only makes sense if the networks to be compared have (roughly) the same number of nodes/actors. In our case, for example, a lower diameter could imply that lesson-relevant information reaches all students more quickly.
Clustering coefficient, transitivity, and dense triad	The calculation of clustering coefficient, transitivity, and dense triads provides information (probability between 0 and 1) about whether the nodes/actors in a network tend to form groups (meaning: A being connected with B and C also implies a high probability of B being connected with C). High values indicate that there is increased clique or triad formation. Depending on the background of the network, this can be assessed as positive or negative. As the children in the EOtC are able to interact more freely with each other, it seems possible that this will either lead to the strengthening of existing groups or to a break-up of them. It is important to note that the calculation of the clustering coefficient (based on clustering for each node) on the one hand and transitivity and dense triads (proportion of triangles compared to total number of connected triples), despite their similarity, can show different values and even different tendencies.
Similarity index	Corresponding values provide information about how similar two networks are. The possible values range from 0 (no similarity) to 1 (identical networks). This could mean two networks of different groups or, like in our case, the same network at two different time points. In that case, one could also talk about a “stability index.” While the density only allows a statement to be made about the proportion of realized connections, the similarity index also considers whether the same nodes/actors remain directly connected over time. Thus, it is possible to have an unchanged density and low similarity at the same time. Therefore, similarity index and density represent important complementary indicators.

also illustrated by the results in Table 4. Given the other results presented, our analysis cannot confirm the existence of co-evolutional associations between the two forms of social interaction on the one hand and social relatedness and (mutual) friendships on the other. Our results, as shown in Table 4, suggest that models 3 and 4 (comparison class) show higher standard errors than models 1 and 2 (EOtC class).

Looking at gender homophily regarding hypothesis (c), strong associations for social interaction during the lessons at T1 within students of the same gender are apparent for EOtC class ($\beta=3.85$; $SE=0.43$; $p<0.001$). For comparison group, that is evident for both during-lesson and during-break social interaction and both time points (Lessons T1: $\beta=2.82$; $SE=0.32$; $p<0.001$; Lessons T2: $\beta=2.81$; $SE=0.3$;

$p<0.001$; Breaks T1: $\beta=3.50$; $SE=0.28$; $p<0.001$; Breaks T2: $\beta=3.53$; $SE=0.29$; $p<0.001$). This is also illustrated in Figures 1 (social interaction during lessons), 2 (social interaction during breaks). Please also see Table 5 for the full results. The EOtC class shows several times that a calculation of gender homophily is not possible. This is because the corresponding networks fragment, and none of these fragments show more than one characteristic – in this case, gender (cf. Figures 1, 2). This means that the formerly connected network of the whole class has become two separate networks – one consisting only of boys, one only of girls. In substance, this is to be evaluated as evidencing even stronger homophily than could be expressed by statistical significance. This also applies to the results regarding hypothesis (a) presented above.

TABLE 3 Network parameters.

Education Outside the Classroom					Comparison				
	Density	DM	CC	JSI		Density	DM	CC	JSI
Model 1 (Lessons)					Model 3 (Lessons)				
T1	0.26	6	0.67			0.20	5	0.47	
T2	0.22	X/3*	0.56			0.22	5	0.41	
				0.467					0.448
Model 2 (Breaks)					Model 4 (Breaks)				
T1	0.30	X/3*	0.74			0.33	4	0.64	
T2	0.36	X/3*	0.84			0.31	4	0.68	
				0.655					0.522

Density (Density), diameter (DM), clustering coefficient (CC) and Jaccard similarity index (JSI) for both groups (Education Outside the Classroom, Comparison) at different time points (T1, T2); Models 1 and 3 concern the interaction during the lesson, models 2 and 4 the interaction during the breaks in the corresponding group. *In the case of fragmentation of the corresponding network (X), the diameter of the largest fragment was calculated instead.

TABLE 4 Results of testing for structural effects and co-evolutional associations over time.

Education Outside the Classroom					Comparison				
		β	SE	p			β	SE	p
Model 1 (Lessons)					Model 3 (Lessons)				
	Transitivity	0.27	0.13	*		Transitivity	0.34	0.26	–
	Density	–1.02	0.53	–		Density	1.06	0.62	–
SR	Degree	0.34	0.70	–	SR	Degree	–0.33	1.19	–
	Dense Triads	–0.12	0.18	–		Dense Triads	0.19	0.80	–
Friends	Degree	0.02	0.21	–	Friends	Degree	0.01	0.44	–
	Dense Triads	0.01	0.05	–		Dense Triads	–0.01	0.21	–
MFC	Degree	–0.11	0.40	–	MFC	Degree	–0.35	3.76	–
	Dense Triads	0.06	0.20	–		Dense Triads	0.49	2.78	–
Model 2 (Breaks)					Model 4 (Breaks)				
	Transitivity	0.54	0.23	*		Transitivity	0.38	0.58	–
	Density	1.88	0.43	*		Density	–1.68	1.59	–
SR	Degree	0.53	0.51	–	SR	Degree	0.50	4.05	–
	Dense Triads	–0.11	0.08	–		Dense Triads	–0.14	0.89	–
Friends	Degree	0.53	1.13	–	Friends	Degree	0.04	0.74	–
	Dense Triads	–0.09	0.23	–		Dense Triads	–0.01	0.33	–
MFC	Degree	0.61	3.96	–	MFC	Degree	0.74	5.33	–
	Dense Triads	–0.16	0.91	–		Dense Triads	–0.06	1.95	–

SR, social relatedness; Friends, friendships; MFC, mutual friends category for both groups (Education Outside the Classroom, Comparison); β = Estimates; SE= Standard error; p= Significance at the corresponding level (* < 0.05); Models 1 and 3 concern the interaction during the lesson, models 2 and 4 the interaction during the breaks in the corresponding group.

In the case of residence, significant associations emerge only in the comparison class concerning social interaction during lessons at T2 ($\beta=0.68$; $SE=0.25$; $p<0.01$).

4. Discussion

Without a doubt, EOTC must be seen as an investment and not a matter of course in the context of traditional public schools in Germany. This concerns only secondarily financial aspects, but primarily an organizational investment. In sum, the school and the teachers involved have to invest time (e.g., adapting the lessons to the new learning location and travel times) and teaching load (often two teachers for one class) in order to implement the concept. The possible outcomes – or return-on-investments – are, in the best case, positive changes in students and/or teachers. These could relate to learning, health, environmental behavior and much more (Becker et al., 2017). Whether the return on organizational investment is sufficient to justify the concept is at the discretion of the school and the actual effort involved in implementing it. As classroom processes as well as social interaction were only rarely focused on in research on EOTC, we contribute to a deeper understanding of those with the results of our social network analysis. We will discuss those results and how to increase the return-on-investments in EOTC, as well as point out future research implications based on learnings from this study.

4.1. Changes in social interaction

Since we observed a decrease in density regarding social interaction during lessons over time in EOTC, but an increase in social interaction during breaks and exactly the opposite tendencies in the comparison class, no clear pattern in favor of the EOTC class can be derived from the present models. The observed trends in the EOTC lessons are surprising considering the existing literature on the influence of natural environments in general and EOTC in particular on social facets (Bolling et al., 2019; Putra et al., 2020). The observed increase in density in social interaction during the breaks in EOTC initially underlines opinions that are based on the assumption that free play in natural spaces positively influences children's cooperation (Tremblay et al., 2015). Based on the values of the clustering coefficients (cf. Table 3) and longitudinal transitivity results (cf. Table 4), there appears to be a substantial degree of grouping in the EOTC class. This is in line with previous impressions of social exclusion in EOTC in qualitative studies (Jørring et al., 2019). Previous studies also indicated that existing or missing didactical concepts or guidelines should be taken into account when interpreting results with regard to EOTC in any case (Mygind, 2009; Hartmeyer and Mygind, 2016). Following this, in this case, processes could even occur that favor segregation: EOTC is at least in Germany a relatively new concept, and often initiated as an "educational experiment." This often leaves teachers with some uncertainties (Barfod, 2018), which could also apply to this case as the studied school year was the first-ever with EOTC being implemented at our cooperation school. Accordingly, the focus is often on the successful delivery of the lesson and less on the targeted mixing of the class. This in turn could lead to teachers leaving the children to organize themselves into groups, which could result in certain group structures being strengthened and established even more, rather than promoting the formation of new interactions. In this respect, a comparison can certainly be drawn with the situation of young teachers in the transition from the "Referendariat" (final practical part of

teacher training in Germany) to actual teaching work in the school. Here, too, it can be observed that disruptions (which do occur frequently in reality) of the ideal-typical lesson lead to a focus on the superordinate organization of the school lesson and that desirable didactic requirements (e.g., the promotion of social exchange) are pushed into the background. Consequently, the implementation of these would only be sought again when a certain level of self-confidence in teaching is perceived by the teacher (Miethling, 1986). Teachers may face a similarly new situation when they take the step of implementing EOTC for the first time. Therefore, it remains to be noted that even in a teaching concept that, like EOTC, makes it increasingly easy to use cooperative forms of learning, the integration of possible outsiders does not happen naturally. This conclusion is also in line with other empirical findings and theoretical considerations regarding integration and inclusion in schools (Koster et al., 2009).

In summary, it can be stated that despite the (partly) high organizational investments and the favorable framework conditions in a natural environment, it is not given that expected effects will actually occur. With regard to increases in social interaction, we consider nature-based learning to be a great opportunity, but we also point out the necessity that concepts such as EOTC are not "self-propelling," but also require concrete didactic-pedagogical principles and guidelines.

4.2. Interrelations with other social factors

In this study, we considered the relationships between social interaction and two social facets that have manifold relevance at the psychosocial level but differ in their substantive meaning: Social relatedness as a highly individual and non-standardized feeling of inclusion in the class on the one hand and the number of (mutual) friendships as a purely quantitative representation of social contacts (of outstanding importance) on the other hand. Contrary to hypothesis (b), there are no indications based on our analysis for a substantial co-evolution between the network parameters of social interaction and social relatedness and (mutual) friendships. Thus, the analysis of our sample does not immediately imply that there is a direct association between social interaction and, for example, perceived social relatedness on an individual level over time. Those results apply for both groups. The first network question particularly targeted classroom interaction during the lessons, which can be understood as social interaction. However, social interaction during lessons may be much more related to learning or academic effects than to psychosocial effects such as social relatedness. Suppose one were to understand this question more as an inquiry into cooperative learning in the classroom. In that case, a variety of possible effects on facets of school motivation, cognitive activation, and academic comprehension in students could be identified from empirical research (Gillies and Ashman, 2000; Hänze and Berger, 2007; Fernandez-Rio et al., 2017), but only very rarely on social facets such as bullying (Van Ryzin and Roseth, 2018). Nevertheless, based on previous research we assumed that those cooperative forms of learning might affect social factors (Roseth et al., 2008). In the future, it should be carefully considered which processes the asked questions explicitly address and with which other parameters an association seems possible. However, this explanatory approach does not apply to the social interaction during breaks, as we suspected playing with peers to be fundamentally relevant to social relatedness – a field of research that still offers great potential for future studies. Unfortunately, we do not have any information on how the breaks were organized in the EOTC and the comparison class, which makes

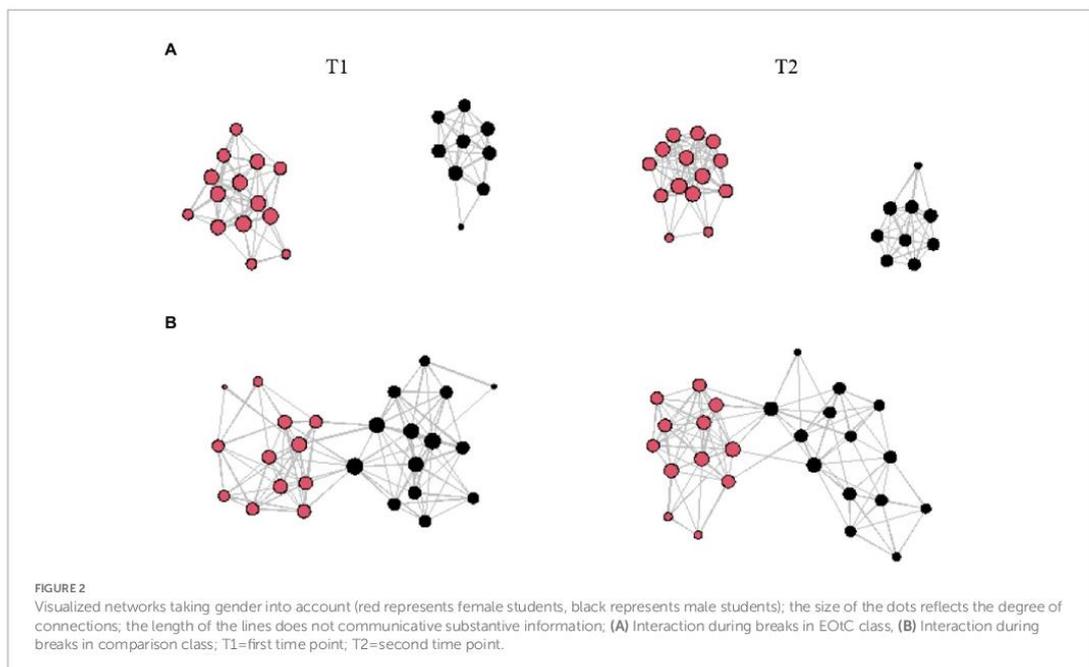
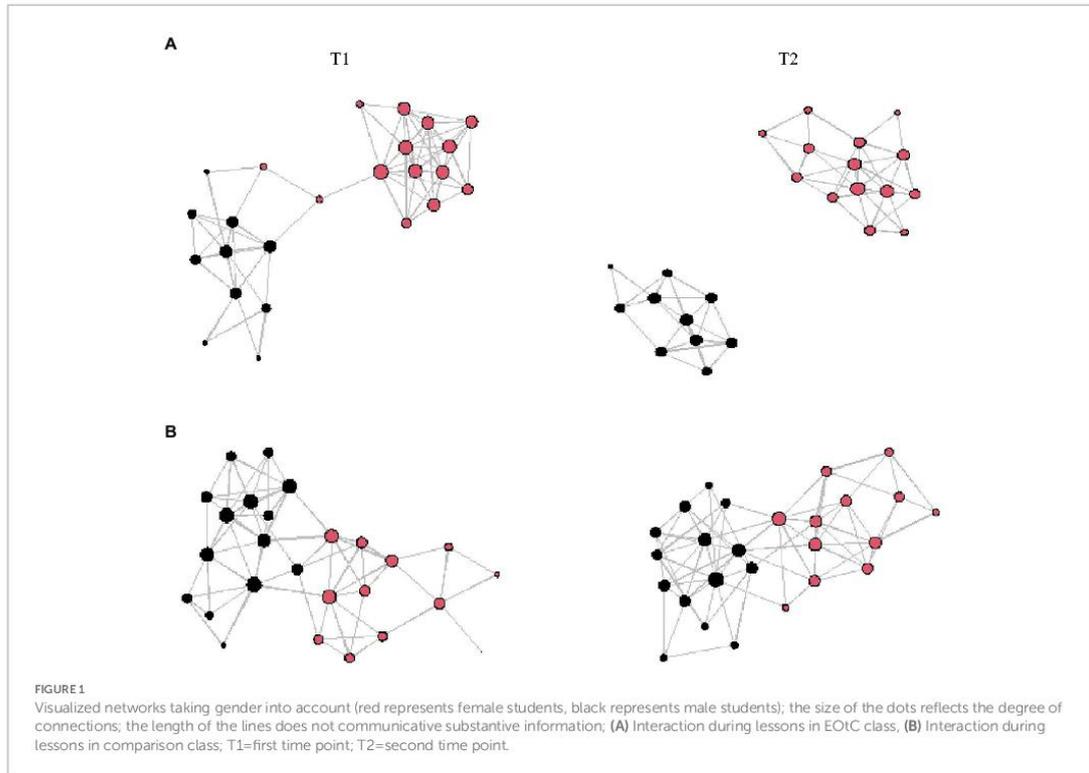


TABLE 5 Results of testing for homophily effects.

Education Outside the Classroom					Comparison			
		β	SE	<i>p</i>		β	SE	<i>p</i>
Model 1 (Lessons)					Model 3 (Lessons)			
T1	Gender	3.85	0.43	***	Gender	2.82	0.32	***
	Residence	0.26	0.25	-	Residence	0.27	0.28	-
T2	Gender	X	X	X	Gender	2.81	0.3	***
	Residence	-55.8	-2.77	-	Residence	0.68	0.25	**
Model 2 (Breaks)					Model 4 (Breaks)			
T1	Gender	X	X	X	Gender	3.50	0.28	***
	Residence	0.12	0.24	-	Residence	-0.32	0.26	-
T2	Gender	X	X	X	Gender	3.53	0.29	***
	Residence	-0.15	0.24	-	Residence	-0.09	0.26	-

Gender and place of residence (Residence) for both groups (Education Outside the Classroom, Comparison) at different time points (T1, T2); β , estimates; SE, standard error; *p*=Significance at the corresponding levels (Codes: *** < 0.001; ** < 0.01; * < 0.05); Models 1 and 3 concern the interaction during the lesson, models 2 and 4 the interaction during the breaks in the corresponding group; X=Not possible to calculate a value for the class as a whole because of fragmentation of the corresponding network.

further explanations very difficult. Such a classification and description of the social situation should be enabled and considered in future studies.

Concerning hypothesis (c), the results indicate strong gender homophily in both groups for both forms of social interaction, which in the case of the EOTC class even seems to be causal for a fragmentation of the network (cf. Figures 1, 2). In general, these results are in line with earlier findings suggesting the importance of having the same gender for the initiation of friendship relationships in childhood and adolescence (Shrum et al., 1988; Block and Grund, 2014). Similar results of the comparison class point to distinctive homophily concerning gender in both forms of social interaction. However, in contrast to the EOTC class, this does not lead to network fragmentation. On the contrary: An increase in the density of social interaction in the comparison class can be observed during lessons, even if corresponding intensifications could not be proven for social interaction during the break. One possible reason for this could be the character of the comparison class. It is for this class to get 45 more minutes of physical education (PE) per week than the other classes, as this class is part of a special school program (PE-profile). This additional lesson of PE was conducted co-educationally, meaning mixed between genders, in contrast to the regular PE lessons. Earlier, the mixing of genders in PE was discussed as being worthwhile (Hills and Croston, 2012), even though a solid scientific basis on the influence of a co-educational approach on social interaction is still lacking. However, it is also explicitly anchored in the curriculum and pedagogical paradigm in the region of our cooperation school that co-educational PE should be utilized to promote gender interaction (Ministerium für Kultus, Jugend und Sport Baden-Württemberg [Ministry of Education, Youth and Sports Baden-Württemberg], 2016). The observed tendency for the genders to be more closely intertwined in the comparison class may be due to this pedagogical paradigm. An equivalent claim of gender interaction does not yet exist for EOTC. Instead, a similar mechanism could come into play here as it has been cited for the changes in social interaction before. The teachers' focus at our cooperation school might have been primarily on the successful delivery of the lessons. This may have led to students organizing themselves in the context of group work, for example. This, in turn, may have consolidated already existing groups, as reflected in the results of this study as well as a study by Jørring et al. (2019).

It also seems conceivable that the observed effects of homophily with respect to place of residence in the comparison class are due to their

affinity for sports: Often, students in PE-profile classes have a relevant sports biography – e.g., many years of membership in sports clubs – as they or their parents actively opt for that school profile. Given the described considerations regarding a closer relationship of the students who come from the same village and possibly already interacted with each other in sports clubs there, these effects could be due to this and apply more to the students within the comparison class.

