Evaluating the impact of forest school programs:

evidence from secondary school students in Northern Germany

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Abstract

This research serves as an advanced pilot study that investigates the effect of a forest school program on secondary school students. The program aims to create a long-term feeling of responsibility through the integration of students in the sustainable management of their "own school forest". Although this study could not reveal statistically significant results, qualitative insights suggest that the program has improved student's understanding of how forests can contribute to combat climate change as well as the multiple consequences climate change can have on ecosystems, including forests. Through the comprehension of these interconnections, students appeared sensitized to the human role in the climate crisis and showed an increased motivation to act. This seems to have increased students' awareness of forests and climate change-related issues. The positive change in attitude is relatively small, but appears to imply a new appreciation of nature protection for some students. A key study insight is that more students wanted to reduce or forgo meat consumption in favor of the environment after the program took place. Results suggest that the most significant effect was an increase in student's wellbeing. The results provide relevant insights about the role of responsibility, practical and scientific participation and interdisciplinarity to enhance the effectiveness of forest school programs for secondary school students.

1 Introduction

Successful counteraction of global environmental issues requires a fundamental transformation towards more sustainable ways of living across the world. It is long known that pro-environmental behavior is influenced by environmental knowledge and attitude (Ramsey and Rickson, 1976), which are both shaped from an early age on. However, due to a cultural shift away from nature towards increased virtual and indoor recreation options, young adults in the modern urbanized society live more and more disconnected from the natural environment (Wolf and Moser, 2011; Kesebir and Kesebir, 2017; Aruguete et al., 2020). This increases the importance of environmental education (EE) programs that aim to foster environmental knowledge, attitudes and awareness amongst the young generation and prepare them how to address future environmental challenges (Bradley, et al., 1999). Forest schools are a type of EE in which children, mostly in the age of 3-11 years, regularly visit a specific natural place for a prolonged period of time to engage in various outdoor activities (Knight, 2018; Leather, 2018; Smith et al., 2018; Dabaja 2020). Amongst other beneficial impacts, they have proven to positively influence children's relationship to nature, environmental attitude, awareness, behavior and wellbeing (Smith et al., 2017).

In this paper, I applied the concept of forest schools to secondary school students in Germany to investigate the program's impact on student's knowledge, awareness, attitudes, willingness to donate (WTD), diet preferences and wellbeing. The program focused on the interrelations between forests and climate change and used an approach based on citizen science, stewardship and interdisciplinarity. For the impact evaluation, five classes from the 9th grade (ages 14-16 years) were divided into a control and treatment group. The treatment group consisted of three classes (82 students) which participated in four project interventions while the remaining two classes (51 students) did not take part in any of the interventions. A survey was distributed to the students before the first intervention to elicit student's initial level of knowledge, awareness, attitudes, WTD, diet preferences and wellbeing. Once the last intervention was concluded, the survey was distributed to the students again and treatment effects on the six outcome variables were estimated using a difference in difference estimator. Open-ended questions, short semi-structured interviews conducted throughout the project interventions and four in-depth interviews with treated students facilitated the

interpretation of quantitative results and revealed valuable insight into the mechanisms driving the impact of the program.

Forest school programs have been widely implemented at primary schools with children in the age of 3-11 years, using playful activities or tree planting events on small areas to increase connectedness to nature and learn about the natural environment (Turtle et al., 2015). Drawing on Waite et al. (2016), Smith, et al. (2018) and Dabaja (2021), the effects of these forest schools have been studied since more than two decades and indicate various positive impacts on involved children. There is little to no evidence, however, of approaches that adapt and advance the concept of forest school programs to secondary school students (Knight, 2016; Harris, 2021). Despite the existence of some projects at secondary schools in Germany, their design is still focused on the idea of afforesting small-scale areas (0.5 hectares) or using a forest to study and experience nature more generally.

This dissertation leveraged the unique opportunity to closely collaborate with the German nature protection foundation "Stiftung Wälder für Morgen" (Forests for Tomorrow). The foundation provides 85 hectares of existing forest stands to be integrated into the daily life of students at the Gymnasium Carolinum Neustrelitz, one of the largest secondary schools in Mecklenburg-Western Pomerania, Northern Germany. Together, the foundation and the school aim to develop and implement a "reinterpreted" forest school program over a period of 30 years. Due to the existing long and close relation I have to both the foundation and the school, I was trusted to significantly shape the design of the first project phase and conduct the interventions under guidance of the foundation myself.

Distinct from existing forms of forest schools, our program aims to actively integrate students into the sustainable management of existing forest stands which are around 100 years old. Starting with 10 hectares in 2021, this does not only encourage students to develop a strong feeling of responsibility and stewardship for "their school forest", but it also promotes a project-based, scientifically-oriented educational approach to enhance student's knowledge and awareness about the various interconnections of forests and climate change. This thematic focus is specifically relevant due to the rising importance of forests as one of the largest natural carbon sinks and the already visible impacts of climate change on forests in Germany (BMEL, 2021). While more recent forest school

projects also involve the planting of trees to actively help combating climate change (Schröer and Sauerwein, 2014), our project extents this form of climate action to a *long-term climate change mitigation and adaptation project* with students. Informed by an advanced study of the interaction of forests and climate change with scientific methods from forestry research, students will support the transformation of pine monocultures into more climate-resilient mixed forests in cooperation with practitioners and scientists. This responds to the issue that EE programs often do not adequately address the complexity and interrelation of specific environmental problems and do not offer concrete opportunities for participants to become active (Hudson, 2001; Davis, 2003). As an innovative and new interpretation of forest schools for teenagers, the project also contributes to Germany's aspirations of more sustainable forest management. This presents a prospect important for policy makers and other stakeholders who strive for collective climate action and coherent EE programs for students of all ages.

These aspects clearly differentiate our forest school program from other programs and offers a promising insight on how responsibility and scientifically-oriented activities might impact secondary school students. Although my results do not show any statistical significance, the direction of coefficients and qualitative insights from interviews suggest that the participation in the project positively influenced student's knowledge and awareness about forests and climate change. After their participation, students also showed an increased preference for more environmentally friendly diets and greater wellbeing compared to the control group. Due to time and resource constraints, my field experiment only reveals some first insights of potential impacts rather than quantifiable treatment effects. Further research would require a higher number of schools and students to achieve more robust and statistically significant results.

The major challenge in identifying the impact of forest school programs, even when using a field experiment involving a control group, is understanding the mechanisms that drive observed results. Through open-ended questions in the survey, short semi-structured and long in-depth interviews, I collected detailed information about student's perception about the project, revealing valuable additional insights. In particular, I find evidence that the changes in the outcome variables were mostly driven by the increase in knowledge. I also document that respondents enjoyed the prospect of sustainably managing "their school forest" and to build a long-term personal connection to it. Some students expressed

an increased interest in forests and climate change as well as stronger environmental future aspirations. Further, students showed a feeling of responsibility for "their" forests and stronger self-efficacy to solve environmental problems. Hence, this dissertation can be understood as an advanced pilot study that speaks to the literature on forest school programs for secondary school students as well as collective action to foster sustainable forest management (Hausler and Scherer-Lorenzen, 2001; CEPF, 2019).

The rest of this dissertation is organized as follows. Section 2 lays out the theoretical framework and the key research questions and hypotheses. Section 3 describes the methodology, including the experimental design and qualitative research methods. Section 4 presents the quantitative results complemented by additional insights revealed during qualitative interviews. Section 5 discusses key limitations, and section 6 concludes the dissertation.

2 Theoretical Framework

More and more children in modern urbanized environments seem to suffer from a decreasing connectedness to nature (Ramesteiner, 2009). Nature-based, experiential EE programs like forest schools have proven to counteract this development by fostering student's nature connectedness and understanding of the natural environment (Turtle et al., 2015). Drawing on key papers about forest school programs (Waite et al. 2016; Smith, et al., 2018; Dabaja, 2021), forest schools can have many different positive impacts on involved children. On the one hand, they improve social and cooperative skills, physical skills, motivation to learn and cognitive skills as well as emotional and mental wellbeing. On the other hand, involved children show improved environmental knowledge and stronger pro-environmental attitude, awareness and behavior (Knight, 2011).