4.3. Limitations and future research implications

We examined EOTC in natural environments as a feasible long-term concept in terms of different facets of social interaction as outcomes. With that, new insights could be gained for research in this area. Subsequent investigations should be aware of and address the limitations and learnings derived from this study. In this study we compared the results of the EOTC class with those of a comparison group that has special characteristics (PE-profile), which offers additional approaches for the interpretation of the results. In the future nevertheless, it would be worthwhile to proceed in a similar way with a real non-treatment group. Second, the sample size must be considered small, which could be the reason for the variance in the level of standard error when comparing the models. However, in this context (examination of complete and closed school classes), it can also only be expanded to a limited extent. It should therefore be examined which strategies exist to enlarge the sample or which statistical approaches could be considered in the future to compensate for this weakness [e.g., Bayesian estimations (Farine and Strandburg-Peshkin, 2015)]. In addition, there are the previously described concerns about the validity of the network questions. Pilot testing could help remedy this in the future. Finally, consideration should also be given to whether certain network data (e.g., social interaction during lessons) could be collected more objectively, for example, through observations by an external person or by electronic sensors. This would help to avoid possible bias due to social desirability. A comparison of this data with qualitative interview data would offer the chance of great insights – e.g., whether the observed developments from the perspective of the teachers are due to the strong influence of individuals or tendencies of the entire

group. In particular, observations would also include the opportunity to test the assumptions about the organization of the school hours (e.g., for example, the use of certain social forms in the EOtC). In a larger follow-up study, consideration should also be given to grading the networks' interactions in terms of intensity, frequency, and reciprocity.

5. Conclusion

There is no doubt that both natural environments and the characteristics of EOtC concepts itself make it possible to realize new and intensified forms of social interaction. However, based on our results, but also those of previous research, it also appears that this realization and intensification of social interaction because of EOtC should not be mistakenly assumed as an automatism. On the contrary, under certain circumstances, the frequently observed and praised freedom of choice for students in EOtC or other nature-based educational and learning concepts might lead to a solidification of existing contacts and groups, as well as the social exclusion of individuals. From our perspective, in addition to the need for methodologically well-constructed research, there is also a high demand for the development and evolution of specific didactic frameworks for EOtC and other nature-based forms of teaching and learning. In countries in which EOtC historically and currently plays a larger role (especially in Scandinavia), corresponding concepts have already been adopted in ministerial recommendations. In other countries such as Germany, where the concept is still rarely used, there is a lack of such. Last but not least, the example of the PE-profile shows that objectives that go beyond academic learning—e.g., in terms of social factors—can be effectively anchored in official recommendations. Only under these conditions there seems to be a possibility that EOtC as a social situation in natural environments can unfold its full potential in terms of social interaction and thus hold a return on investment that justifies a consequent dissemination of the concept.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

References

- Barfod, K. S. (2018). Maintaining mastery but feeling professionally isolated: experienced teachers' perceptions of teaching outside the classroom. *J. Adv. Educ. Outdoor Learn.* 18, 201–213. doi: 10.1080/14729679.2017.1409643
- Baron, R., Byrne, D., and Suls, J. (2000). *Exploring Social Psychology*. Boston: Allyn and Bacon.
- Becker, C., Lauterbach, G., Spengler, S., Dettweiler, U., and Mess, F. (2017). Effects of regular classes in outdoor education settings: a systematic review on students' learning, social and health dimensions. *Int. J. Environ. Res. Public Health* 14:485. doi: 10.3390/ijerph14050485
- Becker, C., Schmidt, S., Neuberger, E., Kirsch, P., Simon, P., and Dettweiler, U. (2019). Children's cortisol and cell-free DNA trajectories in relation to sedentary behavior and physical activity in school: a pilot study. *Front. Public Health* 7:26. doi: 10.3389/fpubh.2019.00026
- Bentsen, P., Mygind, L., Elsberg, B., Nielsen, G., and Mygind, E. (2021). Education outside the classroom as upstream school health promotion: 'adding-in' physical activity into children's everyday life and settings. *Scand. J. Public Health* 50, 303–311. doi: 10.1177/1403494821993715
- Bentsen, P., Mygind, E., and Randrup, T. B. (2009). Towards an understanding of udeskole: education outside the classroom in a Danish context. *Education* 37, 29–44. doi: 10.1080/03004270802291780
- Block, P., and Grund, T. (2014). Multidimensional homophily in friendship networks. *Netw. Sci.* 2, 189–212. doi: 10.1017/nws.2014.17
- Block, P., Stadtfeld, C., and Snijders, T. A. B. (2019). Forms of dependence: comparing SAOMs and ERGMs from basic principles. *Sociol. Methods Res.* 48, 202–239. doi: 10.1177/0049124116672680
- Bølling, M., Mygind, E., Mygind, L., Bentsen, P., and Elsberg, P. (2021). The association between education outside the classroom and physical activity: differences attributable to the type of space? *Children* 8:486. doi: 10.3390/children8060486
- Bølling, M., Otte, C. R., Elsberg, P., Nielsen, G., and Bentsen, P. (2018). The association between education outside the classroom and students' school motivation: results from a one-school-year quasi-experiment. *Int. J. Educ. Res.* 89, 22–35. doi: 10.1016/j.ijer.2018.03.004
- Bølling, M., Pfister, G. U., Mygind, E., and Nielsen, G. (2019). Education outside the classroom and pupils' social relations? A one-year quasi-experiment. *Int. J. Educ. Res.* 94, 29–41. doi: 10.1016/j.ijer.2019.02.014
- Borgatti, S. P., Everett, M. G., and Johnson, J. C. (2018). *Analyzing Social Networks*. Thousand Oaks: Sage Publications.
- Chalkiadaki, A. (2018). A systematic literature review of 21st century skills and competencies in primary education. *Int. J. Instr.* 11, 1–16. doi: 10.12973/iji.2018.1131a
- Deci, E., and Ryan, R. (2000). The "what" and "why" of goal pursuits: human needs and the self-determination of behavior. *Psychol. Inq.* 11, 227–268. doi: 10.1207/S15327965PLI1104_01

Ethics statement

The studies involving human participants were reviewed and approved by Technical University of Munich (Institute of Medicine). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

The study was designed by FM and CM. Data collection was performed by JE and CM. Statistical analysis was performed by JE with the assistance of JB and CM. JE prepared the draft of the manuscript. JA, FM, JB, and CM made essential comments and substantial revisions to it. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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- Dettweiler, U., Lauterbach, G., Becker, C., and Simon, P. (2017). A Bayesian mixed-methods analysis of basic psychological needs satisfaction through outdoor learning and its influence on motivational behavior in science class. *Front. Psychol.* 8:2235. doi: 10.3389/fpsyg.2017.02235
- Doucette, P. A. (2004). Walk and talk: an intervention for behaviorally challenged youths. *Adolescence* 39, 373–388.
- Ellinger, J., Mess, F., Blaschke, S., and Mall, C. (2022a). Health-related quality of life, motivational regulation and basic psychological need satisfaction in education outside the classroom: an explorative longitudinal pilot study. *BMC Public Health* 22:49. doi: 10.1186/s12889-021-12450-9
- Ellinger, J., von Au, J., Bernhardt, L., Singer, M., Tangerding, S., and Mall, C. (2022b). Eine Frage der Perspektive: die Unterrichtssituation im Draußenunterricht [A matter of perspective: the classroom situation in outdoor education]. In: Au, J. von and R. Jucker (eds). *Draußenlernen Neue Forschungsergebnisse und Praxiseinblicke für eine Bildung für nachhaltige Entwicklung [Outdoor Learning New Research Findings and Practical Insights for Education for Sustainable Development]*. Bern: hep. 387–406.
- Faber Taylor, A., Wiley, A., Kuo, F., and Sullivan, W. (1998). Growing up in the inner city. Green spaces as places to grow. *Environ. Behav.* 30, 3–27. doi: 10.1177/0013916598301001
- Fägerstam, E. (2014). High school teachers' experience of the educational potential of outdoor teaching and learning. *J. Adv. Educ. Outdoor Learn.* 14, 56–81. doi: 10.1080/14729679.2013.769887
- Farine, D., and Strandburg-Peshkin, A. (2015). Estimating uncertainty and reliability of social network data using Bayesian inference. *R. Soc. Open Sci.* 2:150367. doi: 10.1098/rsos.150367
- Fernandez-Rio, J., Sanz, N., Fernandez-Cando, J., and Santos, L. (2017). Impact of a sustained cooperative learning intervention on student motivation. *Phys. Educ. Sport Pedagog.* 22, 89–105. doi: 10.1080/17408989.2015.1123238
- Fullerton, C. S., and Ursano, R. J. (1994). Preadolescent peer friendships: a critical contribution to adult social relatedness? *J. Youth Adolesc.* 23, 43–63. doi: 10.1007/BF01537141
- Fyfe-Johnson, A., Hazlehurst, M., Perrins, S., Bratman, G., Thomas, R., Garrett, K., et al. (2021). Nature and children's health: a systematic review. *Pediatrics* 148:e2020049155. doi: 10.1542/peds.2020-049155
- García-Carrión, R., Villarejo-Carballedo, B., and Villardón-Gallego, L. (2019). Children and adolescents mental health: a systematic review of interaction-based interventions in schools and communities. *Front. Psychol.* 10:918. doi: 10.3389/fpsyg.2019.00918
- Gifford-Smith, M. E., and Brownell, C. A. (2003). Childhood peer relationships: social acceptance, friendships, and peer networks. *J. Sch. Psychol.* 41, 235–284. doi: 10.1016/S0022-4405(03)00048-7
- Gillies, R. M., and Ashman, A. F. (2000). The effects of cooperative learning on students with learning difficulties in the lower elementary school. *J. Spec. Educ.* 34, 19–27. doi: 10.1177/002246690003400102
- Glackin, M. (2018). 'Control must be maintained': exploring teachers' pedagogical practice outside the classroom. *Br. J. Sociol. Educ.* 39, 61–76. doi: 10.1080/01425692.2017.1304204
- Hanfingling, B., Andreitz, I., Müller, F. H., and Thomas, A. (2010). Are self-regulation and self-control mediators between psychological basic needs and intrinsic teacher motivation? *J. Educ. Res. Online* 2, 55–71. doi: 10.25656/01:4575
- Hänze, M., and Berger, R. (2007). Cooperative learning, motivational effects, and student characteristics: an experimental study comparing cooperative learning and direct instruction in 12th grade physics classes. *Learn. Instr.* 17, 29–41. doi: 10.1016/j.learninstruc.2006.11.004
- Harris, M. A., and Orth, U. (2020). The link between self-esteem and social relationships: a meta-analysis of longitudinal studies. *J. Pers. Soc. Psychol.* 119, 1459–1477. doi: 10.1037/pspp0000265
- Hartmeyer, R., and Mygind, E. (2016). A retrospective study of social relations in a Danish primary school class taught in 'u deskolē. *J. Adv. Educ. Outdoor Learn.* 16, 78–89. doi: 10.1080/14729679.2015.1086659
- Hartup, W. W. (1989). Social relationships and their developmental significance. *Am. Psychol.* 44, 120–126. doi: 10.1037/0003-066X.44.2.120
- Hartup, W. W. (1999). "Peer experience and its developmental significance," in *Developmental Psychology: Achievements and Prospects*, ed. M. Bennett (Hove: Psychology Press), 106–125.
- Hay, D. F., Caplan, M., and Nash, A. (2018). "The beginnings of peer relations," in *Handbook of Peer Interactions, Relationships, and Groups*, eds. W. Bukowski, B. Laursen and K. Rubin (New York City: The Guilford Press), 200–221.
- Hills, L. A., and Croston, A. (2012). 'It should be better all together': exploring strategies for 'undoing'gender in co-educational physical education. *Sport Educ. Soc.* 17, 591–605. doi: 10.1080/13573322.2011.553215
- Hirsh-Pasek, K., Hadani, H. S., Blinkoff, E., and Golinkoff, R. M. (2020). A new path to education form: playful learning promotes 21st century skills in school and beyond. *Policy Brookings* 2020. Available at: https://www.brookings.edu/wp-content/uploads/2020/10/Big-Ideas_Hirsh-Pasek_PlayfulLearning.pdf (Accessed August 29, 2022).
- Hunter, D. R., Handcock, M. S., Butts, C. T., Goodreau, S. M., and Morris, M. (2008). Ergm. A package to fit, simulate and diagnose exponential-family models for networks. *J. Stat. Softw.* 24:mhp454860. doi: 10.18637/jss.v024.i03
- Hurst, B., Wallace, R. R., and Nixon, S. B. (2013). The impact of social interaction on student learning. *Reading Horiz.* 52, 375–398.
- Jorring, A. H., Bolling, M., Nielsen, G., Stevenson, M. P., and Bentsen, P. (2019). Swings and roundabouts? Pupils' experiences of social and academic well-being in education outside the classroom. *Education* 48, 413–428. doi: 10.1080/03004279.2019.1614643
- Koster, M., Nakken, H., Pijl, S. J., and Van Houten, E. (2009). Being part of the peer group: a literature study focusing on the social dimension of inclusion in education. *Int. J. Incl. Educ.* 13, 117–140. doi: 10.1080/13603110701284680
- La Guardia, J., Ryan, R., Couchman, C., and Deci, E. (2000). Basic psychological needs scales. *J. Pers. Soc. Psychol.* 79, 367–384. PMID: 10981840
- Lee, E. Y., de Lannoy, L., Li, L., de Barros, M., Bentsen, P., Brussoni, M., et al. (2022). Play, learn, and teach outdoors—network (PLaTO-net): terminology, taxonomy, and ontology. *Int. J. Behav. Nutr. Phys. Act.* 19. doi: 10.1186/s12966-022-01294-0
- Lee, R. L. T., Lane, S., Brown, G., Leung, C., Kwok, S. W. H., and Chan, S. W. C. (2020). Systematic review of the impact of unstructured play interventions to improve young children's physical, social, and emotional well-being. *Nurs. Health Sci.* 22, 184–196. doi: 10.1111/nhs.12732
- Li, J., Li, J., Jia, R., Wang, Y., Qian, S., and Xu, Y. (2020). Mental health problems and associated school interpersonal relationships among adolescents in China: a cross-sectional study. *Child Adolesc. Psychiatry Ment. Health* 14, 12–10. doi: 10.1186/s13034-020-00318-6
- Luke, D. A. (2015). *A User's Guide to Network Analysis* in R. Berlin: Springer.
- Ma, J. (2018). Qualitative change in social situation of development as the starting point of children's role adjustment during the transition to school. *Early Child Dev. Care.* 190, 750–765. doi: 10.1080/03004430.2018.1490895
- Macoby, E. E. (1988). Gender as a social category. *Dev. Psychol.* 24, 755–765. doi: 10.1037/0012-1649.24.6.755
- Mall, C., von Au, J., and Dettweiler, U. (2021). "Students' appropriation of space in education outside the classroom. Some aspects on physical activity and health from a pilot study with 5th-graders in Germany," in *Nature and Health*, eds. E. Brymer, M. Rogerson and J. Barton (London: Routledge), 223–232.
- McArdle, K., Harrison, T., and Harrison, D. (2013). Does a nurturing approach that uses an outdoor play environment build resilience in children from a challenging background? *J. Adv. Educ. Outdoor Learn.* 13, 238–254. doi: 10.1080/14729679.2013.776862
- McNamara, L., Colley, P., and Franklin, N. (2017). School recess, social connectedness and health: a Canadian perspective. *Health Promot. Int.* 32, dav102–dav402. doi: 10.1093/heapro/dav102
- Miethling, W.-D. (1986). *Belastungssituationen im Selbstverständnis junger Sportlehrer. Ein Beitrag zur Praxisforschung im Sportunterricht [Stressful Situations in the Self-concept of Young Physical Education Teachers. A Contribution to Practice Research in Physical Education]*. Schorndorf: Verlag Karl Hofmann.
- Ministerium für Kultus, Jugend und Sport Baden-Württemberg [Ministry of Education, Youth and Sports Baden-Württemberg] (2016). Bildungsplan des Gymnasiums. Sport [Educational plan of the high school. Sports]. Available at: https://www.bildungsplaene-bw.de/site/bildungsplan/get/documents/lsw/export-pdf/depot-pdf/ALLG/BP2016BW_ALLG_GYM_SPO.pdf (Accessed August 29, 2022).
- Moriguchi, Y. (2014). The early development of executive function and its relation to social interaction: a brief review. *Front. Psychol.* 5:388. doi: 10.3389/fpsyg.2014.00388
- Mygind, E. (2009). A comparison of children's statements about social relations and teaching in the classroom and in the outdoor environment. *J. Adv. Educ. Outdoor Learn.* 9, 151–169. doi: 10.1080/147296790902860809
- Mygind, L., Kjeldsted, E., Hartmeyer, R., Mygind, E., Bolling, M., and Bentsen, P. (2019). Mental, physical and social health benefits of immersive nature-experience for children and adolescents: a systematic review and quality assessment of the evidence. *Health Place* 58:102136. doi: 10.1016/j.healthplace.2019.05.014
- Nynke, M. D., Niezink, T., Snijders, M., and van Duijn, M. (2019). No longer discrete: modeling the dynamics of social networks and continuous behavior. *Sociol. Methodol.* 49, 295–340. doi: 10.1177/0081175019842263
- Pachucki, M. C., Ozer, E. J., Barrat, A., and Cattuto, C. (2015). Mental health and social networks in early adolescence: a dynamic study of objectively-measured social interaction behaviors. *Soc. Sci. Med.* 125, 40–50. doi: 10.1016/j.socscimed.2014.04.015
- Perry, D. G., Pauletti, R. E., and Cooper, P. J. (2019). Gender identity in childhood: a review of the literature. *Int. J. Behav. Dev.* 43, 289–304. doi: 10.1177/0165025418811129
- Powlishta, K. K. (2004). "Gender as a social category: intergroup processes and gender-role development," in *The Development of the Social Self*, eds. M. Bennett and F. Sani (London: Psychology Press), 103–133.
- Putra, I., Astell-Burt, T., Cliff, D. P., Vella, S. A., John, E. E., and Feng, X. (2020). The relationship between green space and prosocial behaviour among children and adolescents: a systematic review. *Front. Psychol.* 11:859. doi: 10.3389/fpsyg.2020.00859
- Ridgegway, C., and Smith-Lovin, L. (1999). The gender system and interaction. *Annu. Rev. Sociol.* 25, 191–216. doi: 10.1146/annurev.soc.25.1.191
- Ripley, R. M., Snijders, T. A. B., Boda, Z., Vörös, A., and Preciado, P. (2012). Manual for Siena version 4.0. Available at: https://www.stats.ox.ac.uk/~snijders/siena/s_man401.pdf (Accessed August 29, 2022).
- Roberts, A., Hinds, J., and Camic, P. M. (2020). Nature activities and well-being in children and young people: a systematic literature review. *J. Adv. Educ. Outdoor Learn.* 20, 298–318. doi: 10.1080/14729679.2019.1660195

- Roe, J., and Aspinall, P. (2011). The emotional affordances of forest settings: an investigation in boys with extreme behavioural problems. *Landsc. Res.* 36, 535–552. doi: 10.1080/01426397.2010.543670
- Roseth, C. J., Johnson, D. W., and Johnson, R. T. (2008). Promoting early adolescents' achievement and peer relationships: the effects of cooperative, competitive, and individualistic goal structures. *Psychol. Bull.* 134, 223–246. doi: 10.1037/0033-2909.134.2.223
- Ryan, R. M., and Deci, E. L. (2017). *Self-Determination Theory: Basic Psychological Needs in Motivation, Development, and Wellness*. New York: Guilford Publications.
- Sarason, S. B., and Klaber, M. (1985). The school as a social situation. *Annu. Rev. Psychol.* 36, 115–140. doi: 10.1146/annurev.ps.36.020185.000555
- Schneller, M. B., Duncan, S., Schipperijn, J., Nielsen, G., Mygind, E., and Bentsen, P. (2017). Are children participating in a quasi-experimental education outside the classroom intervention more physically active? *BMC Public Health* 17:523. doi: 10.1186/s12889-017-4430-5
- Seppala, E., Rossomando, T., and Doty, J. R. (2013). Social connection and compassion: important predictors of health and well-being. *Soc. Res.* 80, 411–430. doi: 10.1353/sor.2013.0027
- Shrum, W., Cheek, N. H. M. D. Jr., and Hunter, S. (1988). Friendship in school: gender and racial homophily. *Sociol. Educ.* 61, 227–239. doi: 10.2307/2112441
- Shumate, M., and Palazzolo, E. T. (2010). Exponential random graph (p^*) models as a method for social network analysis in communication research. *Commun. Methods Meas.* 4, 341–371. doi: 10.1080/19312458.2010.527869
- Simmel, G. (2013). "Soziologie: Untersuchungen über die Formen der Vergesellschaftung [Sociology: studies on the forms of socialisation]," in *Hauptwerke der Emotionssoziologie [Major Works in the Sociology of Emotion]*, eds. K. Senge and R. Schützeichel (Wiesbaden: Springer), 311–332.
- Snijders, T., van de Bunt, G., and Steglich, C. (2010). Introduction to stochastic actor-based models for network dynamics. *Soc. Networks* 32, 44–60. doi: 10.1016/j.socnet.2009.02.004
- Sugiyama, T., Leslie, E., Giles-Corti, B., and Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships? *J. Epidemiol. Community Health* 62:e9. doi: 10.1136/jech.2007.064287
- Torkos, H. (2017). Social and psychological aspects of outdoor education. *Agora Psycho Pragmat.* 11, 215–223.
- Tremblay, M. S., Gray, C., Babcock, S., Barnes, J., Bradstreet, C. C., Carr, D., et al. (2015). Position statement on active outdoor play. *Int. J. Environ. Res. Public Health* 12, 6475–6505. doi: 10.3390/ijerph120606475
- van Laar, E., van Deursen, A. J., van Dijk, J. A., and de Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: a systematic literature review. *SAGE Open* 10:215824401990017. doi: 10.1177/2158244019900176
- Van Ryzin, M. J., and Roseth, C. J. (2018). Cooperative learning in middle school: a means to improve peer relations and reduce victimization, bullying, and related outcomes. *J. Educ. Psychol.* 110, 1192–1201. doi: 10.1037/edu0000265
- Waite, S., Bolling, M., and Bentsen, P. (2016). Comparing apples and pears?: a conceptual framework for understanding forms of outdoor learning through comparison of English Forest schools and Danish udeskole. *Environ. Educ. Res.* 22, 868–892. doi: 10.1080/13504622.2015.1075193
- Wang, Y., Tian, L., and Huebner, S. (2019). Basic psychological needs satisfaction at school, behavioral school engagement, and academic achievement: longitudinal reciprocal relations among elementary school students. *Contemp. Educ. Psychol.* 56, 130–139. doi: 10.1016/j.cedpsych.2019.01.003

5 General discussion

The theory part of this dissertation explains to what extent EOtC may meet the requirements of a future-oriented school concept. The two empirical publications examined specific relationships based on data collected at a German secondary school focusing on social, motivational and health-related aspects of EOtC. Within these publications, the implications of the specific results were also discussed. The following general discussion of the findings obtained in the context of this dissertation shall give an impression of how the results position themselves in the current state of research – both specifically with regard to EOtC and as a future-oriented school concept. At the same time, it is also intended to give an overarching outlook of how the implementation and practice-relevant derivations of comparable projects and concepts can be better designed in the future.