Building on these positive findings about the effect forest school programs can have on primary school students, the main research question investigated through my field experiment is the following:

How do the first interventions of an advanced, long-term forest school program affect secondary school students in Northern Germany?

A wide range of authors in this strand of literature found that outdoor learning activities improve student's environmental knowledge (Rickinson, 2001; Liefländer et al., 2015; Otto and Pensini, 2017). In particular, the regular exploration of nature over an extended period of time seems to encourage individuals to question their knowledge about the current ecological crises, including climate change (O'Brien and Murray, 2007; Dunkley, 2016; Whitburn et al., 2020). Experiential learning also seems to inspire the understanding of complex relations between the environment and society and encourages young people to think about how environmental problems might influence their future (Mannion et al., 2013; Hung, 2014; Dunkley, 2016). After their participation, young students appear to increase their environmental attitudes and awareness of environmental problems (Ballantyne and Packer, 2009; Duerden and Witt, 2010; Monroe, 2019).

Another important strand of EE literature suggests that programs in which students take on responsibility, like school gardens or school farms (Bowker and Tearle, 2007; Feenstra and Ohmart, 2012), also show a positive effect on environmental knowledge and attitudes (Sellmann and Bogner, 2013a, 2013b; Sellmann, 2014). Similarly, using the example of climate change, Monroe et al. (2019) show that awareness and knowledge about potential global and local impacts are increased when students have the opportunity to conduct their own climate project in the larger context of their school or community. They explain that the feeling of self-efficacy motivates students and reduces the psychological distance they have to the environment (Corner et al., 2015). Pooley and O'Connor (2000) stress the importance of addressing emotional dimensions and cognitive beliefs of students when aiming to change their attitudes. Such emotions might involve the feeling of responsibility, pride or self-efficacy (Corner et al., 2015).

Taking the idea of responsibility and self-efficacy even further, Redondo et al. (2018) show that citizen science projects in schools can support meaningful learning and lead to a positive change in student's understanding of and attitudes towards science and the natural environment (Crane et al. 1994; George and Kaplan 1998; Brossard et al. 2005;

Queiruga and Saiz-Manzanares, 2018). Actively integrating students into sciences through performing authentic measurements and associated data analysis has proven to enhance their interest in the given topic. They also showed a stronger motivation to act as multiplicators spreading their knowledge and raising awareness about the issue they worked on (Gadermaier et al., 2018). Hence, the concept of citizen science offers a promising opportunity to raise public awareness, empower students and promote their environmental stewardship through EE programs (Brossard et al., 2005; Wals et al., 2014; ECSA, 2018; Schleicher and Schmidt, 2020).

Monroe et al. (2019) highlights the importance of EE to include personally relevant and meaningful information for students as well as using active and engaging teaching methods. They stressed the effectiveness of interacting with scientists, implementing school or community projects and addressing misconceptions about the issue at hand. Programs should be designed to build skills for assessing scientific conclusions and empower learners to contribute to solutions for the given environmental problem. Integrating these aspects into EE programs is rarely found but increasingly important to successfully build a new generation of environmentally-aware citizens (UNESCO, 2017).

Our forest school program for secondary school students builds on these findings and consciously integrated the above-mentioned aspects. Hence, I aim to answer the following research sub-questions and test the associated hypotheses:

Sub-question 1: Does the program affect student's knowledge, attitude and awareness about forests and climate change?

Hypothesis 1.1: *The program improves student's knowledge about forests and climate change.*

Hypothesis 1.2*: The program positively influences student's attitude about the importance of forests and their protection.*

Hypothesis 1.3*: The program raises student's awareness about issues related to forests and climate change.*

As a result of strengthened environmental attitudes and awareness, forest schools seem to encourage pro-environmental behavior (Ballantyne and Packer, 2009; Duerden and Witt, 2010) and action for sustainability (Higgins, 2009). Further, Otto and Pensini (2017) and Whithburn et al. (2019) explain that both increased environmental knowledge and connectedness to nature can take on a mediating function to promote ecological behavior. Littledyke (2008) found that the feeling of care has an additional positive effect on pro-environmental behavior. A sense of relationship and aesthetic appreciation of nature seems to foster this feeling of care (Midgely 1995; Ridley 1997). Interestingly, students with a larger affiliation towards the environment, pro-environmental attitudes or enhanced knowledge of ecosystem functions also seem to have a willingness to pay or donate for the environment (Ku and Zaroff, 2014; Forleo et al., 2019; Lundberg et al., 2019; Dardanoni and Guerriero, 2021).

In the context of mitigation and adaptation efforts to environmental problems, like climate change, individuals who have direct experience with potential consequences seem to be more concerned. As a result, they are more inclined to undertake sustainable behaviors or contribute to finding solutions for the specific problem (Schultz, 2002; Spence et al., 2011; Myers et al., 2013). Hence, conducting scientific research about the interconnection between forests and climate change and experiencing climate change impacts in "their own forest" might encourage student to help combating climate change through their own projects or changed behaviors (Athman and Monroe, 2002).

Since our forest school program was designed with a major focus on climate change and forest-related issues and discusses the detrimental consequences meat consumption has on both climate change and forest ecosystems, the following second sub-question and related hypotheses have been formulated:

Sub-question 2: Does the program affect student's dietary preferences or willingness to donate for forest protection?

> ***Hypothesis 2.1****: The program increases student's motivation to have a more sustainable diet for environmental reasons.*

Hypothesis 2.2*: The program increases student's willingness to donate (WTD) for an organization protecting forest ecosystems.*

Knight (2011) highlights the positive impact forest school programs can have on children's wellbeing through the regular direct contact to nature and outdoor experience. At the same time, emerging literature on eco-anxiety raises the question whether an EE program about environmental challenges might potentially decrease student's wellbeing (Pihkala, 2020a, 2020b). In our project, students should not only learn about the already visible consequences of climate change on forests in their region, which could leave them with a feeling of fear and powerlessness. Rather, through the intensive integration in sustainable forest management practices students will have the concrete opportunity to counteract the environmental problems they learn about. This leads to the third sub-question:

Sub-question 3: Does the program improve student's wellbeing?

The major challenge when studying the impacts of forest school programs is to understand the mechanisms that underlie observed results. For example, various authors suggest that increased knowledge after EE programs leads to changes in attitude and awareness. In addition, emotions when being outside might enhance the appreciation of nature and, hence, influence participants. Especially due to the continuing COVID-19 pandemic, students might particularly enjoy seeing each other outside after a long time (Caffo et al., 2020).

Since a holistic evaluation of underlying mechanisms through a mediation analysis (Thapa, 2010) would have been outside the scope of this study, qualitative semi-structured interviews were not only conducted to investigate the above three research sub-questions in further detail, but also to get a deeper insight into the mechanisms that underlie the potential impacts of the project on the secondary school students. Thus, the qualitative investigation aimed to get insights about the following sub-question:

Sub-question 4: Which mechanisms led to (potentially) observed changes?

Due to limited resources, the scope of my research is limited to identifying first tendencies of potential effects of the advanced forest school program. I attempt to draw on theory of

EE to explain the direction of my results, complemented by valuable qualitative insights from semi-structured and in-depth interviews.

3 Methodology

3.1 Experimental Design

I employed a mixed-method experimental approach using a treatment and a control group to investigate a potential treatment effect of our forest school program on six outcome variables, namely knowledge, attitude, awareness, diet, willingness to donate (WTD) and wellbeing of secondary school students. I collaborated with the local nature protection foundation "Stiftung Wälder für Morgen" to design and implement the forest school program. The combination of quantitative and qualitative research methods will allow me to learn about the effects of my program from various analytical perspectives and to answer my research questions more holistically (Barraza and Pineda, 2003). Written consent to participate both in the study and the interventions was received from student's parents before the first survey was distributed. Before the field work started, my study has been reviewed and approved by the LSE Research Ethics Committee and a risk assessment has been approved by the Health and Safety team for in-person interviews during the outside intervention.

3.1.1 Sampling and Compliance

The Gymnasium Carolinum Neustrelitz in Northern Germany was chosen for my field experiment due to the high interest of the headmaster to implement the forest school program at his school. The 9th grade participated in the project since students were in the ideal age range for my research purposes (ages 14-16 years) and due to organizational reasons. The field experiment was conducted with a total of 133 students (from five classes). 82 students received the four main project interventions and served as the experimental group, 51 students served as a control group. The control group was selected at the same school since students from the nearest available secondary school were expected to come from different catchment areas, creating possible confounders that might be difficult to control for.

Unfortunately, a random selection of students receiving the treatment was not possible due to the following reasons. First, this would have had significant organizational implications for me as a researcher and involved teachers who already faced additional difficulties due to ongoing remote teaching requirements. Second, mixing students from different classes during the in-person excursion would have been more problematic due to COVID-19 restrictions. Third, randomly selecting single students from the classes could have been perceived as unfair by other students in the class that were not selected and would have increased the likelihood of spillover effects, since more interaction is expected to take place within than across classes. Although the failure of random allocation impedes one of the main necessary assumptions of a randomized controlled trial with the analysis occurring at the individual level, I had to follow a clustered randomization process at the class level (Stock and Watson, 2015).

All five classes were asked to fill out a questionnaire before the treatment started and again after the treatment ended (Figure 3) (Cetin and Nisanci, 2010). My initial data base of 133 students was significantly reduced because only 82 students filled out both the first and second questionnaire, including 53 students from the treatment group and 29 students from the control group (Table 1), corresponding to a response rate of 62%. The gender and age distributions within the treatment and control group are presented in Figures 1 and 2, respectively. Attendance lists allowed me to ensure that all students of the treatment group received the treatment, so I could exclude the problem of non-compliance. This justifies the estimation of the Average Treatment Effect (ATE) as opposed to the Local Average Treatment Effect (LATE), i.e. the ATE among compliers (Angrist et al., 1996).

	Total number of students	
	Control	**Treatment**
Male	8	26
Female	21	27
Total	**29**	**53**

Table 1: Summary statistics on the size and gender distribution of the control and treatment group

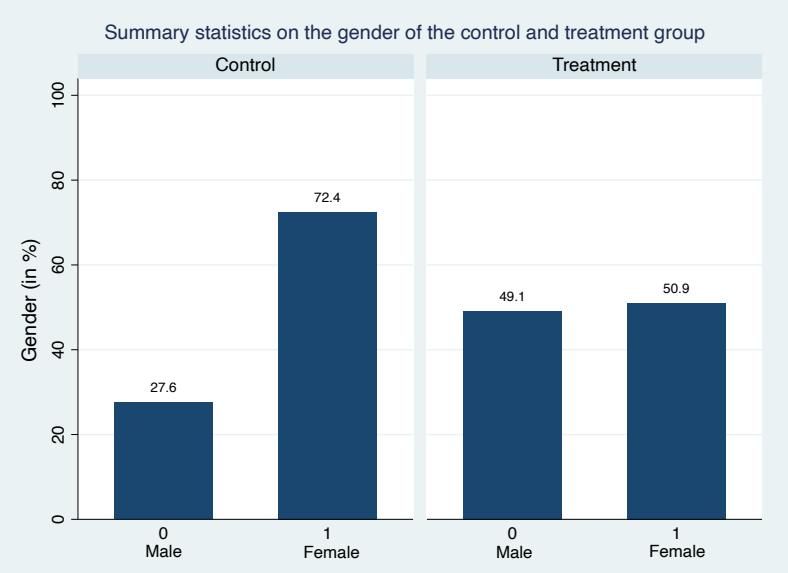

Figure 1: Gender distribution of the control and treatment group (in percentages)

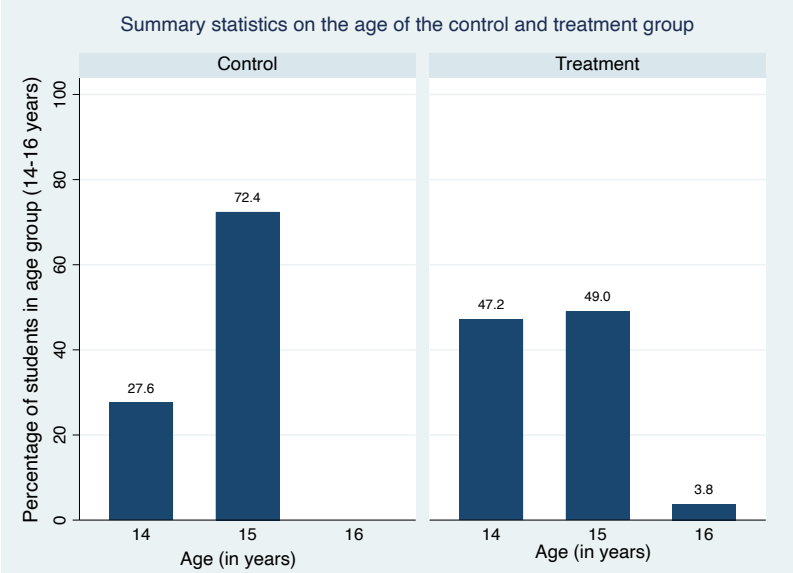

Figure 2: Age distribution of the control and treatment group (in percentages)

3.1.2 Treatment Interventions

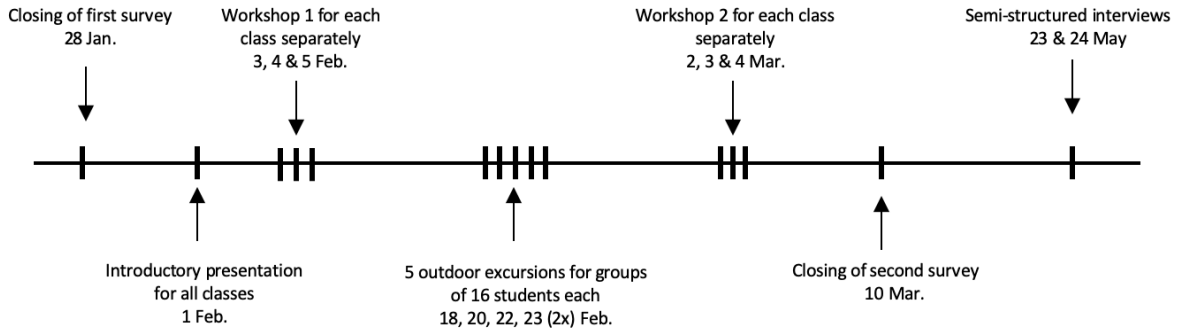

Figure 3: Timeline of the experiment

The structure of the forest school program was developed in cooperation with the foundation "Stiftung Wälder für Morgen". Various other experts were consulted and we attended a conference about forests schools in Germany to improve the design of the program (SDW, 2020). Existing material for forest schools was adapted to the specific age group and focus of our program. The interventions were tested with students in the same age group to ensure that the difficulty of the content and activities was appropriate. Given the limited time that was available to design the program and to conduct my research, we focused on four main interventions taking place from January to March 2021 (Figure 4). The outdoor excursion (intervention 3) was focused on one forest stand of 7 hectares close to the school (Figure 5). Due to the ongoing COVID-19 pandemic and remote teaching, the first, second and final intervention were conducted online via Zoom. To reduce variation associated with different teaching styles and techniques, I conducted all interventions myself together with the CEO of the foundation. The active participation allowed me to build trust with participants, enabling more open and undistorted communication (Wals, 1994). Although volunteers differed in the excursions for different classes, each student was exposed to the same ideas and concepts throughout the program. A detailed project description for teachers and assistants as well as selected material and pictures from the outdoor excursion can be found in Appendix 1.