5.1 Positioning in the state of scientific research on EOtC

Since the first systematic review of the state of research on effects and associations of EOtC by Becker et al. in 2017, a large number of new studies has been conducted. These largely avoided the weaknesses of previous studies (Mall et al., 2022 [PROSPERO registration]), originating to a large extent from Scandinavia. On average, the focus on physical and mental health-related issues was more dominant than other perspectives – both in Scandinavia and, for example, in Germany. Within the field of research on EOtC, the presented publications fit in well, but at crucial points they go beyond what has been investigated before. This dissertation can thus be classified as partly exploratory (both method and content wise), but also partly confirmatory. In general, the publications presented here represent the trend in EOtC research that has been observed for the last few years: the attempt to actually gain a deeper understanding of the previously recorded differences in the comparison between EOtC and traditional teaching. In the case of this dissertation, this is evident in the approach that previously isolated variables (e.g., BPN, HRQoL, motivational regulation) are subjected to a combined analysis and that discussable items are not identified solely on the basis of significance levels (e.g., homophily effects in sociograms of SNA).

With regard to self-determined learning motivation, the results presented here are in line with earlier findings in EOtC (Bølling et al., 2018), so that they contribute to a solid foundation that

enables more in-depth analyses now (see chapter 5.3). The findings on HRQoL open the perspective on new questions and admittedly do not contribute to clarify the already comparatively diffuse and inconsistent state of research. In view of the great complexity of constructs such as HRQoL or well-being both on the model-theoretical level (e.g. Duangchan & Matthews, 2021), but also the operationalizability (Berzon et al., 1993; Németh, 2006; Husson et al., 2020), the need for future research in this area is by no means surprising.

Human social interaction represents a no less complex field. Although the present findings of this dissertation usefully complement previous studies in this area (Mygind, 2009; Fägerstam, 2014; Bølling et al., 2019b) and partially confirm observations (e.g., the risk of social exclusion), there is no question that this study was incapable of conclusively clarifying certain issues in this area. Nevertheless, important conclusions can be drawn from the results, but also from the accompanying background knowledge, as will be explained in the following chapters.

5.2 Contribution of EOtC in shaping modern schools

The importance of schools as a setting for children and adolescents will not diminish in the not too distant future. It is therefore in society's interest to examine and strengthen schools in terms of their ability to promote and maintain health of the students, to teach future-oriented skills and to meet a wide range of needs in academic learning.

In the context of the discussion about criteria that make up supposedly good teaching, the necessary balance between instruction and student-centeredness has often been pointed out (Hattie, 2011; Helmke, 2015; Meyer, 2007; Wiater, 2021). In particular, the importance of the teacher as well as the involvement of the students should be mentioned here. This in turn corresponds to the fundamental understanding of education beyond the mere reproduction of specific facts but rather the enabling of life-long and self-determined learning (Böhm & Seichter, 2022; Humboldt, 1920; Klafki, 1964; Meyer & Renartz, 2013; Robinsohn, 1969; Tenorth, 2003). The effects shown of EOtC both in this thesis and previous studies in this area underpin its claim to be able to make a valuable contribution. With regards to social interaction, the concept of EOtC does not have initial advantages (the characteristics of which would have to be defined first) compared to classical teaching – however, it broadens the spectrum of realizable forms of social interaction and exchange and thus enables real individualization.

Given that studies generally suggest the importance of social interaction for students' involvement and engagement (Frisby & Martin, 2010; Havik & Westergård, 2020), which in turn seems central for learning (Meyer, 2007; Rosa, 2019), similar relationships should urgently be investigated in the future (see chapter 5.3). A successful balance of instruction of the teacher and involvement of the students could also be seen in the satisfaction of the BPN, in particular the needs of autonomy and competence (Felder & Brent, 1996; Vansteenkiste et al., 2020). Considering this spectrum of promoting social interaction, student involvement, autonomy and competence, the impression arises, that EOtC could pragmatically contribute to the realization of desired methodical-didactic principles (see chapter 2.1.2).

Earlier in this thesis, it was argued that the overarching goal of 21st century skills is analogous to that education: enabling self-determined living in a changing world. At the same time, the described methodical-didactic principles of supposedly good teaching can help to effectively learn the few 21st century skills based on "hard" skills (e.g. technology and media literacy). So far, only very few studies can prove the connection to the 21st century skills, especially for EOtC/Outdoor Learning (Mann et al., 2022; Dettweiler et al., 2022). In particular, increased real-world references seem to be of crucial importance here, e.g., in science education (Dettweiler et al., 2022). The present dissertation offers further pieces of the puzzle, in the form of the consideration of motivational regulation (e.g., especially the required 21st century skills creativity and information literacy seem to be linked to this), autonomy (e.g., leadership, flexibility), competence (e.g., critical thinking, initiative) and social interaction and relatedness (e.g., collaboration, communication, social skills). At the same time, the previously described difficulty of operationalizing 21st century skills in the context of surveys in EOtC and school in general remains (Lemley et al., 2014; Mann et al., 2022).

While the presented results could not provide clarity in the area of increased social interaction during the lessons, the results of the first publication (see chapter 4.1) pointed out the importance of social factors for HRQoL. EOtC appears to have great potential in this area in particular. The possible effects of social factors on mental health issues in children and adolescents alone (McNamara et al., 2017; Pachucki et al., 2015) make it worthwhile to consider increased implementation and much needed additional research in this regard (Hascher, 2003). Although the examination of changes in these areas is difficult, the influence on social factors and

their effects on mental health may have the greatest potential. The meanwhile well-documented effects regarding an increase of physical activity in other studies (e.g. Schnellert et al., 2017a; Bølling et al., 2021) complete the triad of the central potentials of EOtC as a future-oriented school concept in motivational, social and health-related regards.

5.2.1 Research as a catalyst of third mission

It would be fatal to view the school setting as a field of scientific investigation in isolation, as interventions at the school level can also have an impact on society – or societal developments can set the framework for necessities at school. Separating the two makes it difficult to design and implement effective und sustainable innovations. The same applies in principle to all research conducted at universities: In addition to research and teaching, the "third mission" of universities is to reflect findings and/or theoretical considerations back to civil society (Pineiro et al., 2015). Many universities in Germany and Europe are financed to a substantial extent by third-party funds, which, like regular budget funds, are in turn largely based on taxpayers' money. In this light, the claim to share the results of research with society seems not only desirable but compelling, even if this is often accompanied by challenges (Berghaeuser & Hoelscher, 2020; Compagnucci & Spigarelli, 2020). In some disciplines it is traditionally easier to transfer the results into the respective field of practice (as part of civil society) than in other disciplines. Neither of these aspects represents an evaluation of research in one direction or the other, but only illustrates the different characteristics of the various disciplines.

The topic of this dissertation already naturally shows comparatively large real-world links. Nevertheless, questions that are highly interesting from a scientific point of view (in terms of content or methodology) cannot always be smoothly translated into practice-relevant or policy-implicating recommendations. One goal of the project, in which this dissertation was embedded, was from the beginning to proactively enforce the interrelations to practice and politics. The researchers involved in the conception of the project were convinced early on that both the reception of the research results and the future researchability of the concept in the German-speaking region depend decisively on closely linking the research with civil society. In addition to the research, which is the core of this dissertation, numerous activities were undertaken in the corresponding period, which should promote an exchange with the society. These activities are presented in Appendix Table 1 (page 99 of this document) in the appendix

of this thesis. The result of this process was that, in addition to basic research, efforts were also made that were of practical relevance from the very onset. This is also reflected in publications by the author of this thesis, which are less directly related to research than to third-mission. With this ulterior motive, it is possible to interpret rather smaller investigations content wise in a meaningful way. Ultimately, this approach allows EOtC research to catalyze the third mission with respect to this topic.

5.2.2 Derivations for school practice and politics

Following this claim, important derivations for school practice and politics can be drawn from the project work as well as the research results. A book chapter published by the author of this thesis in a German-language edited volume dealt with possible differences in the experience of experienced EOtC teachers and the perception/assumption of teachers who teach exclusively indoors with regard to various aspects (Ellinger et al., 2022b). There are clear differences, for example, with regard to the use of social forms (frontal teaching, group and partner work), factors hindering learning success, securing results, and students' self-activity (Ellinger et al., 2022b). An interpretation of these results can be found in the corresponding book chapter, but the mere presence of these differences between groups draws attention to a deeper problem. For importantly, some of the differences are certainly due to the comparatively low level of awareness of the concept in Germany. In part, however, this also reflects what was also discussed in detail in the second publication presented (see chapter 4.2): the lack of freely available and easily accessible teaching concepts and frameworks. Thus, the knowledge and experience for implementation (and problem solving) remains a treasure of those who actively deal with EOtC – at the same time, outsiders remain unaffected. The extremely and consistently high interest since publication of a handout our group conducted, which can be downloaded free of charge and attempts to address this gap (Mall et al., 2021), supports this impression. The most immediate way to remedy this situation would be a decree or recommendation from education policy on the use of EOtC and outdoor learning in schools ("top-down"). In the immediate future, this does not seem realistic due to more pressing problems in the education system, as well as the traditionally sluggish nature of the German education system. Instead, the Danish model should be followed. There, it is thanks to an initially small, later rapidly growing group of teachers that EOtC was carried into dozens of schools and, in view of its

success, could not be ignored by policymakers for long ("bottom-up") until the concept finally found its way into the country-wide recommendations (Barfod et al., 2021). Such an institutional embedding could then again accelerate the development of new materials and concepts and above all create an "official" basis for teachers and schools.

5.3 Future research directions

The individual investigations and results of this dissertation do not claim to be generalizable. The weaknesses and limitations of each theoretical and methodological approach are discussed in detail in the publications (see chapters 4.1 and 4.2). Nevertheless, the results and interpretative approaches point to important aspects whose future investigation is crucial for the successful further development and with a view to maximizing the effects of the concept of EOtC. More specific perspectives for future research directions will be explained below.

How the findings of this dissertation position themselves into the state of research on EOtC has already been described in chapter 5.1. The still existing gaps in connection with the constructs described therein, which were also used in this thesis, are to be urgently regarded as foci of future research. Specifically, this concerns the measurement of multidimensional indicators of mental health (e.g., HRQoL). At the same time, future research should investigate the question to what the now already repeatedly observed advantages of students in EOtC in the area of self-determined learning motivation can be attributed. For this purpose, it seems essential to pay more attention to the teaching situation itself, as well as to its detailed analysis and its connection to additional factors like emotion (Hascher, 2010). For this purpose, it would be necessary in a first step to identify and describe criteria that can be regarded as indicators of teaching that promotes (self-determined) learning motivation in students. As a starting point for this admittedly complex process, (not least because criteria for supposedly good teaching are highly dynamic in view of the new challenges to schools already described several times), those criteria could serve, that have a high level of acceptance among experts in the respective national and also international context (e.g. Hattie, 2011; Helmke, 2015; Meyer, 2007; Wiater, 2021) or are based on very basal theories, such as SDT. In any case, an iterative discourse would be necessary in which representatives of different groups (science [pedagogy, school development, psychology], school practice, politics, society) further develop or modify those criteria. In a subsequent step, EOtC, classical school teaching and additional alternative

school concepts (e.g. "Montessori", "Jena-Plan") could be examined with regard to these criteria and these results could in turn be linked to those of self-determined learning motivation. Researchers from Denmark, who were already involved in TEACHOUT, are also aware of this gap. Accordingly, precisely such content is currently finding its way into the new major Danish project "MOVEOUT", which has been underway since mid-2022 (Københavns Universitet, 2023), but with a different methodological approach as described before. Connected to these considerations, due to the ability to link and deepen several of the central strengths of EOtC in terms of content, a special focus in future research should also be on the construct of "cooperative learning" (CL). Central characteristics of CL are, besides the direct social interaction, the interdependencies of the (learning) group members through the individually necessary contribution, as well as the development of the ability to reflect (Johnson & Johnson, 2007). On the one hand, CL shows a close, positive link with improved motivation to learn (Fernández-Espínola et al., 2020; Brown, 2021). In the other hand, social skills, as listed in the 21st century skilly are naturally promoted (Johnson & Johnson, 2014). The general addressing of 21st century skills in schooling and EOtC, as well as their linkage to constructs such as self-determined learning motivation, CL, and BPN satisfaction, should additionally receive greater focus.

It is almost a little surprising that, as described in chapter 2.2.2, studies on the effects or correlates of EOtC in (semi) natural environments with environmentally related aspects (e.g., environmental awareness, nature connectedness, environmental behavior) have been addressed comparatively rarely. However, it is very specifically in this area that real future potential seems to lie; after all, increased embodiment of explicit and implicit nature experience and learning in school could lead to improved nature connectedness (Cleary et al., 2018) and ultimately increased nature-aware behavior (Broom, 2017; Ives et al., 2018). Increased contact with natural environments over an extended period of time can be expected to result in increased and stable nature connectedness (Gifford, 2014; Tam, 2013), which is in some studies clearly reflected in the extent of pro-environmental behaviors (Whitburn, Linklater & Milfont, 2019). Although children around the world and in Germany are increasingly distancing themselves from natural spaces (Brämer, Schild & Koll, 2016; Richardson, Hussain & Griffiths, 2018; Soga & Gaston, 2016), they are also demonstrating a desire for a lifestyle that is increasingly oriented towards sustainability, a phenomenon that can be observed in the media on a daily basis (Sommer et al., 2019; Wahlström et al., 2019). Both the students themselves and society as a whole

would ultimately benefit from a (re)approach of schools to nature, especially through the perception of the worthiness of protection and options for using natural spaces. Therefore, it can be defined as an urgent task of research on (partly) nature-related teaching concepts such as EOtC to grasp the correlations of these constructs (both motivational and volitional) and to advance a promotion of these aspects.

Similar to many other research areas, most research questions in the context of learning, innovative schooling, and EOtC cannot be seriously answered by exclusively following one research paradigm (quantitative or qualitative). Accordingly, mixed methods approaches are clearly recommended in the future. Since the central (mediating or self-constituting) role of social factors in particular is increasingly emerging, SNA should therefore be pointed out specifically. By its very nature, SNA has the capacity to capture social factors and relations - and when understood in its full breadth of instruments and evaluation strategies, it also has the potential to meaningfully intertwine quantitative and qualitative elements in survey, visualization, analysis, and interpretation in an extraordinary way (Bolíbar, 2016; Nooraie et al., 2018). In fact, there is a real added value especially in mixed method approaches in SNA in the gain of knowledge through the interlacing of both research paradigms within a single analysis (e.g. Kolley & Bormann, 2014). In future research, for example, quantitative (e.g., by means of questionnaires or sensors) and qualitative (e.g., by means of observations) data collection methods could be used simultaneously in the context of analysis in school classes. The generated results could be used for inferential statistics (on the one hand for the analysis of the empirical networks, and on the other hand for the comparison of the similarity of these), as well as for the discussion of the visualized networks (sociograms), e.g. with teachers. The result would be a rounded picture that approximates reality and thus could eradicate weaknesses of an isolated qualitative or quantitative approach. Of course, it cannot be ruled out that this procedure ultimately leads to all the more inconsistencies as a basis for future research (e.g., Froehlich et al., 2020); but those do not diminish the potential of SNA in future research of EOtC and other innovative and future-oriented teaching concepts.

6 Better learning in the outdoors?

It would be wrong to assume that moving school lessons from the classroom to the outdoors would change everything for the better. This assumption cannot be supported either theoretically nor empirically and would ignore the fact that there are multiple approaches to achieving certain goals and rarely does the truth lie in just one approach. It is true, however, that the sum of research results in many different areas may suggest advantages of EOtC over traditional classroom teaching in the overall tendency. This also relates to the area of self-determined learning motivation, which initially suggests that under certain circumstances EOtC enables school teaching that is more in line with an understanding of education that is oriented towards self-determined, life-long learning and problem solving.

Nevertheless, there are still many gaps in the argumentation, as well as many debatable results in social, motivational and health-related aspects. In particular, a closer look at teaching practice, as well as an examination of the transferability of observed characteristics of EOtC to other teaching concepts, must be considered as a basis for approaching an answer to this overarching question of "better learning in the outdoors".

Especially in countries where the tradition does not go back so far and can build on such a broad base as in Scandinavia, there are also numerous methodological steps to be taken in order to exploit the potential of the concept. These steps, in turn, cannot be taken by science, school practice or politics alone. These stakeholders need to join forces in order to establish EOtC as an alternative and/or additional teaching concept in the school system in the long term and on a sustainable basis. The research and dissemination of EOtC illustrates the need, but also the potential for synergy when different stakeholders work together to generate real value for society.