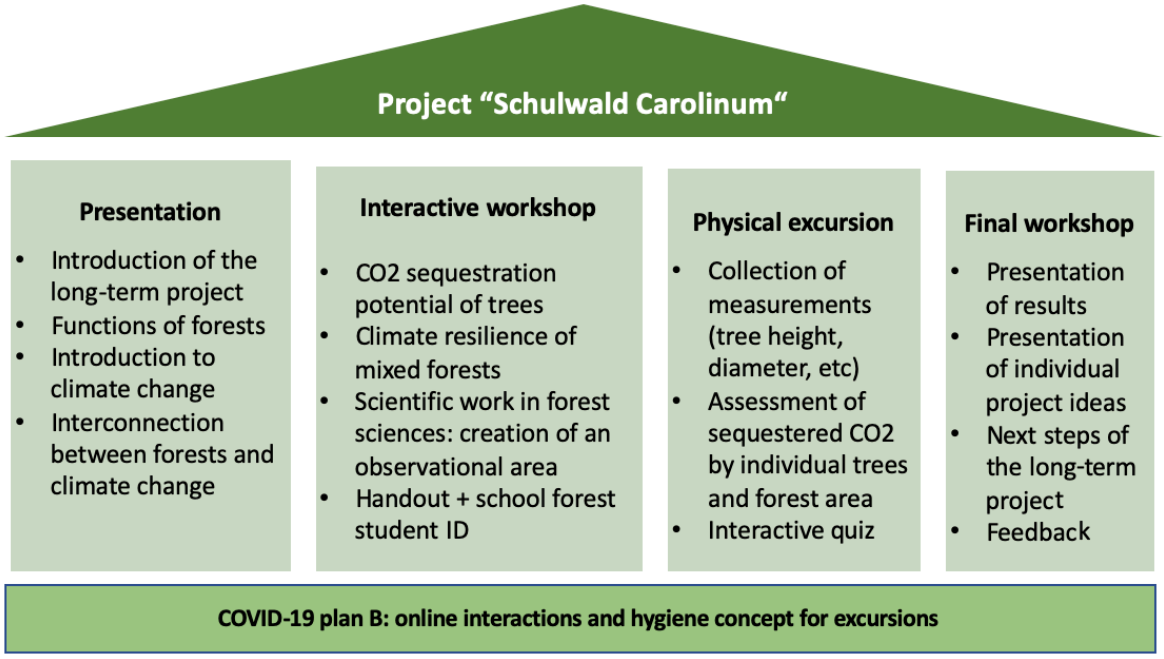

Figure 4: Summary of the treatment interventions

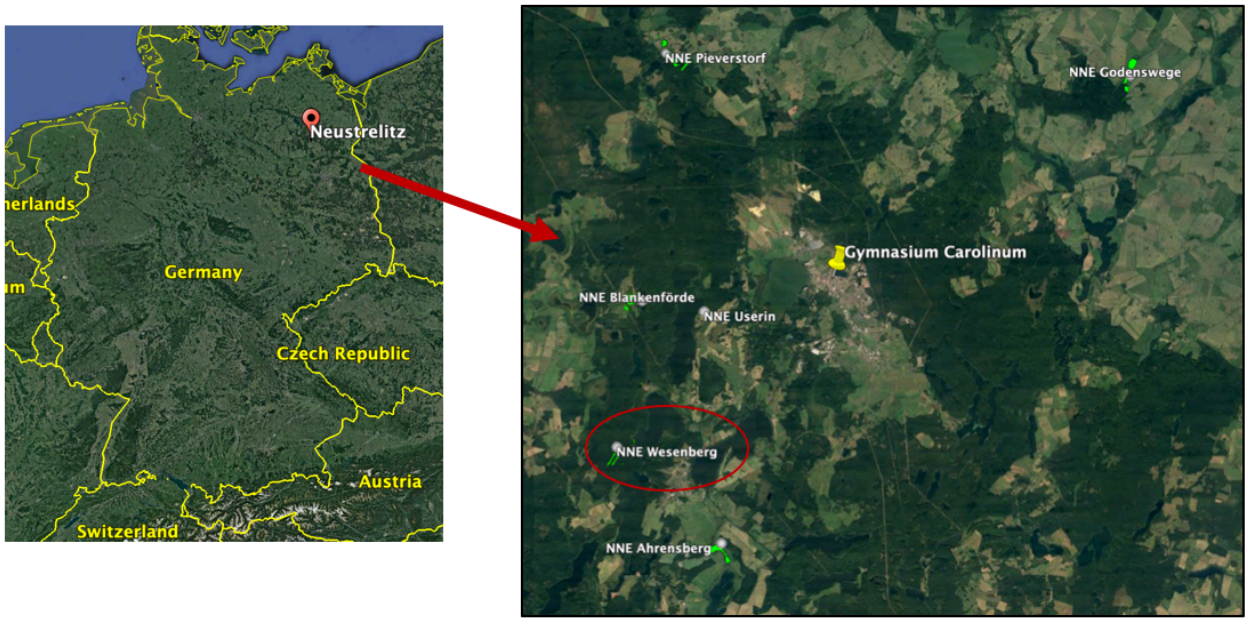

Figure 5: Location of the forest area where the third intervention took place

3.1.3 Outcome Variables

Despite the existence of standardized, reliable and psychometrically valid scales to measure children's environmental knowledge, attitudes and awareness (Musser and Malkus, 1994; Leeming et al., 1995; Manoli et al., 2007; Larson, 2008; Turtle et al., 2015) these were not ideal for the purposes of my research for two main reasons: First, our forest school program addressed very specific aspects of attitude and awareness that were tailored to forests and climate change. Second, most scales were targeted either for younger children or adults, making the questions and response scales not perfectly appropriate for the age group of my research. Therefore, items from existing scales were adapted and new items were developed (Kellert ,1996; Kaiser et al., 1999; Schultz, 2001; Frick et al., 2018). I acknowledge that the lack of external validity of my scales creates a limitation to my study (Larson, 2009). To reduce this limitation, I conducted an exploratory factor analysis (EFA) for the three outcome variables that included more than one item to identify underlying latent constructs with which I could test my results (Costello and Osborne, 2005). The scree plots of the EFA for knowledge, attitude and awareness can be found in Appendix 2.1 (Figures 1, 2, 3, respectively).

My research hypotheses (section 2) will be tested with the following six outcome variables:

Knowledge: This indicator measures student's knowledge about forests, climate change and their interrelation, using 14 questions that are specifically tailored to my forest school program. Five questions were multiple choice questions with one or multiple correct responses. 9 questions were formulated as statements where students could select *definitely wrong, probably wrong, definitely true, probably true or I don't kn*ow. Students received one point when they chose the right answer with uncertainty, and two points when they chose the right answer with certainty. Students that chose the wrong answer received -1 or -2 points when they were uncertain or certain, respectively. The points were summed up, leading to a minimum possible score of -23 and a maximum score of 31 (Bradley et al., 1999; Grodzinska-Jurczak et al., 2003; Kaiser et al. 2008; Liefländer et al., 2015). The knowledge indicator had a Cronbach's alpha reliability coefficient of 0.72, which is satisfactory.

Employing EFA, two components had an eigenvalue above 1, explaining 69.7% of variance. Conducting a Keyser-Mayer-Olkin (KMO) test revealed a value of 0.64 and all questions could be retained based on their factor loadings above 0.4 (Loewen and Gonulal, 2015). Questions about "Climate change consequences and forests" loaded highest in the first factor while questions on "Climate change causes" loaded highest in the second factor.

Attitude: This is a single score ranging from 0 to 5. It captures student's self-reported attitude towards the protection and importance of nature and forests. It was derived by averaging responses to the following 5 items with a five-point Likert-type response scale (*1 strongly disagree, 2 disagree, 3 neither, 4 agree, 5 strongly agree* and *1 not at all important, 2 not important, 3 neither, 4 important, 5 very important*):

- *Nature protection creates benefits for humans, for example their health, quality of life, happiness or recreation.*
- *Every human being should stand up for nature and the environment.*
- *I feel responsible for find solutions to environmental problems.*
- *How important is nature to you personally?*
- *How important are forests to you personally?*

The internal consistency of the scale, as assessed by Cronbach's alpha revealed a value of 0.65, which is acceptable.