7 References

- Ahn, S., & Fedewa, A. L. (2011). A meta-analysis of the relationship between children's physical activity and mental health. *J Pediatr Psychol*, 36(4):385-397. <https://doi.org/10.1093/jpepsy/jsq107>
- Alismail, H. & McGuire, P. (2015). 21st Century Standards and Curriculum: Current Research and Practice. *J. educ. pract.*, 6(6):150-154. <https://eric.ed.gov/?id=EJ1083656>
- Ambusaidi, A., Al-Yahyai, R., Taylor, N., & Taylor, S. (2018). Introducing school gardens to the Omani context: A preliminary study with Grade 7 classes. *EURASIA J Math Sci Tech Ed*, 14:1043-1055. <https://doi.org/10.12973/ejmste/80859>
- Ambusaidi, A., Alyahyai, R., Taylor, S., & Taylor, N. (2019). School gardening in early childhood education in Oman: a pilot project with grade 2 students. *Science Education International*, 30(1):45-55. <http://orcid.org/0000-0001-8438-319X>
- Anniko, M., Boersma, K. & Tillfors, M. (2019). Sources of stress and worry in the development of stress-related mental health problems: A longitudinal investigation from early-to midadolescence. *Anxiety Stress Coping*, 32(2):155-67. <https://doi.org/10.1080/10615806.2018.1549657>
- Armbrüster, C., Gräfe, R., Harring, M., Sahrakhiz, S., Schenk, D., & Witte, M. D. (2016). Spielen, Bewegen, Erkunden-Praktiken der Raumaneignung von Grundschulkindern in der Draußenschule [Playing, moving, exploring-Practices of space appropriation by elementary school children in outdoor school.]. *Diskurs Kindheits-und Jugendforschung/Discourse*, 11(4):15-16. <https://doi.org/10.3224/diskurs.v11i4.25605>
- Bakioglu, B., Karamustafaoglu, O., Karamustafaoglu, S., & Yapici, S. (2018). The effects of out-of-school learning settings science activities on 5th graders' academic achievement. *Eur. Educ. Res. J.*, 7(3):451-464. Available from (11/05/23): <https://www.eu-jer.com/the-effects-of-out-of-school-learning-settings-science-activities-on-5th-graders-academic-achievement>
- Barfod, K. (2018). Maintaining mastery but feeling professionally isolated: experienced teachers' perceptions of teaching outside the classroom. *J. Adventure Educ. Outdoor Learn.*, 18(3):201-213. <https://doi.org/10.1080/14729679.2017.1409643>
- 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 For Urban Green*, 60:127044. <https://doi.org/10.1016/j.ufug.2021.127044>
- Beames, S. & Ross, H. (2010). Journeys outside the classroom. *J. Adventure Educ. Outdoor Learn.*, 10(2):95-109. <https://doi.org/10.1080/14729679.2010.505708>
- Beames, S. (2006) Losing my religion: The struggle to find applicable theory. *Pathways: The Ontario Journal of Outdoor Education*, 19(1):3-11. Available from (11/05/23): <https://www.research.ed.ac.uk/en/publications/losing-my-religion-the-struggle-to-find-applicable-theory>

- 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. *Int. J. Environ. Res. Public Health.*, 14(5):485. <https://doi.org/10.3390/ijerph14050485>
- Becker, C., Schmidt, S., Neuberger, E., Kirsch, P., Simon, P. & Dettweiler, U. (2019). Children's Cortisol and Cell-Free DNA Trajectories in Relation to Sedentary Behavior and Physical Activity in School: A Pilot Study. *Front. Public Health*, 7:26. <https://doi.org/10.3389/fpubh.2019.00026>
- Bentsen, P., Mygind, E. & Randrup, T.B. (2009). Towards an understanding of udeskole: education outside the classroom in a Danish context. *Education 3–13*, 37(1):29–44. <https://doi.org/10.1080/03004270802291780>
- Bentsen, P., Mygind, L., Elsborg, B., 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. *Scand J Public Health*, 1(9). <https://doi.org/10.1177/1403494821993715>
- Berghaeuser, H., & Hoelscher, M. (2020). Reinventing the third mission of higher education in Germany: political frameworks and universities' reactions. *Tert. Educ. Manag.*, 26:57-76. <https://doi.org/10.1007/s11233-019-09030-3>
- Bertelsmann Stiftung [Bertelsmann Foundation] (2022). Was bewegt die Jugend in Deutschland. Einstellung und Sorge der jungen Generation Deutschlands [What affects the youth in Germany. Attitudes and concerns of Germany's young generation]. Available from (11/05/23): <https://www.bertelsmann-stiftung.de/de/publikationen/publikation/did/was-bewegt-die-jugend-in-deutschland>
- Berzon, R., Hays, R., & Shumaker, S. (1993). International use, application and performance of health-related quality of life instruments. *Qual Life Res*, 2(6):367-368. <https://doi.org/10.1007/BF00422214>
- Biddle, S. J., & Asare, M. (2011). Physical activity and mental health in children and adolescents: a review of reviews. *Br J Sports Med*, 45(11):886-895. <http://dx.doi.org/10.1136/bjsports-2011-090185>
- Block, P., Stadtfeld, C. & Snijders, T. A. B. (2019). Forms of dependence: Comparing SAOMs and ERGMs from basic principles. *Sociol Methods Res*, 48(1):202–239. <https://doi.org/10.1177/0049124116672680>
- Blume, C. (2020). German Teachers' Digital Habitus and Their Pandemic Pedagogy. *Postdigital Science and Education*, 2:879–905. <https://doi.org/10.1007/s42438-020-00174-9>
- Bohnsack, F. (2004). Persönlichkeitsbildung von Lehrerinnen und Lehrern [Personality development of teachers]. In Blömeke, S., Reinhold, P., Tulodziecki, G., Wildt, J. (eds). *Handbuch Lehrerbildung* [Handbook teacher education]. Braunschweig: Klinkhardt. 152-164.
- Bolíbar, M. (2016). Macro, meso, micro: broadening the 'social' of social network analysis with a mixed methods approach. *Qual Quant*, 50:2217–2236. <https://doi.org/10.1007/s11135-015-0259-0>
- Bolker, B. M. (2015). Linear and generalized linear mixed models. In Fox, G., Negrete-Yankelevich, Sosa, V. (eds). *Ecological statistics: contemporary theory and application*. Oxford: University Press. 309-333.

- Bølling, M., Mygind, E., Mygind, L., Bentsen, P. & Elsborg, P. (2021). The Association between Education Outside the Classroom and Physical Activity: Differences Attributable to the Type of Space? *Children*, 8(6):486. <https://doi.org/10.3390/children8060486>
- Bølling, M., Niclasen, J., Bentsen, P., & Nielsen, G. (2019a). Association of Education Outside the Classroom and Pupils' Psychosocial Well-Being: Results From a School Year Implementation. *J Sch Health*, 89(3):210-218. <https://doi.org/10.1111/josh.12730>
- 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. *Int J. Educ. Res.* 89:22-35. <https://doi.org/10.1016/j.ijer.2018.03.004>
- Bølling, M., Pfister, G. U., Mygind, E. & Nielsen, G. (2019b). Education outside the classroom and pupils' social relations? A one-year quasi-experiment. *Int J Educ Res.*, 94:29–41. <https://doi.org/10.1016/j.ijer.2019.02.014>
- Borgatti, S., Mehra, A., Brass, D., & Labianca, G. (2009). Network analysis in the social sciences. *science*, 323(5916):892-895. <https://doi.org/10.1126/science.1165821>
- Borgatti, S., Everett, M., & Johnson, J. (2018). *Analyzing social networks*. New York: Sage.
- Brämer, R., Koll, R., & Schild, K. H. (2016). 7. *Jugendreport Natur 2016. Erste Ergebnisse. Natur Nebensache?* [7th Youth Report Nature 2016. First results. Nature as a secondary matter?]. Available from (11/05/23): https://www.wanderforschung.de/files/jugendreport2016-web-final-160914-v3_1903161842.pdf
- Broom, C. (2017). Exploring the relations between childhood experiences in nature and young adults' environmental attitudes and behaviours. *J Environ Educ*, 33(1):34-47. <https://doi.org/10.1017/aee.2017.1>
- Brown, C. L. (2021). Literature review: Effect of cooperative learning on intrinsic motivation. *Int. j. res. sci. innov.*, 8(7):1-7. Available from (11/05/23): <https://www.rsisinternational.org/journals/ijrsi/digital-library/volume-8-issue-7/01-07.pdf>
- Bundesministerium für Familie, Senioren, Frauen und Jugend (2008). *Bildung, Betreuung und Erziehung für Kinder unter drei Jahren – elterliche und öffentliche Sorge in gemeinsamer Verantwortung* [Education, care and upbringing for children under three years of age - parental and public care in joint responsibility]. Available from (11/05/23): <https://www.bmfsfj.de/resource/blob/93382/c12b49783ca9fda82f0b03c9b05a295b/bildung-betreuung-und-erziehung-kurzgutachen-data.pdf>
- Bundesregierung [German Government] (2018). Ein neuer Aufbruch für Europa. Eine neue Dynamik für Deutschland. Ein neuer Zusammenhalt für unser Land. Koalitionsvertrag zwischen CDU, CSU und SPD [A new dawn for Europe. A new dynamic for Germany. A new cohesion for our country. Coalition agreement between CDU, CSU and SPD]. Berlin: Bundesregierung. Available from (11/05/23): <https://www.bundesregierung.de/breg-de/themen/koalitionsvertrag-zwischen-cdu-csu-und-spd-195906>.
- Burchartz, A., Anedda, B., Auerswald, T., Giurgiu, M., Hill, H., Ketelhut, S., Kolb, S., Mall, C., Manz, K., Nigg, C. R., Reichert, M., Sprengeler, O., Wunsch, K., & Matthews, C. E. (2020). Assessing physical behavior through accelerometry – State of the science, best practices and future directions. *Psychol Sport Exerc*, 49: 101703. <https://doi.org/10.1016/j.psychsport.2020.101703>

- Cachay, K. & Thiel, A. (2002). *Erziehung im und durch Sport in der Schule – Systemtheoretisch-konstruktivistische Überlegungen* [Education in and through sport in school - system-theoretical-constructivist considerations]. In Voss, R. (ed.). *Die Schule neu erfinden* [Reinventing schools]. Neuwied: Luchterhand. 333-353.
- Calvin, C., Deary, I.J. & Fenton, C. (2011). Intelligence in youth and all-cause-mortality: systematic review with meta-analysis. *Int J Epidemiol*, 40(3):626–44. Available from (11/05/23): <https://pubmed.ncbi.nlm.nih.gov/21037248/>
- Camacho, D., Panizo-LLedot, Á., Bello-Orgaz, G., Gonzalez-Pardo, A., & Cambria, E. (2020). The four dimensions of social network analysis: An overview of research methods, applications, and software tools. *Inf Fusion*, 63:88-120. <https://doi.org/10.1016/j.inffus.2020.05.009>
- Center for Open Science (2019). *Learning in nature - Aspects of physical and mental health, learning motivation, learning achievements and nature connectedness during Education Outside the Classroom*. Available from (11/05/23): <https://osf.io/6unbf>
- Chaddha, A., Robinson, E. A., Kline-Rogers, E., Alexandris-Souphis, T., & Rubenfire, M. (2016). Mental health and cardiovascular disease. *Am. J. Med.*, 129(11):1145-1148. <https://doi.org/10.1016/j.amjmed.2016.05.018>
- Christodoulou, A., & Korfiatis, K. (2019). Children's interest in school garden projects, environmental motivation and intention to act: A case study from a primary school of Cyprus. *Appl Environ Educ Commun*, 18(1):2-12. <https://doi.org/10.1080/1533015X.2017.1419104>
- Clark, H., Coll-Seck, A. M., Banerjee, A., Peterson, S., Dalglish, S. L., Ameratunga, S., ... & Costello, A. (2020). *A future for the world's children? A WHO–UNICEF–Lancet Commission*. *Lancet*, 395(10224):605-658. [https://doi.org/10.1016/S0140-6736\(19\)32540-1](https://doi.org/10.1016/S0140-6736(19)32540-1)
- Cleary, A., Fielding, K. S., Murray, Z., & Roiko, A. (2018). Predictors of nature connection among urban residents: Assessing the role of childhood and adult nature experiences. *Environ Behav*, 52(6):579–610. <https://doi.org/10.1177/0013916518811431>
- Compagnucci, L., & Spigarelli, F. (2020). The Third Mission of the university: A systematic literature review on potentials and constraints. *Technol Forecast Soc Change*, 161:120284. <https://doi.org/10.1016/j.techfore.2020.120284>
- CSDT (Center for Self-Determination Theory) (2023). *Selfdeterminationtheory*. <https://selfdeterminationtheory.org/>
- Dettweiler, U., Becker, C., Auestad, B. H., Simon, P., & Kirsch, P. (2017). Stress in School. Some Empirical Hints on the Circadian Cortisol Rhythm of Children in Outdoor and Indoor Classes. *Int. J. Environ. Res. Public Health*, 14(5):475. <https://doi.org/10.3390/ijerph14050475>
- Dettweiler, U., Gerchen, M., Mall, C., Simon, P., & Kirsch, P. (2022). Choice matters: Pupils' stress regulation, brain development and brain function in an outdoor education project. *Br J Educ Psychol*, 00:1-22. <https://doi.org/10.1111/bjep.12528>
- Dettweiler, U., Lauterbach, G., Becker, C. & Simon, P. (2017). A Bayesian mixed-methods analysis of basic psychological needs satisfaction through outdoor learning and its influence on motivational behavior in science class. *Front. Psychol.* 8:2235. <https://doi.org/10.3389/fpsyg.2017.02235>

- Dettweiler, U., Lauterbach, G., Mall, C. & Kermish-Allen, R. (2022). Fostering 21st Century Skills Through Autonomy Supportive Science Education Outside the Classroom. In Jucker, R., von Au, J. (eds). *High-Quality Outdoor Learning*. Cham: Springer. 231–253. https://doi.org/10.1007/978-3-031-04108-2_13
- Dettweiler, U., Ünlü, A., Lauterbach, G., Becker, C., & Gschrey, B. (2015). Investigating the motivational behavior of pupils during outdoor science teaching within self-determination theory. *Front. Psychol.*, 6:125. <https://doi.org/10.3389/fpsyg.2015.00125>
- Duangchan, C., & Matthews, A. K. (2021). Application of Ferrans et al.'s conceptual model of health-related quality of life: A systematic review. *Res Nurs Health*, 44(3):490-512. <https://doi.org/10.1002/nur.22120>
- Ellinger, J., Mess, F., Bachner, J., von Au, J. & Mall, C. (2023). Changes in social interaction, social relatedness, and friendships in Education Outside the Classroom: A social network analysis. *Front. Psychol.*, 14:1031693. <https://doi.org/10.3389/fpsyg.2023.1031693>
- Ellinger, J., Mess, F., Blaschke, S. & Mall, C. (2022a). Health-related quality of life, motivational regulation and Basic Psychological Need Satisfaction in Education Outside the Classroom: an explorative longitudinal pilot study. *BMC Public Health*, 22(49). <https://doi.org/10.1186/s12889-021-12450-9>
- Ellinger, J., von Au, J., Bernhardt, L., Singer, M., Tangerding, S. & Mall, C. (2022b) Eine Frage der Perspektive: Die Unterrichtssituation im Draußenunterricht [A matter of perspective: the classroom situation in outdoor education]. In von Au J., Jucker R. (eds). *Draussenlernen Neue Forschungsergebnisse und Praxiseinblicke für eine Bildung für nachhaltige Entwicklung* [Outdoor Learning New research findings and practical insights for education for sustainable development]. Bern: hep. 387–406. <https://www.hep-verlag.ch/draussenlernen>
- Ernst, J. & Stanek, D. (2006). The prairie science class: A model for re-visioning environmental education within the national wildlife refuge system. *Hum. Dimens. Wildl.*, 11:255–265. <https://doi.org/10.1080/10871200600803010>
- Fägerstam, E. (2014). High school teachers' experience of the educational potential of outdoor teaching and learning. *J. Adventure Educ. Outdoor Learn.*, 14(1):56-81. <https://doi.org/10.1080/14729679.2013.769887>
- Felder, R. M., & Brent, R. (1996). Navigating the bumpy road to student-centered instruction. *College teaching*, 44(2):43-47. <https://doi.org/10.1080/87567555.1996.9933425>
- Fernández-Espínola, C., Abad Robles, M., Collado-Mateo, D., Almagro, B., Castillo Viera, E. & Giménez Fuentes-Guerra F. (2020). Effects of Cooperative-Learning Interventions on Physical Education Students' Intrinsic Motivation: A Systematic Review and Meta-Analysis. *Int. J. Environ. Res. Public Health.*, 17(12):4451. <https://doi.org/10.3390/ijerph17124451>
- Ferreira, M., Martinsone, B., & Talić, S. (2020). Promoting sustainable social emotional learning at school through relationship-centered learning environment, teaching methods and formative assessment. *J. Teach. Educ.*, 22(1):21-36. <https://doi.org/10.2478/jtes-2020-0003>
- Finger, J. D., Varnaccia, G., Borrmann, A., Lange, C., & Mensink, G. (2018). Körperliche Aktivität von Kindern und Jugendlichen in Deutschland – Querschnittergebnisse aus KiGGS Welle 2 und Trends [Physical Activity of Children and Adolescents in Germany

- Cross-sectional Results from KiGGS Wave 2 and Trends]. *Journal of Health Monitoring*, 3(1):24-31. <https://doi.org/10.17886/RKI-GBE-2018-006.2>
- Fiskum, T. & Jacobsen, K. (2013). Outdoor education gives fewer demands for action regulation and an increased variability of affordances. *J. Adv. Educ. Outdoor Learn.*, 13:76–99. <https://doi.org/10.1080/14729679.2012.702532>
- Frisby, B. N., & Martin, M. M. (2010). Instructor–student and student–student rapport in the classroom. *Communication Education*, 59(2):146-164. <https://doi.org/10.1080/03634520903564362>
- Froehlich, D. E., Rehm, M., & Rienties, B. C. (2020). *Mixed methods social network analysis. Mixed methods social network analysis: Theories and methodologies in learning and education*. London: Routledge.
- Froehlich, D., Van Waes, S., & Schäfer, H. (2020). Linking Quantitative and Qualitative Network Approaches: A Review of Mixed Methods Social Network Analysis in Education Research. *Rev. Res. Educ.*, 44(1):244–268. <https://doi.org/10.3102/0091732X20903311>
- Gaviria, M., & Kilic, B. (2021). A network analysis of COVID-19 mRNA vaccine patents. *Nat. Biotechnol.*, 39(5):546-548. <https://doi.org/10.1038/s41587-021-00912-9>
- Geary, D. & Bjorklund, D. (2000). Evolutionary Developmental Psychology. *Child Dev*, 71(1), 57-65. <https://doi.org/10.1111/1467-8624.00118>
- Geißler, G. (2014). *Schulgeschichte in Deutschland. Von den Anfängen bis in die Gegenwart* [School History in Germany. From the beginnings to the present]. Berlin: Peter Lang GmbH.
- Gifford, R. (2014). Environmental Psychology Matters. *Annu. Rev. Psychol.*, 65(1):541-579. <https://doi.org/10.1146/annurev-psych-010213-115048>
- GKV-Spitzenverband [GKC Central association] (2023). *Leitfaden Prävention* [Guidelines for prevention]. Available from (11/05/23): https://www.gkv-spitzenverband.de/krankenversicherung/praevention_selbst-hilfe_beratung/praevention_und_bgf/leitfaden_praevention/leitfaden_praevention.jsp
- Glackin, M. (2018). ‘Control must be maintained’: exploring teachers’ pedagogical practice outside the classroom. *Br J Sociol Educ*, 39(1):61-76. <https://doi.org/10.1080/01425692.2017.1304204>
- Glaserfeld, E. v. (1997). *Radikaler Konstruktivismus. Ideen, Ergebnisse, Probleme* [Radical Constructivism. Ideas, Results, Problems]. Frankfurt a.M.: Suhrkamp.
- Glöckel, H (2003). *Vom Unterricht: Lehrbuch der Allgemeinen Didaktik* [Of teaching: textbook of general didactics] (4. Edition). Bad Heilbrunn: Klinkhardt.
- Gnambs, T. & Hanfstingl, B. (2016). The decline of academic motivation during adolescence An accelerated longitudinal cohort analysis on the effect of psychological need satisfaction. *Educ Psychol.*, 36(9):1691–705. <https://doi.org/10.1080/01443410.2015.1113236>
- Goodman, A., Joyce, R., & Smith, J. P. (2011). The long shadow cast by childhood physical and mental problems on adult life. *Proceedings of the National Academy of Sciences*, 108(15), 6032-6037. <https://doi.org/10.1073/pnas.1016970108>
- Harris, J. (2013). *An introduction to exponential random graph modeling*. New York: SAGE
- Hartmeyer, R. & Mygind, E. (2015). A retrospective study of social relations in a Danish primary school class taught in “udeskole”. *J. Adv. Educ. Outdoor Learn.*, 16:78–89. <https://doi.org/10.1080/14729679.2015.1086659>