The EFA revealed two factors with an eigenvalue above 1, explaining 64.9% of variance. Based on the questions that loaded highest on the factors, the first factor describes "Importance of nature" more generally, while the second captured "Importance of nature protection". All variables had a KMO value of 0.6 or above and the overall KMO value was 0.63, indicating that it was appropriate to conduct EFA and to retain all items (Watson, 2017).

Awareness: This is a score ranging from 0 to 4, averaging student's responses to four items. It measures student's concerns about forest and climate change-related issues. The response scale was a five-point Likert-type scale *(1 not at all worried, 2 slightly worried, 3*

somewhat worried, 4 moderately worried, 5 extremely worried). A don't know response (0) was available for students who did not hear about these issues before.

How worried are you about the following environmental problems?

- *Destruction of forests*
- *Forest fires*
- *Climate change*
- *Species extinction (plants and animals)*

Cronbach's alpha was 0.75, indicating a satisfactory level of internal consistency. EFA revealed only one factor, the KMO value was 0.72.

Willingness to donate: For this variable, students could participate in a draw to win a 25€ Amazon voucher. They were then asked how much of the 25€ they would be willing to donate to an organization that protects forests. In order to reduce the potential of hypothetical bias, students were made aware that their decision is consequential, i.e. the amount they select will actually be subtracted from their voucher in case they win it. Making the decision consequential for each student by offering them the voucher with certainty would have potentially reduced the bias, but was not possible due to budget constraints.

Diet: For this variable, students were first asked whether they reduce or forgo meat consumption. Only if yes was selected, they were asked for the reason. The binary variable indicates 1 if a student has chosen "due to my concern about the environment" and 0 otherwise.

Wellbeing: This is a one item variable asking students how satisfied they are with their overall life on a scale from 1 to 10. While concerns have been raised about children's cognitive ability to respond adequately to questions about subjective well-being (Ben-Arieh, 2005), empirical evidence suggests that the assessment is accurate and reliable for children above 8 years (Gliman et al., 2000).

3.1.4 Covariate Balance and Power Analysis

I present summary statistics of key baseline variables and statistical tests of balance for covariates in Table 2. Further information about the variables can be found in Appendix 2.2. The treatment and control group are balanced across most covariates, except for: gender, whether the student can walk to the next forest, time spent on homework, time spent on the internet, social media and time spent on hobbies. This is an indicator of imperfect randomization that has already been discussed in section 3.1.1. The control group seems to live significantly closer to the forest, which might be a potential source of concern since it could impact knowledge, attitude or awareness about forest-related issues. A further variable of concern is time spend on homework, as it could influence student's knowledge. In section 4.4, I perform different robustness checks and control for the unbalanced covariates in additional regressions.

Standard power analysis shows that the experiment cannot identify plausible treatment effects since the given sample size is too small. For all of the six outcome variables, the minimum number of students that would be required to detect realistic treatment effects is much larger than 82 (sample size in my study). Conducting retrospective power analysis for the outcome variables, I get a power of 0.75 for knowledge, 0.12 for attitude, 0.05 for awareness, 0.06 for WTD, 0.12 for diet and 0.3 for wellbeing. This means that my analysis is considerably underpowered and no statistically significant results can be expected.

3.2 Survey Design

The questionnaire (Appendix 3) was adapted from studies about connectedness to nature, environmental attitude, awareness and wellbeing (Clayton, 2003; Mayer and Frantz, 2004; Skianis, 2013). Most items were answered on a five-point Likert scale, which is a validated tool to measure attitude patterns (Barraza and Pineda, 2003). Following good practice in the design of surveys (Fowler and Cosenza, 2009), the questions were grouped by content into four main categories: A) Background information, B) Behavior, C) Knowledge and attitude and D) Wellbeing. The order of these parts is based on the respective difficulty to answer the involved questions. Open-ended questions were included to assess the student's attitudes and knowledge more comprehensively and

allow for alternative responses (Barraza and Pineda, 2003). The questionnaire was piloted with five students in the same age like the students in my treatment and control group. This allowed to observe whether students understand what is meant by the questions or whether response options should be adapted or rescaled. The second survey included the above mentioned four sections and a separate section about the project interventions themselves (only revealed to the treatment group). The survey was conducted digitally with Qualtrics and students could reach out to me at any time if questions would arise. The questionnaire and interviews were translated from English to German. Limited budget and time constraints did not allow an external assessment of the translation quality. To account for complex meanings, "free translation" was applied instead of direct and literal translation, capturing the conceptual content of the questions (Harkness and Schoua-Glusberg, 1998).

3.3 Qualitative Research Methods

All treated participants (53) gave their feedback as part of the final workshop (intervention 4), elaborating on their individual learning experiences. Further, I conducted 10 short semi-structured interviews after the end of the outside excursion (intervention 3) and four in-depth interviews (30-90 minutes) seven weeks after the end of the last intervention to complement the data obtained from the quantitative questionnaires and to gain a more holistic picture of students who indicated different levels of changes (Bergman, 2016; Patton, 1990). The number of interviews was not pre-determined. Since answers followed similar patterns and only few new themes came up after the seventh short interview and the third in-depth interview, the code saturation levels were considered to be reached (Hennink et al., 2016; Saunders et al, 2018; Guest et al., 2020). Due to time constraints, no interviews were conducted with students from the control group.

The interviewees and their parents have given written consent to the interview. No names will be mentioned within this study. The interviews were transcribed with the software "Trint". The transcribed content was thematically analyzed with a combination of inductive and deductive coding to identify emerging patterns and classify responses into

groups of ordered categories relevant to my research questions (Patton, 1990; Dey, 1993; Saldana, 2009).

Table 2: Baseline summary statistics and test of balance for covariates

	(1) Control	(2) Treatment	(3) Control vs. Treatment
Gender	0.724	0.509	-0.215*
	(0.455)	(0.505)	(0.113)
Age	14.724	14.566	-0.158
	(0.455)	(0.572)	(0.123)
Favorite subject is Biology or Geography	0.310	0.208	-0.103
	(0.471)	(0.409)	(0.100)
Amount of nature in home area	4.379	4.245	-0.134
	(0.677)	(0.782)	(0.173)
Can walk to next forest	0.966	0.830	-0.135*
	(0.186)	(0.379)	(0.075)
Has access to garden	0.793	0.868	0.075
	(0.412)	(0.342)	(0.085)
Has view on nature from room	0.828	0.887	0.059
	(0.384)	(0.320)	(0.079)
Time spent on homework	3.103	2.769	-0.334**
	(0.673)	(0.581)	(0.143)
Time spent on social media	3.586	3.212	-0.375*
	(0.825)	(0.893)	(0.201)
Time spent on hobbies	3.414	3.038	-0.375*
	(0.907)	(0.791)	(0.193)
Time spent on computer games	2.034	2.385	0.350
	(1.239)	(1.331)	(0.301)
Time spent with friends	3.241	2.923	-0.318
	(0.951)	(1.045)	(0.235)
Nature Experience Index (NEI)	23.966	24.075	0.110
	(6.560)	(6.810)	(1.553)
Has contacted environmental NGO	0.345	0.404	0.059
	(0.484)	(0.495)	(0.114)
Is member of environmental NGO	0.000	0.038	0.038
	(0.000)	(0.192)	(0.036)
Observations	82	82	-

Notes: Columns 1 and 2 of this table report summary statistics of baseline variables for the control and treatment groups. Columns 3 reports statistical (t-test) results on mean differences between the control and the treatment group. Standard errors are reported in parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively. I also performed a rank-sum (Wilcoxon-Mann-Whitney) test for the variables that do not approximate a normal distribution. Rank-sum tests and t-tests differed only for two variables: the mean difference between the control and treatment group for the variable "Time spent on social media" is significant at the 5% level (p-value= 0.0396) and for the variable "Time spent with friends" at the 10% level (p-value=0.0797).

4 Results

4.1 Empirical Strategy

To test whether there is an impact of my forest school program on the six outcome variables described in section 3.1.3 the difference-in-difference model is specified as:

$$Y_{it} = \alpha + \beta_1 T_i + \beta_2 Post_t + \beta_3 T_i \times Post_t + \beta_4 X_{it} + \varepsilon_{it}$$

where Y_{it} is the key outcome variable, i.e. knowledge, attitude, awareness, diet, WTD or wellbeing of the student; T_i is a dummy variable coding for whether a student i is in the treatment group (1), $Post_t$ is a binary variable which is 0 in the period before the treatment (January) and 1 in the period after the treatment (March). The i^{th} student received the treatment interventions if he or she is in the treatment group in the second period (interaction between $T_i \times Post_t$). Hence, my objective is to estimate β_3. Given that perfect randomization was not possible, the differences-indifferences estimator is extended to include additional regressors X_{it}. These variables are the unbalanced characteristics of students prior to the experiment (Table 2). By controlling for unbalanced characteristics, I gain conditional mean independence, making the OLS estimator of $\hat{\beta}_3$ in my model unbiased. ε_{it} is an idiosyncratic random error term. The regression is conducted with robust standard errors to account for heteroscedasticity. In this empirical framework, my hypothesis is that β_3>0 in the regression model for each of the six outcome variables.

Mean comparisons do not control for unobserved time-invariant heterogeneity across classes. While proceeding with fixed effects would be a reasonable option, this was not applied in my study since, by design, classes correlate with my treatment. I am further aware that clustering standard errors at the class level would be needed to account for correlation between observations within the same class (Stock and Watson, 2015). According to theory, however, it is necessary to have at least 30 clusters in order to extract meaningful estimates, which was not given in my research setting (Wooldridge, 2002; Cameron et al., 2008).

My preference towards the employment of a simple ordinary least squares (OLS) model is based on two main reasons. First, it is a simple and robust method where the interpretation of the estimated parameters is easily understandable and straightforward. Second, Likert-type, ordinal variables can be treated as continuous (Norman, 2010). Especially, when an index is calculated taking the mean across multiple questions, this results in a much higher number of categories than the ordinal Likert scale, creating an approximately continuous variable, which applies to my outcome variables (Nunnally and Bernstein, 1994; Sullivan and Artino, 2013). Being aware that the knowledge, attitude and awareness outcome variables are only quasi-continuous, next steps could involve to test the results with a multinomial logit regression model.

4.2 Treatment Effects

In this section, results will be analyzed with respect to each research sub-question and corresponding hypotheses. The interpretation and analysis will be complemented by insights from qualitative interviews. The main results are shown in Table 3. To allow for comparability across the different outcome variables, all variables were standardized. The main regression table with non-standardized results can be found in Appendix 5 (Table 5.1). The quantitative analysis was conducted with Stata 16.

4.2.1 Knowledge

The knowledge score in the treatment group increased by 0.27 standard deviations compared to the control group. This corresponds to 1.48 more points, i.e. more correct responses to knowledge questions in the survey. While this result is not statistically significant at any confidence level, as expected, the direction of the coefficient is consistent with the theory. According to the regression with factors extracted through EFA, knowledge about climate change consequences and forests improved more than knowledge about climate change causes (Table 4). Students seem to have an overall better understanding of how forest contribute to climate change mitigation and how forests might be impacted by climate change.

According to Frick et al. (2018), knowledge can also be assessed subjectively, asking respondents to rate how much they feel they know about a specific topic. Quantitative analysis showed that student's self-perceived level of knowledge about climate change

and forest (measured on a level of 1 to 4) increased by 0.21 standard deviations, corresponding to an increase of 0.13 units compared to the control group.

Insights from interviews support these findings. Students explained that the project offered much more detail compared to what they had learned at school before. For example, most students were not aware that trees store carbon in the long term. Measuring trees and calculating their sequestered CO2, helped students to imagine quantities of CO2 and better comprehend the dimensions and severity of climate change. Two students acknowledged that they were not aware of the already noticeable impacts climate change has on forests. For example, they did not know words like "windthrow" or "beetle calamities", which can occur after extreme weather events like storms and droughts. Two students pointed out that they became more aware about the diversity of tree species and forests and their different potential to sequester CO2. As a result, they understood the importance of mixed-forests which are better prepared for climatic changes and have a greater potential to sequester carbon in the long term.

Another theme that appeared in all interviews was the appreciation of unexpected connections to other topics which raised student interest in the topic. They further mentioned new knowledge about the various interconnections between forests and climate change and the feedback mechanisms that can accelerate global warming.

"… learning about the melting of permafrost soils showed me much clearer how everything is connected and how it will accelerate itself at some point. It is really … knowing more about the consequences and that the consequences can further enhance the causes. I would certainly say that this increased my concern about these issues."

4.2.2 Attitude

The attitude score of treated students increased by 0.13 standard deviations compared to the control group. Measured on a scale of 1 to 5, this translates into an increase of 0.09, which is, again, not statistically significant. The two factors obtained through EFA also show positive coefficients, whereby the change in attitude to protect nature was greater than for importance of nature (0.47 compared to 0.19).

Supporting these results, all students agreed that they now believe sustainable forest use and forest preservation were highly important. They learned in more detail to what extent forests contribute to human's wellbeing, beyond pure recreational benefits. One student explained that she thought forests need to be more protected when she realized the wide range of negative impacts human action have on forests. All students acknowledged that their attitudes did not fundamentally change through their participation in the program, but that the importance of forests and "saving the environment" became more present in their lives.

"I am now more aware what forests and nature more generally can do for us and what we have to do for them. … and that we should be more aware how lucky we are to have them and that we should therefore also preserve them."

I note that all in-depth interviews revealed an aspect about attitude, that was not anticipated. Students explained that, through their participation in the project, they realized that little positive contributions to the environment are more important than they thought before for solving environmental problems. They highlighted that the forest school program provided an ideal platform for them to become active for the climate collectively. One student extended the discussion by saying that she realized the importance to change *attitudes* within the wider society through education about climate change and environmental issues as well as showing concrete approaches to counteract them.

4.2.3 Awareness

The awareness score showed the second largest change compared to the other five outcome variables. The treatment group increased their awareness about forest and climate change-related issued by 0.45 standard deviations compared to the control group. On the scale of 1-5, this represents an increase of 0.38 units. A similar result (β=0.54) was given in the regression with the single awareness factor that was revealed after EFA. Both results are not statistically significant and hence, are only interpreted as a qualitative confirmation of the expected direction of change.

The insights from interviews complemented these results. One participant pointed out that she always believed that global warming was a normal process of the Earth and it cannot be attributed to human activity. After learning about the scientific and socio-economic causes of climate change through the project, she acknowledged that the problem is more complex and serious than she thought before. Other participants who had already expressed a high conviction about the human influence on global warming observed an increase in their worry about its severity and consequences after they understood the meaning and impact of feedback mechanisms. This also increased their awareness about the potential impacts climate change can have on their own future.

4.2.4 Diet

After the interventions took place, more students indicated that they reduce or forgo meat consumption for environmental reasons than in the control group. In fact, the increase was 29.5% larger in the treatment than in the control group. While the number of students reducing or forgoing meat fell from 10 out of 29 (34.5%) to 8 out of 29 (27.6%), in the treatment group it increased from 15 out of 53 (28.3%) to 27 (50.9%).

In the interviews, several students noted that becoming more aware of the severity of climate change, motivated them to think more consciously about their own ecological footprint and behavior. Specifically, one student explained that she was confirmed in her efforts to eat less meat or stop consuming products with palm oil or soy, which cause deforestation in other areas of the world. She further noted that she informs herself more about where products come from and how much CO2 is associated with their production and transportation. This was echoed by another student who further brought to my attention another unexpected effect. She explained that she now spends more time in forests, appreciating it not only as a source of recreation but for all ecosystem services they provide.