- Hartup, W. (1999). Peer experience and its developmental significance. In Bennett, M. (ed). *Developmental Psychology: Achievements and Prospects*. Hove: Psychology Press. 106–125.
- Hascher, T. (2003). Well-being in school – why students need social support. In Mayring, P., C. Rhöneck, V. (eds). *Learning Emotions – The influence of affective factors on classroom learning*. Bern: Lang. 127-142.
- Hascher, T. (2010). Learning and Emotion: Perspectives for Theory and Research. *Eur. Educ. Res. J.*, 9(1):13–28. <https://doi.org/10.2304/eerj.2010.9.1.13>
- Hattie, J. (2011). *Visible Learning for Teachers: Maximizing Impact on Learning*. London: Routledge.
- Havik, T., & Westergård, E. (2020). Do teachers matter? Students' perceptions of classroom interactions and student engagement. *Scand. J. Educ.*, 64(4):488-507. <https://doi.org/10.1080/00313831.2019.1577754>
- Hay, D. F., Caplan, M. & Nash, A. (2018). The beginnings of peer relations. In Bukowski, W., Laursen, B., K. Rubin, K. (eds). *Handbook of Peer Interactions, Relationships, and Groups*. New York City: The Guilford Press. 200–221.
- Helmke, A. (2015). *Unterrichtsqualität und Lehrerprofessionalität. Diagnose, Evaluation und Verbesserung des Unterrichts* [Teaching quality and teacher professionalism. Diagnosis, evaluation and improvement of teaching]. Seelze-Velber: Klett Kallmeyer.
- Henderson, B. & Vikander, N. (2007). *Nature first: outdoor life the Friluftsliv way*. Ontario: Natural Heritage Books.
- Hollstein, O., Meseth, W. & Proske, M. (2016). „Was ist (Schul)unterricht?“ Die systemtheoretische Analyse einer Ordnung des Pädagogischen [„What is (school) teaching?“ The Systems-Theoretical Analysis of an Order of Pedagogy]. In Geier, T., Pollmanns, M. (eds). *Was ist Unterricht? Zur Konstitution einer pädagogischen Form* [What is teaching? On the constitution of a pedagogical form]. Berlin: Springer. 43–75.
- Huber, G. & Köppel, M. (2017). Analyse der Sitzzeiten von Kindern und Jugendlichen zwischen 4 und 20 Jahren [Analysis of Sedentary Times of Children and Adolescents between 4 and 20 Years]. *Dtsch Z Sportmed.*, 68(4), 101-106. Available from (11/05/23): <https://www.germanjournalsportsmedicine.com/archive/archive-2017/issue-4/analyse-der-sitzzeiten-von-kindern-und-jugendlichen-zwischen-4-und-20-jahren/>.
- Humboldt, W. v. (1920). *Gesammelte Schriften* [Collected Writings]. Berlin.
- Hunter, D., Handcock, M., Butts, C., Goodreau, S., & Morris, M. (2008). ergm: A package to fit, simulate and diagnose exponential-family models for networks. *J. Stat. Soft.*, 24(3):1-29. <https://doi.org/10.18637/jss.v024.i03>
- Husson, O., den Hollander, D. & van der Graaf, W.T.A. (2020). The complexity of assessing health-related quality of life among sarcoma patients. *Qual Life Res*, 29:2613–2614. <https://doi.org/10.1007/s11136-020-02561-y>
- Inchley, J., Currie, D., Budisavljevic, S., Torsheim, T., Jåstad, A., Cosma, A. et al. (2020). *Spotlight on adolescent health and well-being. Findings from the 2017/2018 Health Behaviour in School-aged Children (HBSC) survey in Europe and Canada. International report. Volume 1. Key findings*. Available from (11/05/23): <https://apps.who.int/iris/handle/10665/332091>

- Ives, C. D., Abson, D. J., von Wehrden, H., Dorninger, C., Klaniecki, K., & Fischer, J. (2018). Reconnecting with nature for sustainability. *Sustain Sci*, 13(5):1389–1397. <https://doi.org/10.1007/s11625-018-0542-9>
- Johnson, D. & Johnson, R. (2014). Cooperative Learning in 21st Century. *Anales de Psicologia*, 30(3):841-851. <http://dx.doi.org/10.6018/analesps.30.3.201241>
- Jordet, A. (2009). *Nærmiljøet som klasserom. En undersøkelse om uteskolens didaktikk i et danningsteoretisk og erfaringspedagogisk perspektiv* [The nearby environment as classroom] [Doctoral Dissertation]. Oslo: University of Oslo.
- Jørring, A. H., Bølling, M., Nielsen, G., Stevenson, M. P. & Bentsen, P. (2019). Swings and roundabouts? Pupils' experiences of social and academic well-being in education outside the classroom. *Education 3-13*, 48(4):1-16. <https://doi.org/10.1080/03004279.2019.1614643>
- Kauhanen, L., Wan Mohd Yunus, W., Lempinen, L., Peltonen, K., Gyllenberg, D., Mishina, K., Gilbert, S., Bastola, K., Brown, J. & Sourander, A. (2022). A systematic review of the mental health changes of children and young people before and during the COVID-19 pandemic. *Eur Child Adolesc Psychiatry*, 1-19. <https://doi.org/10.1007/s00787-022-02060-0>
- Kazu, H. & Demiralp, D. (2016). Faculty members' views on the effectiveness of teacher training programs to upskill life-long learning competence. *Eurasian J. Educ. Res.*, 63:205-224. <http://dx.doi.org/10.14689/ejer.2016.63.12>
- Kinshuk, Chen, N., Cheng, I. & Chew, S. (2016). Evolution is not enough: Revolutionizing Current Learning Environments to Smart Learning Environments. *Int J Artif Intell Educ* 26:561–581. <https://doi.org/10.1007/s40593-016-0108-x>
- Klipker, K., Baumgarten, F., Göbel, K., Lampert, T. & Hölling, H. (2018). Psychische Auffälligkeiten bei Kindern und Jugendlichen in Deutschland – Querschnittergebnisse aus KiGGS Welle 2 und Trends [Mental disorders in children and adolescents in Germany - cross-sectional results from KiGGS wave 2 and trends.]. *Journal of Health Monitoring*, 3(3):37–45. <http://doi.org/10.17886/RKI-GBE-2018-084>
- Knights, D., & McCabe, D. (2003). *Organization and innovation*. New York City: McGraw-Hill Education.
- Københavns Universitet (2023). MOVEOUT. En undersøgelse af effekter af udeskole [A study on the effects of Udeskole]. Available from (11/05/23): <https://nexus.ku.dk/forskning/id-raet-individ-samfund/krop-laering-og-social-forandring/boern-og-unges-bevaegelses-aktiviteter-i-skole-og-fritid/moveout/>
- Kolleck, N. & Bormann, I. (2014). Analyzing trust in innovation networks: combining quantitative and qualitative techniques of Social Network Analysis. *Z Erziehungswiss*, 17(5):9–27. <https://doi.org/10.1007/s11618-014-0551-0>
- Kotthoff, H.G. & Terhart, E. (2013). Teacher Education in Germany: Traditional Structure, Strengths and Weaknesses, Current Reforms. *Scuola democratica*, 4(3). Available from (11/05/23): <https://www.rivisteweb.it/doi/10.12828/75802>
- Krueger, C. & Tian, L. (2004). A comparison of the general linear mixed model and repeated measures ANOVA using a dataset with multiple missing data points. *Biol Res Nurs*, 6(2):151-157. <https://doi.org/10.1177/1099800404267682>

- Kultusminister Konferenz [Conference of Ministers of Education] (2020). *Ländervereinbarung über die gemeinsame Grundstruktur des Schulwesens und die gesamtstaatliche Verantwortung der Länder in zentralen bildungspolitischen Fragen* [Agreement of the states on the common basic structure of the school system and the overall responsibility of the states in central educational policy issues]. Available from (11/05/23): <https://www.kmk.org/dokumentation-statistik/beschluesse-und-veroeffentlichungen/bildung-schule/allgemeine-bildung.html#c1260>
- Kuo, M., Barnes, M. & Jordan, C. (2019). Do Experiences With Nature Promote Learning? Converging Evidence of a Cause-and-Effect Relationship. *Front. Psychol.* 10:305. <https://doi.org/10.3389/fpsyg.2019.00305>
- Lamb, S., Maire, Q., & Doecke, E. (2017). *Key Skills for the 21st Century: An Evidence-based Review*. Sydney: NSW Department of Education. Available from (11/05/23): <https://vuir.vu.edu.au/35865/>
- Lambert, P. (2017). *Hard Focus on "Soft" Skills*. Sydney: NSW Department of Education. <https://www.voced.edu.au/content/ngv%3A80086>
- Larson, L. & Miller, T. (2011). 21st Century Skills: Prepare Students for the Future. *Kappa Delta Pi Record*, 47(3):121-123. <https://doi.org/10.1080/00228958.2011.10516575>
- Lee, E.Y., de Lannoy, L., Li, L., de Barros, M., Bentsen, P., Brussoni, M., ... Tremblay, M. & participating PLaTO-Net members (2022). Play, Learn, and Teach Outdoors – Network (PLaTO-Net): terminology, taxonomy, and ontology. *Int. J. Behav. Nutr. Phys. Act.*, 9(66). <https://doi.org/10.1186/s12966-022-01294-0>
- Lee, R., Lane, S., Brown, G., Leung, C., Kwok, S. & Chan, S. (2020). Systematic review of the impact of unstructured play interventions to improve young children's physical, social, and emotional well-being. *Nurs. Health Sci.* 22:184–196. <https://doi.org/10.1111/nhs.12732>
- Leech, R., McNaughton, S. & Timperio, A. (2014). The clustering of diet, physical activity and sedentary behavior in children and adolescents: a review. *Int. J. Behav. Nutr. Phys. Act.*, 11(1), 1-9. <https://doi.org/10.1186/1479-5868-11-4>.
- 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 Bull.*, 98(2):101-125. <https://doi.org/10.1177/019263651452874>
- Li, J., Li, J., Jia, R., Wang, Y., Qian, S. & Xu, Y. (2020). Mental health problems and associated school interpersonal relationships among adolescents in China: a cross-sectional study. *Child Adolesc. Psychiatry Ment. Health*, 14(12):12–10. <https://doi.org/10.1186/s13034-020-00318-6>
- Luhmann, N. (1997). Erziehung als Formung des Lebenslaufs [Education as shaping the course of life]. In Lenzen D., Luhmann N. (eds.). *Bildung und Weiterbildung im Erziehungssystem – Lebenslauf und Humanontogenese als Medium und Form* [Education and Continuing Education in the Educational System - Life Course and Humanontogenesis as Medium and Form]. Frankfurt a. M.: Suhrkamp. 11-29.
- Luhmann, N. (2021). *Soziale Systeme. Grundriß einer allgemeinen Theorie*. 18. Auflage [Social Systems. Outline of a general theory. 18th edition]. Berlin: Suhrkamp.
- Luke, D. A. (2015). *A user's guide to network analysis in R*. Berlin: Springer. <https://doi.org/10.1007/978-3-319-23883-8>

- Mahmoudi, S., Jafari, E., Nasrabadi, H. A., & Liaghatdar, M. J. (2012). Holistic education: An approach for 21 century. *Int. Educ. Stud.*, 5(2):178-186. Available from (11/05/23): <https://www.ccsenet.org/journal/index.php/ies/article/view/17024>
- Mall, C., von Au, J. & Dettweiler, U. (2021). Students' Appropriation of Space in Education Outside the Classroom. Some Aspects on Physical Activity and Health from a Pilot Study with 5th-Graders in Germany. In Brymer E., Rogerson M., Barton J. (eds). *Nature and Health*. London: Routledge. 223–232. <https://www.routledge.com/Nature-and-Health-Physical-Activity-in-Nature/Brymer-Rogerson-Barton/p/book/9781003154419>
- Maltseva, D. & Batagelj, V. (2019). Social network analysis as a field of invasions: bibliographic approach to study SNA development. *Scientometrics*, 121:1085–1128. <https://doi.org/10.1007/s11192-019-03193-x>
- Mann, J., Gray, T. & Truong, S. (2022). Rediscovering the Potential of Outdoor Learning for Developing 21st Century Competencies. In Jucker, R., von Au, J. (eds). *High-Quality Outdoor Learning*. Cham: Springer. 211–229. https://doi.org/10.1007/978-3-031-04108-2_12
- Mann, J., Gray, T., Truong, S., Brymer, E., Passy, R., Ho, S., Sahlberg, P., Ward, K., Bentsen, P., Curry, C. & Cowper, R. (2022). Getting Out of the Classroom and Into Nature: A Systematic Review of Nature-Specific Outdoor Learning on School Children's Learning and Development. *Front. Public Health*, 10:877058. <https://doi.org/10.3389/fpubh.2022.877058>
- Martin, B., Bright, A., Cafaro, P., Mittelstaedt, R. & Bruyere, B. (2009). Assessing the development of environmental virtue in 7th and 8th grade students in an expeditionary learning outward bound school. *J. Exper. Educ.*, 31:341–358. <https://doi.org/10.1177/105382590803100303>
- Mayr, J. (2015). Der Persönlichkeitsansatz in der Lehrerforschung [The personality approach in teacher research]. In Terhart, E., Bennewitz, H., Rothland, M. (eds). *Handbuch der Forschung zum Lehrerberuf* [Handbook of research on the teaching profession]. Münster: Waxmann. 189-215.
- McNamara, L., Colley, P. & Franklin, N. (2017). School recess, social connectedness and health: a Canadian perspective. *Health Promot Int.*, 32(2):392–402. <https://doi.org/10.1093/heapro/dav102>
- Mejeh, M. & Hascher, T. (2021). Soziale Netzwerkanalyse als Erfassungsinstrument sozialer Interaktionen in der Schule [Social network analysis as a tool for recording social interactions in schools]. In Hagenauer, G., Raufelder, D. (eds). *Soziale Eingebundenheit: Sozialbeziehungen im Fokus von Schule und LehrerInnenbildung* [Social inclusion: social relations in the focus of school and teacher education]. Münster, New York: Waxmann. 33-45.
- Meteyard, L. & Davies, R. (2020). Best practice guidance for linear mixed-effects models in psychological science. *J Mem Lang.*, 112:104092. <https://doi.org/10.1016/j.jml.2020.104092>
- Milyavskaya, M. & Koestner, R. (2011). Psychological needs, motivation, and wellbeing: A test of self-determination theory across multiple domains. *Pers Individ Differ.*, 50(3):387–91. <https://doi.org/10.1016/j.paid.2010.10.020>

- Moeed, A. & Averill, R. (2010). Education for the environment: Learning to care for the environment: A longitudinal case study. *Int. J. Learn.*, 17:179–192. <https://doi.org/10.18848/1447-9494/CGP/v17i05/47035>
- Mygind, E. (2007). A comparison between children's physical activity levels at school and learning in an outdoor environment. *J. Adv. Educ. Outdoor Learn.*, 2:161–176. <https://doi.org/10.1080/14729670701717580>
- Mygind, E. (2009). A comparison of childrens' statements about social relations and teaching in the classroom and in the outdoor environment. *J. Adventure Educ. Outdoor Learn.*, 9(2):151–169. <https://doi.org/10.1080/14729670902860809>
- Mygind, E. (2016). Physical activity during learning inside and outside the classroom. *Health behav. policy rev.*, 3(5):455-467. <https://doi.org/10.14485/HBPR.3.5.6>
- Mygind, E., Bølling, M., & Barfod, K. (2018a). Primary teachers' experiences with weekly education outside the classroom during a year. *Education 3-13*, 47(5):599-611. <https://doi.org/10.1080/03004279.2018.1513544>
- Mygind, L., Kjeldsted, E., Hartmeyer, R., Mygind, E., Bølling, M., Bentsen, P. (2019). Mental, physical and social health benefits of immersive nature-experience for children and adolescents: A systematic review and quality assessment of the evidence. *Health Place*, 58:102136. <https://doi.org/10.1016/j.healthplace.2019.05.014>
- Mygind, L., Stevenson, M., Liebst, L., Konvalinka, I., & Bentsen, P. (2018b). Stress Response and Cognitive Performance Modulation in Classroom versus Natural Environments: A Quasi-Experimental Pilot Study with Children. *Int. J. Environ. Res. Public Health*, 15(6):1098. <https://doi.org/10.3390/ijerph15061098>
- Németh, G. (2006). Health related quality of life outcome instruments. *Eur. Spine J.*, 15(1):44-51. <https://doi.org/10.1007/s00586-005-1046-8>
- Ng, J., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E., Ryan, R., Duda, J. & Williams, G. (2012). Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. *Perspect Psychol Sc.*, 4(7):325-340. <https://doi.org/10.1177/1745691612447309>
- Nielsen, G., Mygind, E., Bølling, M., Otte, C., Schneller, M., Schipperijn, J., Ejbye, 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*, 16:1117. <https://doi.org/10.1186/s12889-016-3780-8>
- Nix, F. (2017). *Zweites Staatsexamen KOMPAKT. Gut vorbereitet für die Lehramts-Prüfung* [Second state examina COMPACT. Well prepared for the teacher's examination]. Berlin: Cornelsen.
- Nooraie, R. Y., Sale, J., Marin, A., & Ross, L. (2020). Social Network Analysis: An Example of Fusion Between Quantitative and Qualitative Methods. *J Mix Methods Res*, 14(1):110–124. <https://doi.org/10.1177/1558689818804060>
- Noweski, C., Scheer, A., Büttner, N., von Thienen, J., Erdmann, J. & Meinel, C. (2012). Towards a Paradigm Shift in Education Practice: Developing Twenty-First Century Skills with Design Thinking. In Plattner, H., Meinel, C., Leifer, L. (eds). *Design Thinking Research. Understanding Innovation*. Berlin: Springer. 71-94. https://doi.org/10.1007/978-3-642-31991-4_5

- Otte, C. R., Bølling, M., Elsborg, P., Nielsen, G., & Bentsen, P. (2019b). Teaching maths outside the classroom: does it make a difference? *Educational Research*, 61(1):38-52. <https://doi.org/10.1080/00131881.2019.1567270>
- Otte, C. R., Bølling, M., Stevenson, M. P., Ejbye-Ernst, N., Nielsen, G., & Bentsen, P. (2019a). Education outside the classroom increases children's reading performance: Results from a one-year quasi-experimental study. *Int J Educ Res*, 94:42-51. <https://doi.org/10.1016/j.ijer.2019.01.009>
- Pachucki, M. C., Ozer, E. J., Barrat, A. & Cattuto, C. (2015). Mental health and social networks in early adolescence: A dynamic study of objectively-measured social interaction behaviors. *Soc. sci. med.*, 125:40–50. <https://doi.org/10.1016/j.socscimed.2014.04.015>
- Patton, G. C., Sawyer, S. M., Santelli, J. S., Ross, D. A., Afifi, R., Allen, N. B., ... & Viner, R. M. (2016). Our future: a Lancet commission on adolescent health and wellbeing. *Lancet*, 387(10036):2423-2478. [https://doi.org/10.1016/S0140-6736\(16\)00579-1](https://doi.org/10.1016/S0140-6736(16)00579-1)
- Pinheiro, R., Langa, P. V., & Pausits, A. (2015). The institutionalization of universities' third mission: Introduction to the special issue. *Eur. J. High. Educ.*, 5(3):227-232. <https://doi.org/10.1080/21568235.2015.1044551>
- Pluess, M., Assary, E., Lionetti, F., Lester, K. J., Krapohl, E., Aron, E. N., & Aron, A. (2018). Environmental sensitivity in children: Development of the Highly Sensitive Child Scale and identification of sensitivity groups. *Dev Psychol* 54(1), 51–70. <https://doi.org/10.1037/dev0000406>
- Power, C., Lake, J. & Cole, T. (1997). Measurement and long-term health risks of child and adolescent fatness. *Int J Obes*, 21:507-526.
- Price, J. K. (2015). Transforming learning for the smart learning environment: lessons learned from the Intel education initiatives. *Smart Learn. Environ.*, 2(1):16. <https://doi.org/10.1186/s40561-015-0022-y>
- Richardson, M., Hunt, A., Hinds, J., Bragg, R., Fido, D., Petronzi, D., Barbett, L., Clitherow, T., & White, M. (2018). A Measure of Nature Connectedness for Children and Adults: Validation, Performance, and Insights. *Sustainability*, 11(12):3250. <https://doi.org/10.3390/su11123250>
- Ripley, R. M., Snijders, T. A. B., Boda, Z., Vörös, A., Preciado, P. (2012). *Manual for Siena version 4.0*. Available from (11/05/23): https://www.stats.ox.ac.uk/~snijders/siena/s_man401.pdf
- Robert Bosch Stiftung [Robert Bosch Foundation] (2023). *Das Deutsche Schulbarometer. Aktuelle Herausforderungen der Schulen aus Sicht der Schulleitungen* [The German School Barometer. Current challenges facing schools from the perspective of school principals]. Stuttgart: Robert Bosch Stiftung. Available from: <https://deutsches-schulportal.de/deutsches-schulbarometer/>
- Robinson, S. (1969): *Bildungsreform als Revision des Curriculum* [Educational reform as a revision of the curriculum]. Neuwied/Berlin: Luchterhand.
- Ryan, R. & Deci E. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. New York City: Guilford Publications.
- Rychen, D. (2003). Key competencies: Meeting important challenges in life. In Rychen, D., Salganik, L. (eds). *Key competencies for a successful life and well-functioning society*. New York: Hogrefe Publishing GmbH. 63-108.