4.2.5 WTD

The willingness to donate for forests decreased in the treatment group by 0.21 standard deviations compared to the control group, implying that treated students donated on average 1.61€ less after taking part in the treatment. Even though the result is not

statistically significant, the direction is not as expected. Insight from interviews facilitate the interpretation of these results. First, 15 out of 82 students (18.3%) did not want to participate in the draw for the voucher, indicating that their values are more prone to hypothetical bias. Since they did not have the possibility to actually win the 25€ voucher, they might have just randomly selected a value. In future research, rather than selecting a voucher for a specific company, it might be better to offer 25€. Secondly, one student explained that she did not increase her selected amount because she realized that she would rather contribute to the forest school program than donating money in her current life phase.

4.2.6 Wellbeing

The largest treatment effect appears to have been on wellbeing, i.e. it increased by 0.47 standard deviations. Measured on a scale of 1 to 10, this corresponds to an increase of 0.95 units compared to the control group. While this result is not statistically significant either, the direction of the coefficient is consistent with the expectations and theory (Skianis, 2013). The direct contact students had to nature might have increased their happiness.

This was confirmed by almost all students after the outside excursion in the forests as well as when they gave feedback in the final workshop. The same sentiment was echoed by all four students in the in-depth interviews. They enjoyed working in teams outside and seeing their friends, especially since they did not see them in a long time due to remote teaching arrangements, stressing the importance of social factors influencing student's wellbeing. One participant expressed with strong conviction that he was in a much better mood during and after the project.

Opposed to this, three out four students in the in-depth interviews stated that they are more worried about their future since they learned about the complexity and severity of environmental issues in more detail. Referring to the theory, this could be an indicator of a potential sentiment of eco-anxiety decreasing student's wellbeing (Pihkala, 2020a, 2020b). However, students explained that they do not feel powerless but rather motivated and empowered to actively engage in counteracting these issues through the

project. In the forest school project, they felt supported by the school community which seems to share their worry.

4.3 Mechanisms and Additional Insights

A rigorous quantitative mediation analysis to detect potential mechanisms driving the observed changes would have been out of the scope of this study. Instead, insights from qualitative interviews are used to infer some potential mechanisms that could be tested in future research.

New knowledge appears to be the most significant driver of changes in attitude, awareness and behavior (Frick et al., 2004; Gardner and Stern, 2002; Otto and Kaiser, 2014). Students put significant emphasis on the detail and concrete facts they learned, e.g. about CO2 capture of trees, which was echoed by students that were already very knowledgeable before. Some students explained that they shared their knowledge and motivation to live more environmentally friendly with parents, indicating that participants might in fact act as multipliers in the future. One student described the impact of the forest school program on her as a "push" to learn more and become more aware of an issue she has previously dismissed and ignored.

The knowledge and increased awareness about potential future impacts of climate change seemed to have influenced student's motivation to act as well as future aspirations. Two participants mentioned the project inspired them to think about how they can connect their own interests with a job in which they can also work for the environment. One student who already aimed to work for the environment before, explained that the project directed his career objectives into the field of forestry because he saw how much "fun" it can be to care for your own forest sustainably.

The increased motivation to act for the environment after their participation seems to have several reasons. First, while students often feel that they cannot change much about environmental problems themselves, the project seems to offer students a more concrete tool to become active for the climate and to raise awareness, which increases their perception of self-efficacy. They concluded the project can indeed make a difference, especially when the idea would also be introduced in larger cities and other countries.

This strengthened feeling of self-efficacy might have also inspired students to change their consumption behavior, offering an interesting point to be investigated in future research.

Second, students seemed to have developed a sense of responsibility, pride, personal connection and self-identification with "their school forest". 6 out of 53 students (11.3%) visited the school forest area and their trees to show it to their parents, grandparents or friends. 12 out of 53 students (22.6%) voluntarily took on a partnership for one or more trees, which they can observe in more detail over the coming years. The prospect to actively care for their trees and prepare the forests for the future seems to increase student's motivation (Kals et al., 1999). Third, students enjoyed to become active with their friend group. This is supported by Wallis and Loy (2021) who highlight the importance of perceived activism amongst friends as one of the strongest psychological drivers of pro-environmental activism.

"I definitely want to care for my tree and the rest of the forest. I also like it that we will build fences to protect small seedlings and that we will build boxes for jays. And I definitely want to continue taking part in the project, also once my 9th grade is over. I want to participate also in my 10th grade and until my graduation and even longer if that is possible. I somehow want to stay connected to this project. I have learned so many new things and I hope this is not over, yet!"

All four students highlighted in the in-depth interview that they learned much more compared to previous projects at school, due to the combination of theory and practice and varied types of interactions in which they could apply their knowledge. One student explained, for example, that she was positively surprised how enjoyable it can be to work scientifically. This confirms that the innovative design of the project was successful in reaching different types of students.

"When I look a little bit more in the future, if the school forest will actually develop like we expect it, i.e. in the direction of a secondary old growth forests, then I would really be happy because I will have the feeling that it was me who supported its building and I saw myself how this forest grew and developed. In other forests where I am sometimes, I am also happy (…), but it is just not the same as if you stand in the secondary old growth forest you have shaped yourself as part of this project."

Figure 6: Changes in the six outcome variables in the treatment vs. control group (95% confidence intervals)

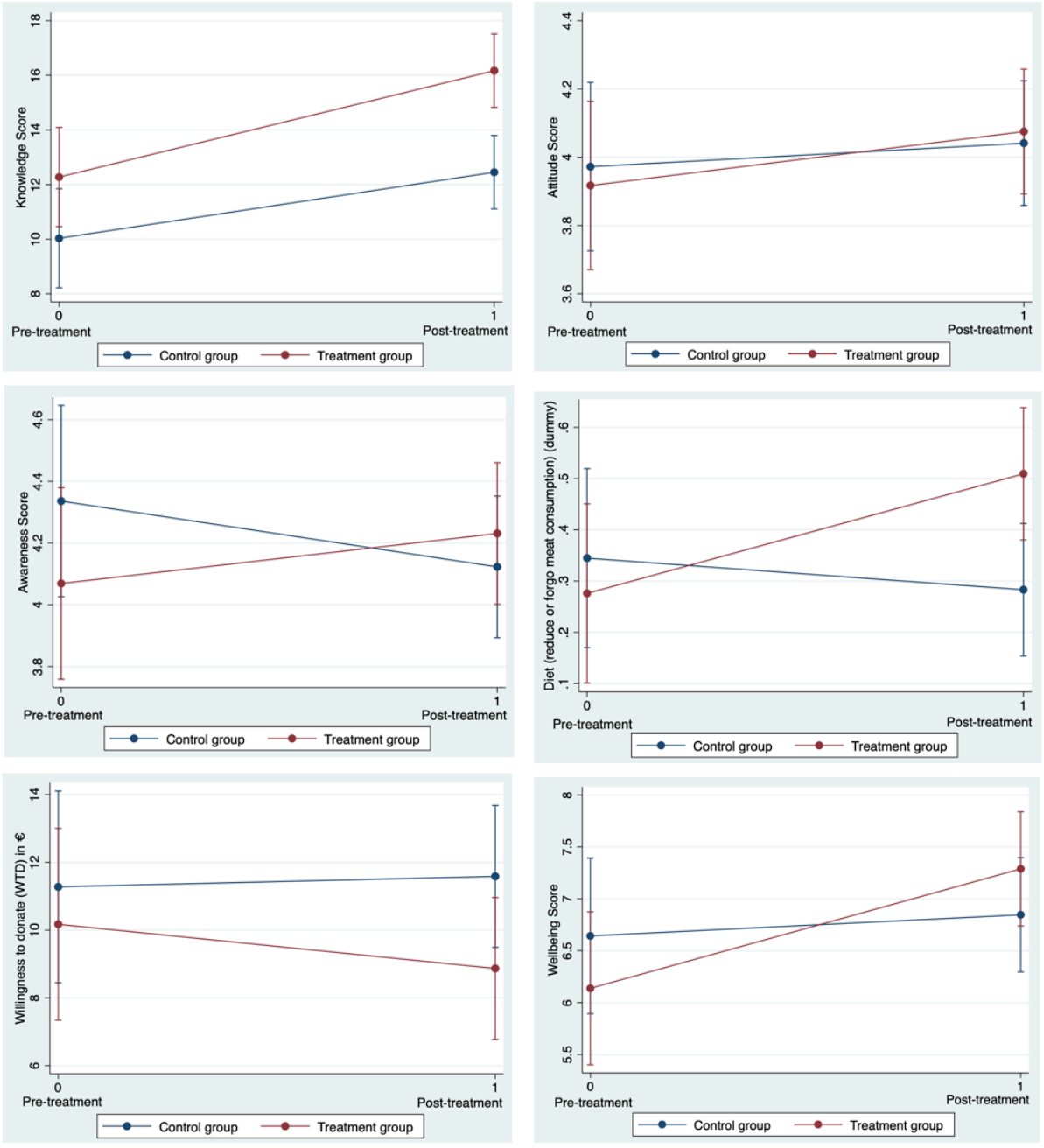

Table 3: The impact of the forest school program on the six outcome variables controlling for covariates