- Saavedra, A. & Opfer, V. (2012). Learning 21st-century skills requires 21st-century teaching. *Phi Delta Kappan*, 94(2):8-13. <https://doi.org/10.1177/003172171209400203>
- Sahrakhiz, S. (2017). The 'outdoor school' as a school improvement process: empirical results from the perspective of teachers in Germany. *Education 3-13*, 46(7):825-837. <https://doi.org/10.1080/03004279.2017.1371202>
- Sahrakhiz, S., Harring, M., & Witte, M. D. (2018). Learning opportunities in the outdoor school—empirical findings on outdoor school in Germany from the children's perspective. *J. Adventure Educ. Outdoor Learn.*, 18(3):214-226. <https://doi.org/10.1080/14729679.2017.1413404>
- Santelmann, M., Gosnell, H. & Meyers, S. (2011). Connecting children to the land: Place-based education in the muddy creek watershed. *Oregon. J. Geogr.*, 110:91-106. <https://doi.org/10.1080/00221341.2011.534172>
- Saqr, M. & Alamro, A. (2019). The role of social network analysis as a learning analytics tool in online problem based learning. *BMC Med Educ*, 19:160. <https://doi.org/10.1186/s12909-019-1599-6>
- Sawyer, S., Afifi, R., Bearinger, L. H., Blakemore, S., Dick, B., Ezeh, A., & Patton, G. (2012). Adolescence: a foundation for future health. *Lancet*, 379(9826):1630-1640. [https://doi.org/10.1016/S0140-6736\(12\)60072-5](https://doi.org/10.1016/S0140-6736(12)60072-5)
- Scherrer, V. & Preckel, F. (2019). Development of motivational variables and self-esteem during the school career: A meta-analysis of longitudinal studies. *Rev Educ Res.*, 89(2):211-58. <https://doi.org/10.3102/0034654318819127>
- Schleicher, A. (2011). The case for 21st century learning. *OECD Observer*, 282(283):42-43. Available from (11/05/23): <https://www.oecd-ilibrary.org/docserver/observer-v2010-6-en.pdf>
- Schneider, R., Sachse, K. A., Schipolowski, S., & Enke, F. (2021). Teaching in Times of COVID-19: The Evaluation of Distance Teaching in Elementary and Secondary Schools in Germany. *Front. Educ.*, 6:702406. <https://doi.org/10.3389/educ.2021.702406>
- Schneller, M. B., Duncan, S., Schipperijn, J., Nielsen, G., Mygind, E., Bentsen, P. (2017a). 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>
- Schneller, M. B., Schipperijn, J., Nielsen, G., & Bentsen, P. (2017b). Children's physical activity during a segmented school week: results from a quasi-experimental education outside the classroom intervention. *Int. J. Behav. Nutr. Phys. Act.*, 14(1):80. <https://doi.org/10.1186/s12966-017-0534-7>
- Scogin, S. C., Kruger, C. J., Jekkals, R. E., & Steinfeldt, C. (2017). Learning by experience in a standardized testing culture: Investigation of a middle school experiential learning program. *J. Exp. Educ.*, 40(1):39-57. <https://doi.org/10.1177/1053825916685737>
- Seppala, E., Rossomando, T. & Doty, J. R. (2013). Social connection and compassion: important predictors of health and well-being. *Soc. Res.*, 80(2):411-430. Available from (11/05/23): <https://muse.jhu.edu/article/528212>
- Shell Jugendstudie [Shell Youth Study] (2019). Jugend 2019. *Eine Generation meldet sich zu Wort* [Youth 2019. A generation speaks out]. Weinheim: Beltz.

- Shumate, M. & Palazzolo, E. T. (2010). Exponential random graph (p^*) models as a method for social network analysis in communication research. *Commun Methods Meas*, 4(4):341–371. <https://doi.org/10.1080/19312458.2010.527869>
- Snijders, T., van de Bunt, G. & Steglich, C. (2010). Introduction to stochastic actor-based models for network dynamics. *Social Networks*, 32(1):44-60. <https://doi.org/10.1016/j.socnet.2009.02.004>
- Soga, M., & Gaston, K. J. (2016). Extinction of experience: The loss of human-nature interactions. *Front Ecol Environ*, 14(2):94-101. <https://doi.org/10.1002/fee.1225>
- Sommer, M., Rucht, D., Haunss, S., & Zajak, S. (2019). *Fridays for Future. Profil, Entstehung und Perspektiven der Protestbewegung in Deutschland [Fridays for Future. Profile, emergence and perspectives of the protest movement in Germany]*. Available from (11/05/23): <https://refubium.fu-berlin.de/handle/fub188/25384>
- Sonnenburg, N., Buddeberg, M., & Hornberg, S. (2022). The German school system in the COVID-19 pandemic era. *Tertium comparationis* 28(3):332-355. <https://doi.org/10.31244/tc.2022.03.05>
- Tam, K.-P. (2013). Concepts and measures related to connection to nature: Similarities and differences. *J Environ Psychol*, 34:64-78. <https://doi.org/10.1016/j.jenvp.2013.01.004>
- Taylor, G., Jungert, T., Mageau, G., 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. *Contemp Educ Psychol*, 39(4):342–358. <https://doi.org/10.1016/j.cedpsych.2014.08.002>
- Tenorth, H.E. (2003). "Wie ist Bildung möglich?". *Einige Antworten - und die Perspektive der Erziehungswissenschaft* ["How is education feasible?". Some Answers - and the Perspective of Educational Science]. *Zeitschrift für Pädagogik*, 49(3):422-430. Available from (11/05/23): https://www.pedocs.de/frontdoor.php?source_opus=3887
- Tenorth, H.E. (2012). *Bildung – Ressource im Konflikt [Education – A Resource in Conflict]*. *GWU*, 63(9/10):567-581. Available from (11/05/23): <https://www.fachportal-paedagogik.de/literatur/vollanzeige.html?FId=992009>
- Tican, C., & Deniz, S. (2019). Pre-service teachers' opinions about the use of 21st century learner and 21st century teacher skills. *Eur. Educ. Res. J.*, 8(1):181-197. <https://doi.org/10.12973/eu-jer.8.1.181>
- United Nations (2015). *Transforming our world: The 2030 agenda for sustainable development*. Available from (11/05/23): <https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf>
- Valeri, M., & Baggio, R. (2021). Social network analysis: Organizational implications in tourism management. *Int. J. Organ. Anal.*, 29(2):342-353. <https://doi.org/10.1108/IJOA-12-2019-1971>
- Vansteenkiste, M., Ryan, R.M. & Soenens, B. (2020). Basic psychological need theory: Advancements, critical themes, and future directions. *Motiv Emot* 44:1–31. <https://doi.org/10.1007/s11031-019-09818-1>
- Voogt, J. & Roblin, N. (2012). A comparative analysis of international frameworks for 21st century competences: Implications for national curriculum policies. *J. Curric. Stud.*, 44(3), 299-321. <https://doi.org/10.1080/00220272.2012.668938>

- Wahlström, M., Kocyba, P., De Vydt, M., & De Moor, J. (Eds.) (2019) *Protest for a future: Composition, mobilization and motives of the participants in Fridays For Future climate protests on 15 March, 2019 in 13 European cities. Project Report. Protest for a Future*. Available from (11/05/23): https://protestinstitut.eu/wp-content/uploads/2019/07/20190709_Protest-for-a-future_GCS-Descriptive-Report.pdf
- Wang, Y., McPherson, K., Marsh, T., Gortmaker, S. L., & Brown, M. (2011). Health and economic burden of the projected obesity trends in the USA and the UK. *Lancet*, 378(9793): 815-825. [https://doi.org/10.1016/S0140-6736\(11\)60814-3](https://doi.org/10.1016/S0140-6736(11)60814-3)
- Weinert, F. (2001). Qualifikation und Unterricht zwischen gesellschaftlichen Notwendigkeiten, pädagogischen Visionen und psychologischen Möglichkeiten [Qualification and teaching between social necessities, pedagogical visions and psychological possibilities]. In Melzer, W., Sandfuchs, U. (eds). *Was Schule leistet. Funktionen und Aufgaben von Schulen* [What school does. Functions and tasks of schools]. Weinheim: Juventa. 65–85. Available from (11/05/23): <https://swb.bsz-bw.de/DB=2.1/PPNSET?PPN=1164362364>
- Welsh, M. & Pennington, B. (1988). Assessing frontal lobe functioning in children: Views from developmental psychology. *Dev Neuropsychol*, 4(3), 199-230. <https://doi.org/10.1080/87565648809540405>
- Whitburn, J., Linklater, W. L., & Milfont, T. L. (2019). Exposure to urban nature and tree planting are related to pro-environmental behavior via connection to nature, the use of nature for psychological restoration, and environmental attitudes. *Environ Behav*, 51(7):787–810. <https://doi.org/10.1177/0013916517751009>
- Wiater, W. (2021). *Unterrichtsprinzipien: Prüfungswissen – Basiswissen Schulpädagogik* [Teaching Principles: Examination Knowledge - Basic Knowledge School Pedagogy] (8. Edition). Donauwörth: Auer.
- Winje, Ø., & Løndal, K. (2021). Wow! is that a birch leaf? In the picture it looked totally different': a pragmatist perspective on deep learning in Norwegian 'uteskole. *Education 3-13*, 51(1):1-14. <https://doi.org/10.1080/03004279.2021.1955946>
- Wolbring, L., Schmidt, S. C. E., Niessner, C., Woll, A., & Wäsche, H. (2022). Community networks of sport and physical activity promotion: an analysis of structural properties and conditions of cooperation. *BMC Public Health*, 22(1):1-14. <https://doi.org/10.1186/s12889-022-14383-3>
- World Health Organization (2023). *Health promoting schools*. Available from (11/05/23): https://www.who.int/health-topics/health-promoting-schools#tab=tab_1
- Yang, J., Zaitlen, N., Goddard, M., Visscher, P., & Price, A. (2014). Advantages and pitfalls in the application of mixed-model association methods. *Nat. Genet.*, 46(2):100-106. <https://doi.org/10.1038/ng.2876>
- Zander, L., Kolleck, N. & Hannover, N. (2014). Soziale Netzwerkanalyse in Bildungsforschung und Bildungspolitik [Social network analysis in educational research and policy]. *Z Erziehungswiss*, 26:1-8. <https://doi.org/10.1007/s11618-014-0545-y>

8 List of publications of the author

8.1 Scientific publications

- Blaschke, S., Carl, J., Ellinger, J., Birner, U. & Mess, F. (2021). The Role of Physical Activity-Related Health Competence and Leisure-Time Physical Activity for Physical Health and Metabolic Syndrome: A Structural Equation Modeling Approach for German Office Workers. *Int. J. Environ. Res. Public Health*, 18(19):10153. <https://doi.org/10.3390/ijerph181910153>
- Butscher, F., Ellinger, J., Singer, M. & Mall, C. (Under Review). Influencing factors for the implementation of school-based interventions promoting obesity prevention behaviors in children with low socioeconomic status: A systematic review. *BMC Public Health*.
- Ellinger, J. (Under Review). Don't put the greatest pressure on the weakest. *Scientometrics*.
- * Ellinger, J. (Under Review). Review on 'High-Quality Outdoor Learning. Evidence-based Education Outside the Classroom for Children, Teachers and Society'. *Child, Youth & Environment*.
- Ellinger, J. & Blaschke, S. (2022). „Mental kompetent und resilient“ - Wirksamkeit einer Intervention zur Förderung mentaler Gesundheitskompetenz und Resilienz bei jugendlichen Vereinsportlern. *Zeitschrift für Sportpsychologie*, 29(1), 33-34. <https://doi.org/10.1026/1612-5010/a000357>
- ** Ellinger, J., Mess, F., Bachner, J., von Au, J. & Mall, C. (2023). Changes in social interaction, social relatedness, and friendships in Education Outside the Classroom: A social network analysis. *Front. Psychol.*, 14:1031693. <https://doi.org/10.3389/fpsyg.2023.1031693>
- ** Ellinger, J., Mess, F., Blaschke, S. & Mall, C. (2022). Health-related quality of life, motivational regulation and Basic Psychological Need Satisfaction in Education Outside the Classroom: an explorative longitudinal pilot study. *BMC Public Health*, 22(49). <https://doi.org/10.1186/s12889-021-12450-9>
- * Ellinger, J., von Au, J., Bernhardt, L., Singer, M., Tangerding, S., Mall, C. (2022b) Eine Frage der Perspektive: Die Unterrichtssituation im Draußenunterricht [A matter of perspective: the classroom situation in outdoor education]. In von Au J., Jukker R. (eds). *Draussenlernen Neue Forschungsergebnisse und Praxiseinblicke für eine Bildung für nachhaltige Entwicklung [Outdoor Learning New research findings and practical insights for education for sustainable development]*. Bern: hep. 387–406. <https://www.hep-verlag.ch/draussenlernen>
- Jansen, P., Ellinger, J. & Lehmann, J. (2018). Increased physical education at school improves the visual-spatial cognition during adolescence. *Educ Psychol*, 38(7):964-976. <https://doi.org/10.1080/01443410.2018.1457777>
- * Lee, E.Y., de Lannoy, L., Li, Lucy, de Barros, M., Bentsen, P., Brussoni, M., Fiskum, T., ... Tremblay, M. & participating PLaTO-Net members (2022). Play, Learn, and Teach Outdoors – Network (PLaTO-Net): terminology, taxonomy, and ontology. *Int. J. Behav. Nutr.*, 9(66). <https://doi.org/10.1186/s12966-022-01294-0>

Unbehaun, D., Mall, C., Ellinger, J., Coskun, A., Jensen, J., Aal, K., Rüller, S., Eckehard, M., Meixner, C., Plangger, U. & Wulf, V. (2022). Augmented-Reality Approaches in Computer Supported Collaborative Sports: Early Empirical Insights explored from and designed with Sport Associations. *Proceedings of 20th European Conference on Computer-Supported Cooperative Work*, 6(2). <https://dl.eusset.eu/handle/20.500.12015/4392>

* Publications related to the topic of Education Outside the Classroom

** Publications, which are part of this dissertation

8.2 Publications related to Third-Mission

Das Netzwerk Draußenunterricht in Deutschland [DNDD] (2021). *Akteur*innen im Draußenunterricht* [Akteurs in Education Outside the Classroom]. <https://draussenunterricht.de/karte>

Mall, C., Ellinger, J., Tangerding, S. & von Au, J. (2022). *Eine Praxishandreichung zum Draußenunterricht* [A practical guideline for Education Outside the Classroom]. <https://doi:10.13140/RG.2.2.31579.59683>

Meyn, S., Ellinger, J. & Mall, C. (2022). Ideen für den Sportunterricht [Ideas for physical education] In: Schutzgemeinschaft Deutscher Wald, e.V. (ed). *Unterricht im Wald. Ordner Klasse 1&2* [Teaching in the forest. Folder grade 1&2]. (214-239).

9 Appendix

9.1 Supplementary materials on health-related quality of life, motivational regulation and Basic Psychological Need satisfaction

Characteristics of Education Outside the Classroom (EOtC) and Outdoor Teaching

EOtC in the form it was conducted at our partner school is inspired by the formats that have been successfully conducted around the world for many years. According to the underlying understanding, all out-of-school places can be considered as places for teaching. Natural spaces in particular are frequently used in regularly implemented concepts. Here, mostly the existing natural materials on site are used to obtain seating, writing supports and teaching materials (1, 2). Those approaches are characterised by student-centred, but teacher-facilitated learning, as well as a lot of experimental, self-determined and real-life practical learning in most of the EOtC-receiving groups and classes (3, 4). This concept is nevertheless closely aligned to the curriculum and, in combination with normal indoor lessons, could contribute to improved learning (5, 3). It can be assumed that the removal of all spatial boundaries and old established structures in the classroom contributes to a restructuring of the learning process and interpersonal relationships with many at least theoretically reasonable effects on the children (3, 6).

Supplementary Table 1 Model-fit parameters

Model		DF	AIC	p-value
1	Lme (Intrinsic ~ (Paut + Pcom + PSRC + PSRT) * Gender * Enquiry * Group, random = ~ 1 Code)	42	295.08	
	Lme (Intrinsic ~ (Paut + Pcom + PSRC + PSRT + Gender + Group) * Enquiry + (Paut + Pcom + PSRC + PSRT) * Group, random = ~ 1 Code)	20	261.59	0.856
2	Lme (Identified ~ (Paut + Pcom + PSRC + PSRT) * Gender * Enquiry * Group, random = ~ 1 Code)	42	285.95	
	Lme (Identified ~ (Paut + Pcom + PSRC + PSRT + Gender + Group) * Enquiry + (Paut + Pcom + PSRC + PSRT) * Group, random = ~ 1 Code)	20	253.23	0.826
3	Lme (Introjected ~ (Paut + Pcom + PSRC + PSRT) * Gender * Enquiry * Group, random = ~ 1 Code)	42	301.75	
	Lme (Introjected ~ (Paut + Pcom + PSRC + PSRT + Gender + Group) * Enquiry + (Paut + Pcom + PSRC + PSRT) * Group, random = ~ 1 Code)	20	290.95	0.029
4	Lme (External ~ (Paut + Pcom + PSRC + PSRT) * Gender * Enquiry * Group, random = ~ 1 Code)	42	277.33	
	Lme (External ~ (Paut + Pcom + PSRC + PSRT + Gender + Group) * Enquiry + (Paut + Pcom + PSRC + PSRT) * Group, random = ~ 1 Code)	20	260.61	0.105
5	Lme (OverallHRQoL ~ (Paut + Pcom + PSRC + PSRT) * Gender * Enquiry * Group, random = ~ 1 Code)	42	828.42	
	Lme (OverallHRQoL ~ (Paut + Pcom + PSRC + PSRT + Gender + Group) * Enquiry + (Paut + Pcom + PSRC + PSRT) * Group, random = ~ 1 Code)	20	709.07	<0.001

DF = Degrees of Freedom; AIC = Akaike Information Criterion; Intrinsic = Intrinsic Motivational Regulation; Identified = Identified Motivational Regulation; Introjected = Introjected Motivational Regulation; External = External Motivational Regulation; PAut = Perceived Autonomy; PCom = Perceived Competence; ; PSRC = Perceived Social Relatedness with Classmates; PSRT = Perceived Social Relatedness with Teachers; OverallHRQoL = Overall Health-Related Quality of Life

Supplementary Table 2 Results of multivariate analysis of variance regarding group differences in BPN scores, p-values (p), effect sizes (η^2), F-statistics (F) and confidence intervals (CI)

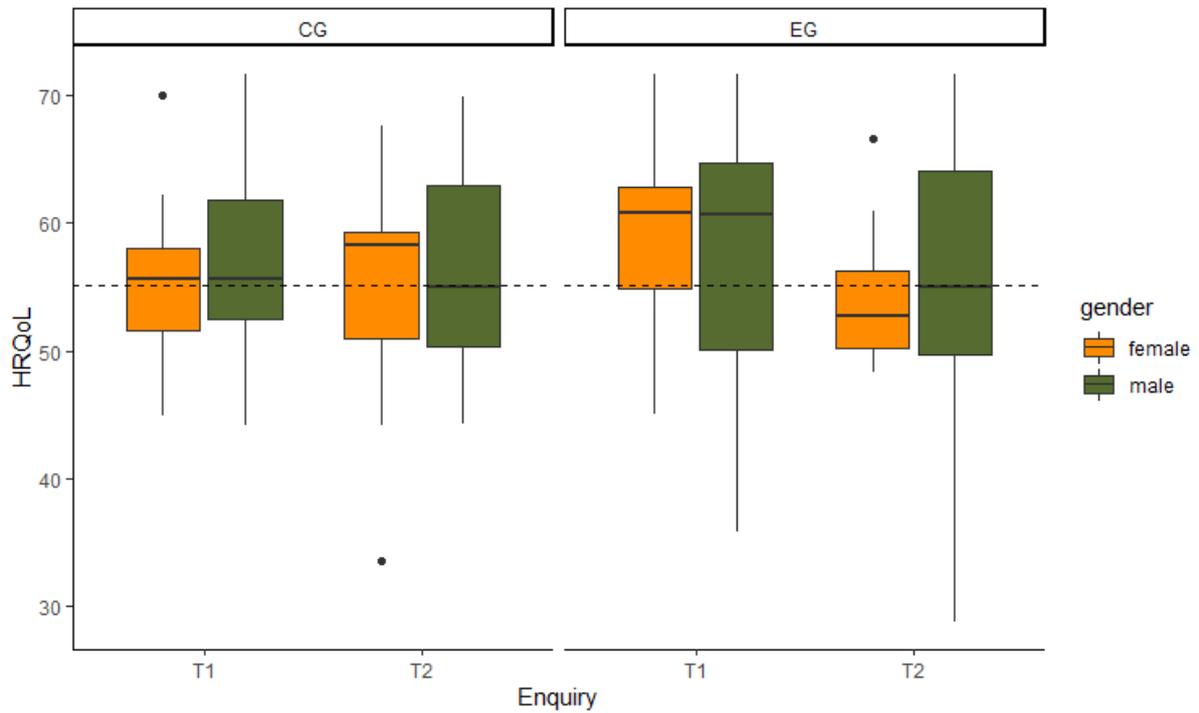
	p	η^2	F	CI*
PAut	<0.05	0.17	6.276	-0.19 / 0.53
PCom	<0.01	0.43	11.218	-0.10 / 0.61
PSRT	0.778	0.15	3.160	-0.18 / 0.40
PSRC	<0.001	0.50	14.547	-0.37 / 0.20

*95%, Lower / Upper confidence interval; PAut = Perceived Autonomy; PCom = Perceived Competence; PSRC = Perceived Social Relatedness with Classmates; PSRT = Perceived Social Relatedness with Teachers

Supplementary Table 3 Statistical characteristics for the satisfaction of the BPN of PSRT, PSRC, PAut and PCom between groups and enquiries.

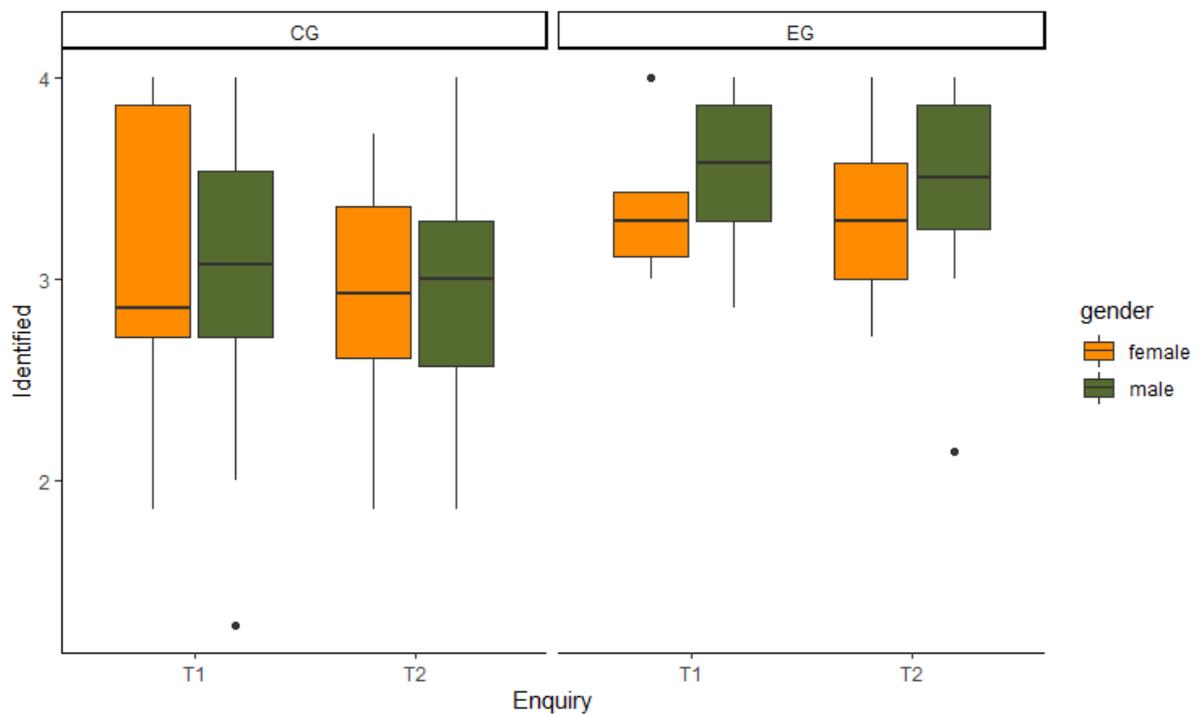
			T 1				T 2			
			PSRT	PSRC	PAut	PCom	PSRT	PSRC	PAut	PCom
EG	Girls	M	4.18	4.25	3.86	4.15	4.27	4.14	4.09	4.19
		SD	0.54	0.76	0.68	0.68	0.39	0.62	0.38	0.32
		CI*	3.86 / 4.5	3.8 / 4.7	3.46 / 4.26	3.75 / 4.55	4.04 / 4.5	3.78 / 4.5	3.87 / 4.28	4.0 / 4.38
	Boys	M	4.37	4.38	4.10	4.21	4.29	4.31	4.18	4.34
		SD	0.60	0.39	0.61	0.52	0.76	0.53	0.66	0.51
		CI*	4.04 / 4.96	4.18 / 4.58	4.42 / 3.78	4.48 / 3.94	3.89 / 4.69	4.03 / 4.59	3.84 / 4.58	4.08 / 4.6
	All	M	4.31	4.34	3.99	4.18	4.28	4.23	4.14	4.27
		SD	0.58	0.60	0.65	0.60	0.61	0.58	0.54	0.43
		CI*	4.08 / 4.54	4.11 / 4.57	3.74 / 4.24	3.95 / 4.41	4.04 / 4.52	4.0 / 4.46	3.93 / 4.35	4.1 / 4.44
CG	Girls	M	4.13	4.42	3.95	4.03	4.13	4.52	3.68	3.81
		SD	0.77	0.50	0.67	0.50	0.78	0.70	0.67	0.67
		CI*	4.52 / 3.74	4.27 / 4.67	3.61 / 4.29	3.78 / 4.28	3.74 / 4.52	4.14 / 4.88	3.34 / 4.02	3.47 / 4.15
	Boys	M	3.81	4.64	3.89	3.91	3.44	4.35	3.57	3.77
		SD	0.63	0.44	0.47	0.63	0.74	0.68	0.61	0.59
		CI*	3.57 / 4.05	4.47 / 4.81	3.71 / 4.07	3.67 / 4.15	3.15 / 3.73	4.09 / 4.61	3.34 / 3.8	3.54 / 4.0
	All	M	3.93	4.56	3.91	3.96	3.59	4.41	3.52	3.79
		SD	0.70	0.48	0.56	0.59	0.82	0.69	0.63	0.62
		CI*	3.72 / 4.14	4.41 / 4.71	3.74 / 4.08	3.16 / 4.14	3.34 / 3.84	4.2 / 4.62	3.33 / 3.71	3.6 / 3.98
All	M	4.07	4.48	3.94	4.04	3.85	4.34	3.75	3.97	
	SD	0.68	0.54	0.60	0.60	0.81	0.66	0.65	0.61	
	CI*	3.91 / 4.23	4.35 / 4.61	3.8 / 4.08	3.9 / 4.18	3.66 / 4.04	3.74 / 4.5	3.59 / 3.91	3.82 / 4.12	

PSRT = Perceived social relatedness with teachers; PSRC = Perceived social relatedness with classmates; PCom = Perceived Competence; PAut = Perceived Autonomy; M = mean; SD = standard deviation; CI = confidence interval; * 95%, Lower / Upper CI



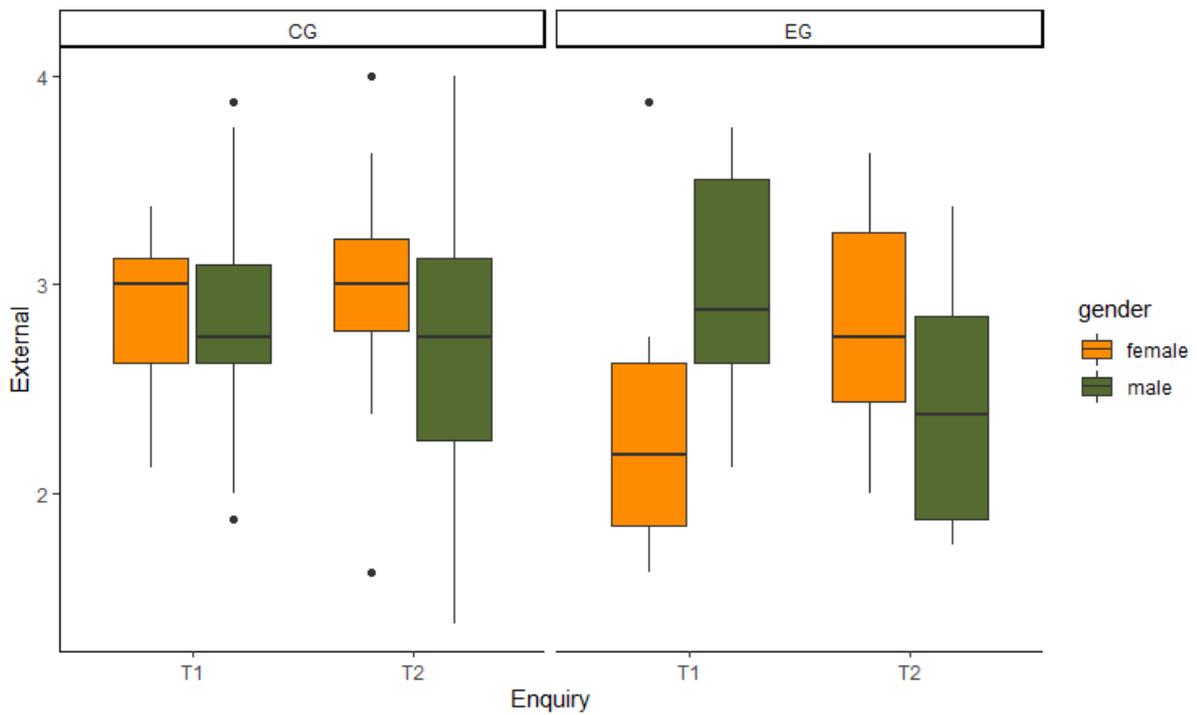
Supplementary Fig. 1 HRQoL scores between groups, genders and time points with reference line representing a large-scale representative study on German children and adolescents (6)

HRQoL = Health-Related Quality of Life; CG = Control Group; EG = Experimental Group; T1 = First time point; T2 = Second time point

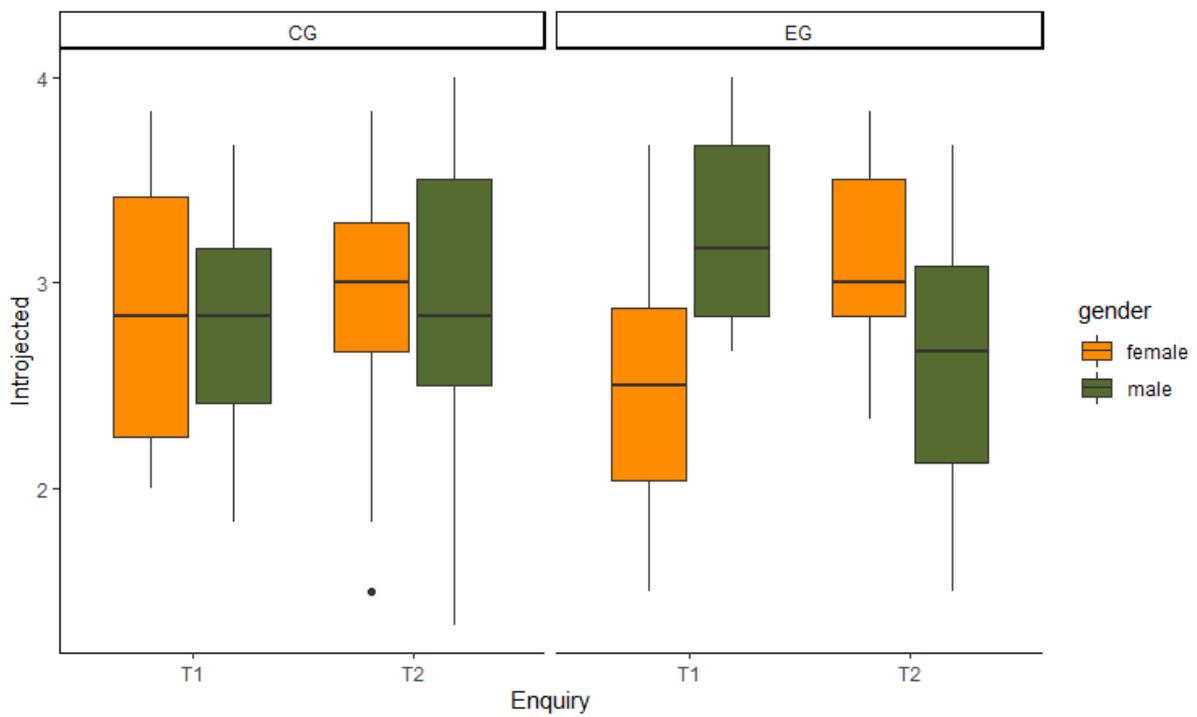


Supplementary Fig. 2 Scores of identified motivational regulation between groups, genders and time points

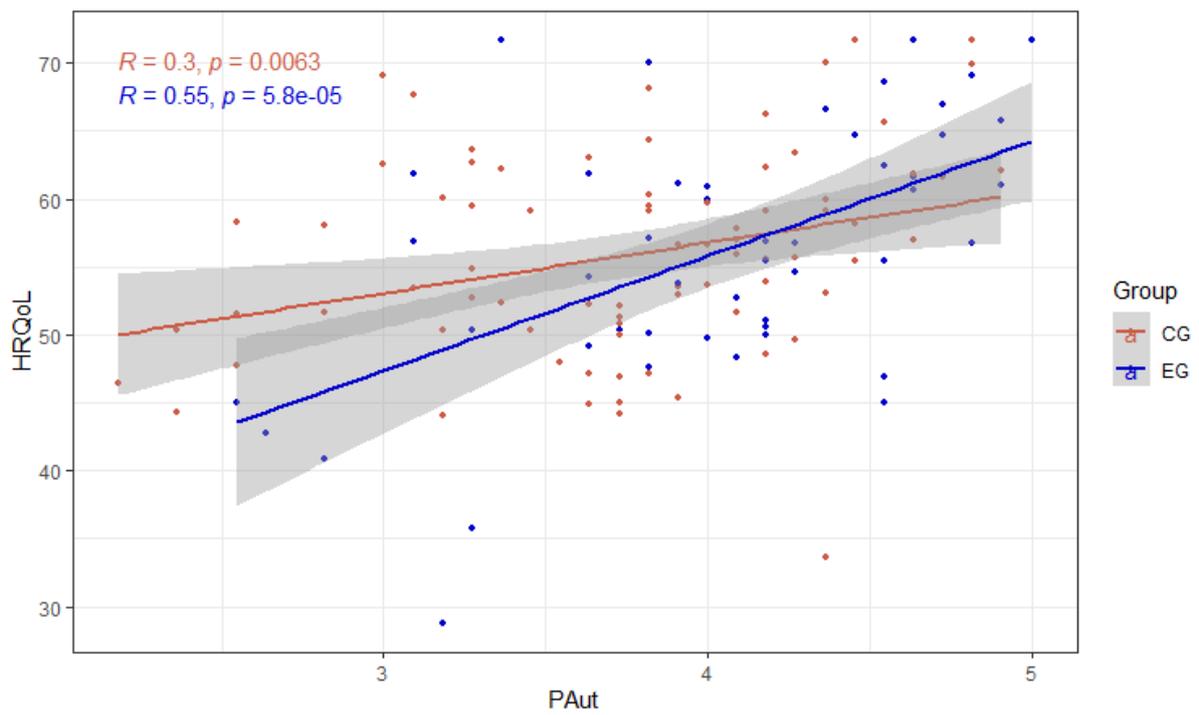
Identified = Identified Motivational Regulation; CG = Control Group; EG = Experimental Group; T1 = First time point; T2 = Second time point



Supplementary Fig. 3 Scores of external motivational regulation between groups, genders and time points
 External = External Motivational Regulation; CG = Control Group; EG = Experimental Group; T1 = First time point; T2 = Second time point

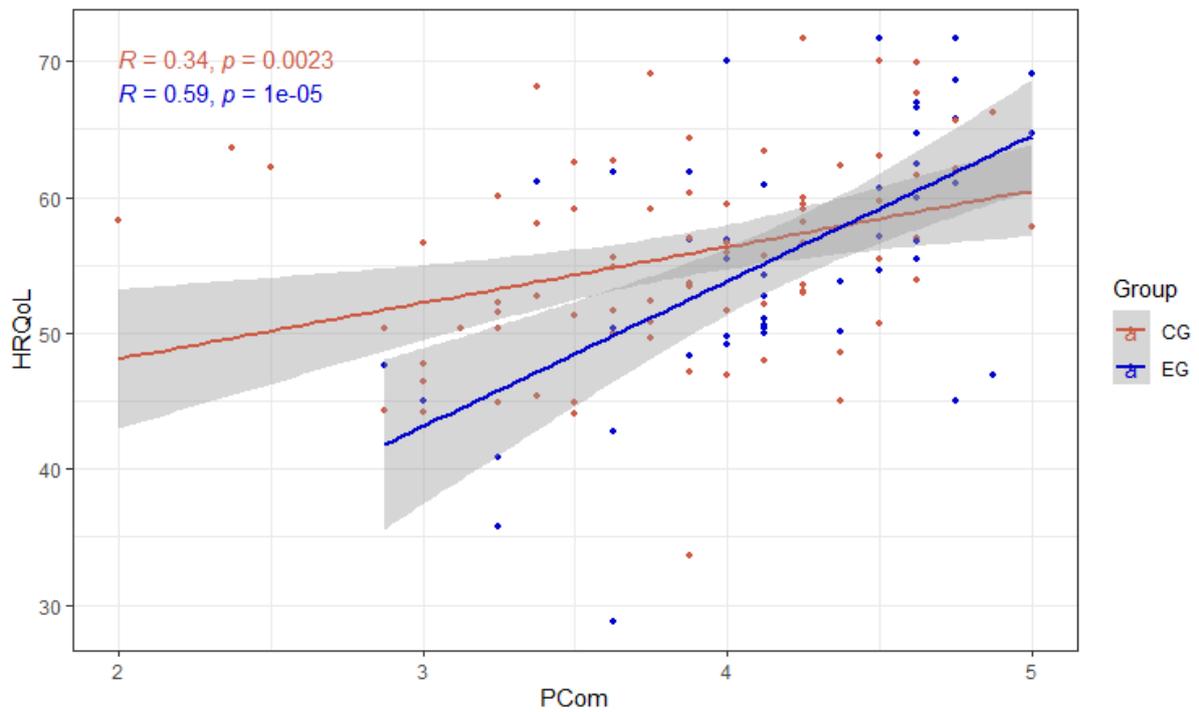


Supplementary Fig. 4 Scores of introjected motivational regulation between groups, genders and time points
 Introjected = Introjected Motivational Regulation; CG = Control Group; EG = Experimental Group; T1 = First time point; T2 = Second time point



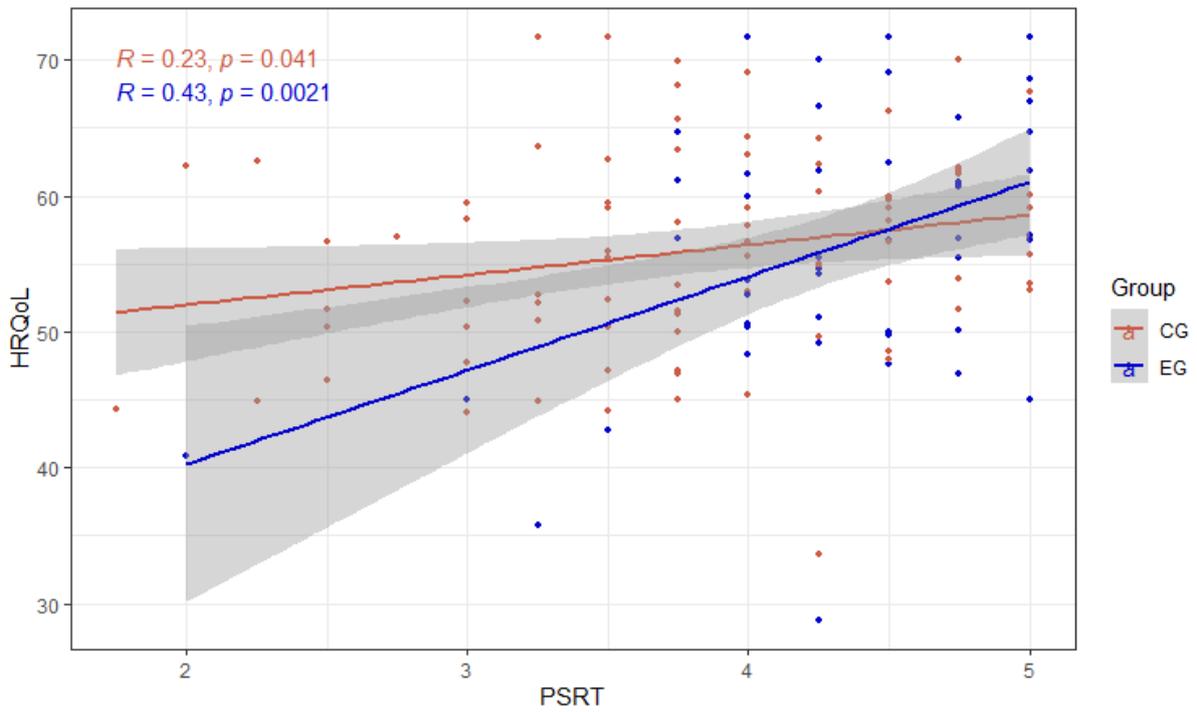
Supplementary Fig. 5 PAut and HRQoL between groups over all time points

HRQoL = Health-related quality of life; PAut = Perceived autonomy; CG = Control group; EG = Experimental group



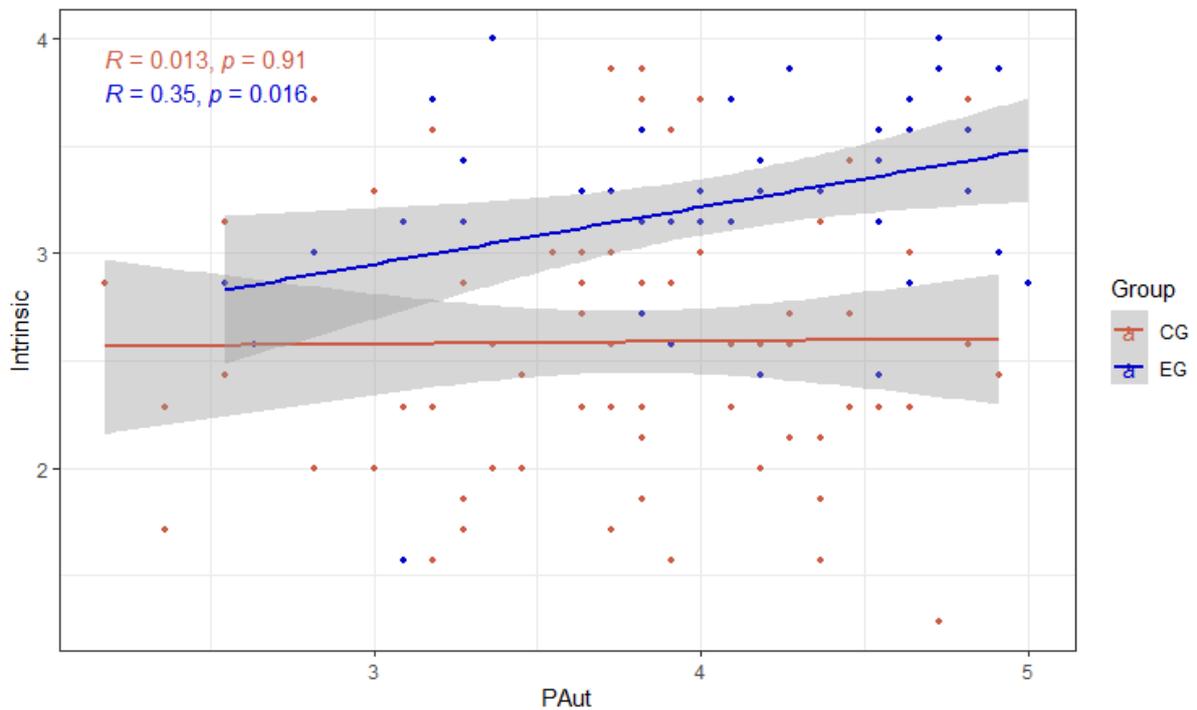
Supplementary Fig. 6 PCom and HRQoL between groups over all time points

HRQoL = Health-related quality of life; PCom = Perceived competence; CG = Control group; EG = Experimental group



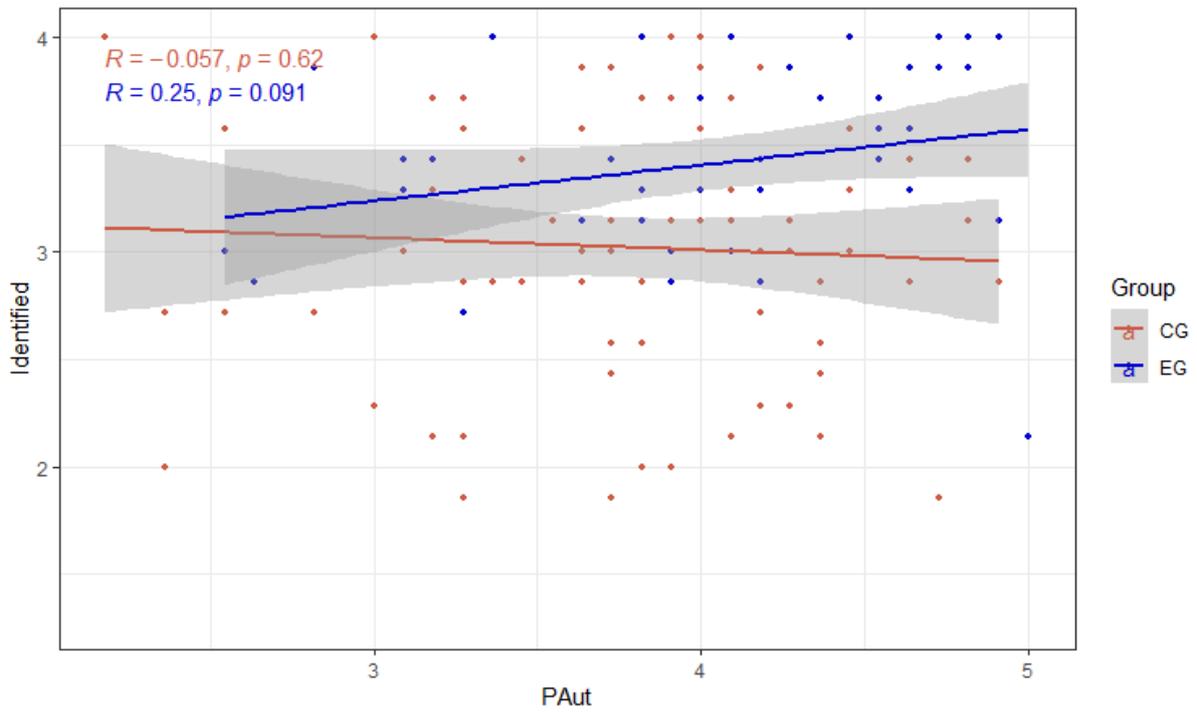
Supplementary Fig. 7 PSRT and HRQoL between groups over all time points

HRQoL = Health-related quality of life; PSRT = Perceived social relatedness with teachers; CG = Control group; EG = Experimental group

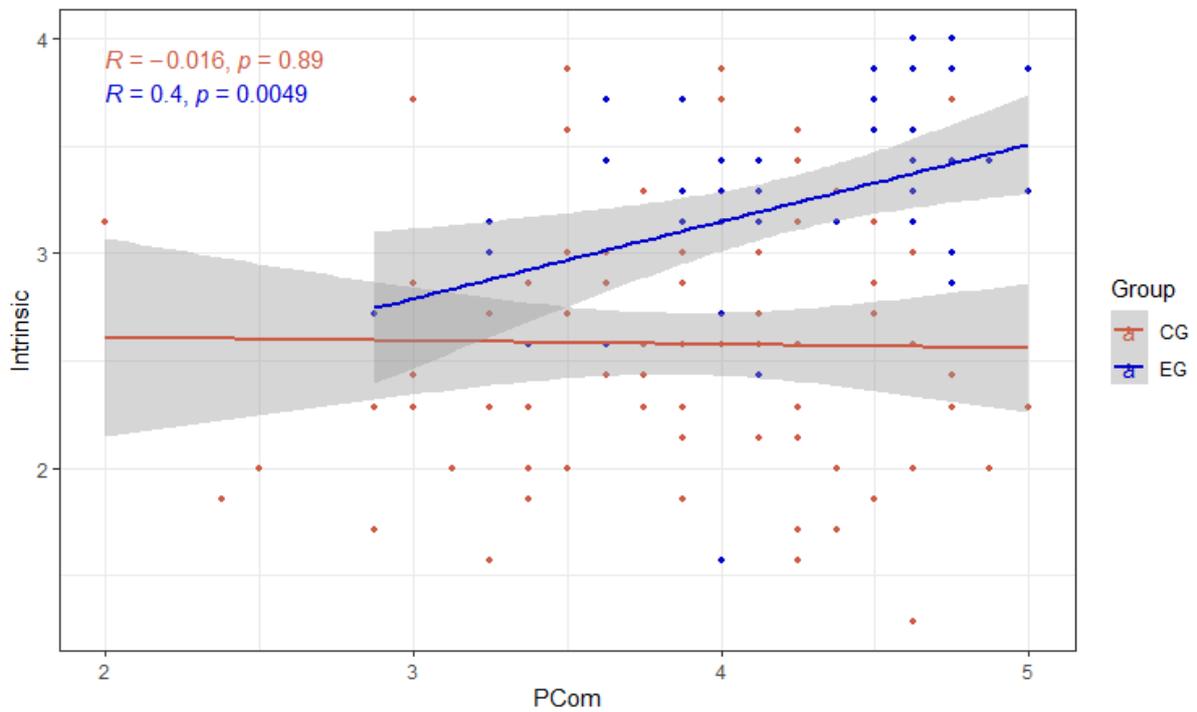


Supplementary Fig. 8 PAut and intrinsic motivational regulation between groups over all time points

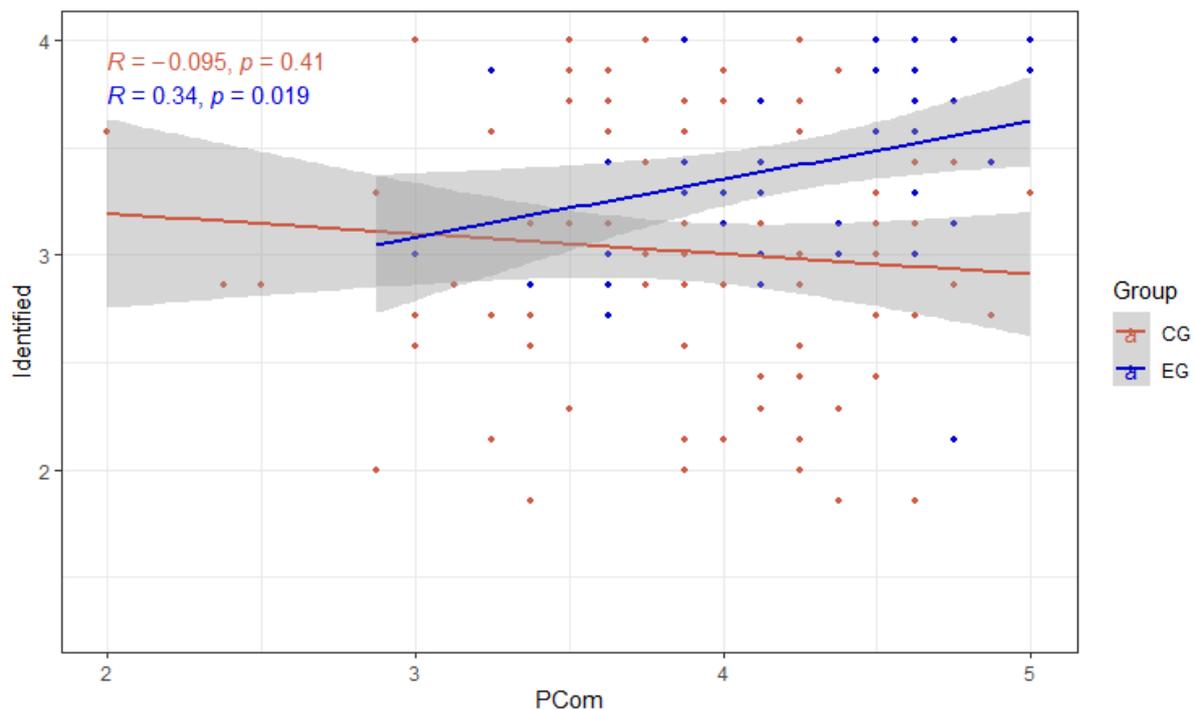
Intrinsic = Intrinsic motivational regulation; PAut = Perceived autonomy; CG = Control group; EG = Experimental group



Supplementary Fig. 9 PAut and identified motivational regulation between groups over all time points
 Identified = Identified motivational regulation; PAut = Perceived autonomy; CG = Control group; EG = Experimental group



Supplementary Fig. 10 PCom and intrinsic motivational regulation between groups over all time points
 Intrinsic = Intrinsic motivational regulation; PCom = Perceived competence; CG = Control group; EG = Experimental group



Supplementary Fig. 11 PCom and identified motivational regulation between groups over all time points
 Identified = Intrinsic motivational regulation; PCom = Perceived competence; CG = Control group; EG = Experimental group

References

1. Beames S, Higgins P, Nicol R. Learning outside the classroom: Theory and guidelines for practice. London: Routledge; 2012.
2. Bentsen P, Jensen F, Mygind E, Randrup T. The extent and dissemination of udeskole in Danish schools. Urban For Urban Green. 2010;9(3):235–243. <https://doi.org/10.1016/j.ufug.2010.02.001>.
3. von Au J. Outdoor Education an Schulen in Dänemark, Schottland und Deutschland – kompetenzorientierte und kontextspezifische Einflüsse auf Intentionen und Handlungen von Erfahrenen Outdoor Education-Lehrpersonen [Outdoor Education in Danish, Scottish and German Schools - Competence Oriented and Context Specific Influences on Intentions and Actions of Experienced Outdoor Education Teachers]. Heidelberg; 2016.
4. Bentsen P, Mygind L, Elsborg B, Nielsen G, Mygind E. Education outside the classroom as upstream school health promotion: 'adding-in' physical activity into children's everyday life and settings. Scand J Public Health. 2021;1(9). <https://doi.org/10.1177/1403494821993715>.
5. Barfod K, Eibye-Ernst N, Mygind L, Bentsen P. Increased provision of udeskole in Danish schools: an updated national population survey. Urban For Urban Green. 2016;20:277-281. <https://doi.org/10.1016/j.ufug.2016.09.012>.
6. von Au J. Outdoor Days - Draußentage - Lernen mit Herz, Hand und viel Verstand [Learning with passion, hand and a clear mind]. Pädagogik. 2018;4(18):10–13.
7. Ellert U, Brettschneider A-K, Ravens-Sieberer U, Group KS. Gesundheitsbezogene Lebensqualität bei Kindern und Jugendlichen in Deutschland [Health-related quality of life among children and adolescents in Germany]. Bundesgesundheitsbl. 2014;57(7):798-806. <https://doi.org/10.1007/s00103-007-0244-4>.

9.2 Activities regarding network development and maintenance

Appendix Table 1: Milestone activities regarding the development and maintenance of a network regarding Education Outside the Classroom and Outdoor Learning in Germany.

Date	Event / Development	Result
October 2019	Research Roundtable and Network Meeting "Draussen unterrichten" in Zurich, Switzerland (organized by SILVIVA Foundation and WWF Switzerland)	Insight into the work of Swiss colleagues; inspiration and vision for the German network; networking with actors from practice, science and society
October 2020	Development and publication of "Praxishinweise für den Draußenunterricht – Eine Handreichung" (Mall et al., 2021)	First freely available abridged version of the most important aspects related to EOtC (introductory reading); reduced barrier to entry for interested teachers; estimated to have been downloaded about 2.500 times to date
March 2021	Launch of the first Google-based map with incomplete representation of EOtC stakeholders in Germany (DNDD, 2021) with estimated 4.000 views up to date	Possibility of networking (e.g. for the purpose of job shadowing of teachers), basis for later estimates of the spread of EOtC in Germany
May 2021	Launch of the website "draussen-unterricht.de" as future landing page of the network to be founded in cooperation with the Schutzgemeinschaft Deutscher Wald - Landesverband Bayern e.V.	First systematic presentation of existing and possible activities of the members of the network and targeted support for interested external persons
July 2021	First digital meeting of the "Netzwerk Draußenunterricht" with different actors from Germany from the fields of practice, science and society (unofficial network establishment)	Formation of a group of committed persons for the initial network work until the financial framework has been created; efficient exchange in thematically closed working groups
October 2022	First official meeting on EOtC and Outdoor Learning in Germany in Bad Sulza under the patronage of the Schutzgemeinschaft Deutscher Wald - Landesverband Bayern e.V.	Experiencing a German EOtC-community for the first time; exchange on many levels; inspiration for the coming months and years
March 2023	Establishment of the foundation "Schule im Leben Die Stiftung für Draußenlernen" for financing and as a legal framework for the future tasks of the network „Schule im Leben Die Stiftung für Draußenlernen“	Professionalization; legal and financial safeguarding (or framing) of network activities; prerequisite for acquisition of donations

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