	(1) Knowledge	(2) Knowledge	(3) Attitude	(4) Attitude	(5) Awareness	(6) Awareness	(7) Diet	(8) Diet	(9) WTD	(10) WTD	(11) Wellbeing	(12) Wellbeing
Treatment	0.449*	0.412	0.103	0.525**	-0.253	0.0102	-0.0618	-0.0369	0.0400	0.131	0.100	-0.0544
	(0.205)	(0.223)	(0.207)	(0.185)	(0.174)	(0.195)	(0.109)	(0.118)	(0.232)	(0.263)	(0.220)	(0.240)
Post	0.416	0.313	-0.0824	2.952*	-0.317	1.659	-0.0690	-0.0651	-0.143	0.124	-0.249	-0.987
	(0.229)	(1.065)	(0.211)	(1.493)	(0.231)	(1.433)	(0.123)	(0.352)	(0.248)	(0.856)	(0.254)	(0.715)
Post x Treatment	0.274	0.310	0.133	-0.289	0.445	0.182	0.295	0.270	-0.209	-0.300	0.467	0.621
	(0.293)	(0.308)	(0.300)	(0.288)	(0.310)	(0.326)	(0.154)	(0.162)	(0.318)	(0.343)	(0.322)	(0.338)
Female		-0.185		0.303		0.0956		0.175		0.504		-0.482*
		(0.214)		(0.167)		(0.193)		(0.101)		(0.260)		(0.215)
Can walk to next forest		-0.173		0.192		0.249		0.0785		-0.371		-0.0508
		(0.366)		(0.314)		(0.313)		(0.149)		(0.393)		(0.379)
Time spent on homework		0.141		0.399		0.401		-0.00882		0.159		0.182
		(0.206)		(0.217)		(0.207)		(0.0785)		(0.179)		(0.182)
Time spent on social media		-0.128		-0.00821		-0.0438		-0.0979		-0.0798		-0.317*
		(0.126)		(0.141)		(0.133)		(0.0531)		(0.129)		(0.144)
Time spent on hobbies		0.0640		0.416**		0.169		0.0527		0.0150		0.0738
		(0.143)		(0.146)		(0.144)		(0.0601)		(0.139)		(0.134)
Constant	-0.586***	-0.484	-0.0685	-3.103*	0.178	-1.798	0.345***	0.341	0.113	-0.154	-0.0903	0.648
	(0.153)	(1.051)	(0.144)	(1.485)	(0.0974)	(1.417)	(0.0894)	(0.342)	(0.176)	(0.838)	(0.168)	(0.688)
Observations	82	82	82	82	82	82	82	82	82	82	82	82
Adjusted R-squared	0.156	0.143	-0.011	0.125	-0.007	0.027	0.027	0.032	0.005	0.026	0.021	0.052

Notes: This table shows the main regression results for the impact of the forest school treatment on the six main outcome variables. Column 1-2 show the main treatment effect on knowledge about forests and climate change; column 3-4 show the effect on attitude towards nature and forests; column 5-6 represent the effect on awareness about forest and climate change related issues; column 7-8 elicit the effect on whether meat was reduced or forgone for environmental reasons; column 9-10 state the effect on willingness to donate (WTD) for an organization that protects forests and column 11-12 elicit the effect on wellbeing. The dependent variables in columns 1-6 and 9-12 are standardized for ease of interpretation.
Standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

Table 4: The impact of the forest school program on factors extracted by EFA for knowledge, awareness and attitude controlling for covariates

	(1) Knowledge about climate change consequences and forests	(2) Knowledge about climate change consequences and forests	(3) Knowledge about climate change causes	(4) Knowledge about climate change causes	(5) Importance of nature	(6) Importance of nature	(7) Importance of nature protection	(8) Importance of nature protection	(9) Awareness	(10) Awareness
Treatment	0.491*	0.333	0.0275	0.0586	0.346	0.575**	-0.582*	-0.607*	-0.166	-0.124
	(0.198)	(0.217)	(0.232)	(0.211)	(0.234)	(0.202)	(0.257)	(0.284)	(0.177)	(0.195)
Post	0.327	-0.976	0.0368	0.581	-0.125	1.387	-0.129	0.0416	-0.378	-0.218
	(0.223)	(0.744)	(0.270)	(0.743)	(0.286)	(0.889)	(0.275)	(1.055)	(0.277)	(0.823)
Post x Treatment	0.209	0.367	0.0572	0.0261	0.192	-0.0378	0.467	0.493	0.535	0.494
	(0.273)	(0.289)	(0.294)	(0.280)	(0.339)	(0.320)	(0.332)	(0.355)	(0.336)	(0.350)
Female		-0.0574		-0.166		0.435*		-0.235		0.108
		(0.210)		(0.264)		(0.200)		(0.257)		(0.213)
Can walk to next forest		-0.344		-0.134		0.170		-0.373		0.218
		(0.293)		(0.146)		(0.346)		(0.347)		(0.316)
Time spent on homework		-0.185		-0.0511		0.203		-0.101		0.201
		(0.167)		(0.223)		(0.144)		(0.198)		(0.130)
Time spent on social media		-0.122		0.199		-0.223		0.180		-0.237*
		(0.114)		(0.118)		(0.123)		(0.162)		(0.106)
Time spent on hobbies		0.0236		0.0704		0.353**		0.107		0.0287
		(0.120)		(0.146)		(0.114)		(0.118)		(0.114)
Constant	-0.546***	0.757	-0.0544	-0.599	-0.221	-1.733*	0.288	0.118	0.123	-0.0361
	(0.154)	(0.726)	(0.222)	(0.727)	(0.196)	(0.863)	(0.209)	(1.040)	(0.118)	(0.783)
Observation	82	82	82	82	82	82	82	82	82	82
Adjusted R-squared	0.157	0.154	-0.015	-0.011	0.029	0.101	0.030	0.034	0.001	-0.000

Notes: This table shows the main regression results for the impact of the forest school treatment on the factors that were extracted with explanatory factor analysis (EFA) for the knowledge, attitude and awareness indices. Applying the Kaiser criterion (Kaiser, 1960), only factors with an eigenvalue > 1 were extracted. Items showing factor loadings > 0.4 for the specific factors were retained (Stevens, 2009). Columns 1-4 show the effect on the two factors extracted from the knowledge index, namely, "Knowledge about climate change consequences and forests" and "Knowledge about climate change causes". Columns 5-8 elicit the effect on two factors extracted from the attitude index, i.e. "Importance of nature" and "Importance of nature protection". Columns 9 and 10 show the only factor with an eigenvalue > 1 extracted from the awareness index. Since all items had a factor loading > 0.73 this factor can be summarized and interpreted as "Awareness" for forest and climate change related issues more generally. Columns 2, 4, 6, 8 and 10 control for imbalanced covariates. The created factor scores are standardized by default and since the imbalanced covariates are either dummies or measured on the same scale, they were not standardized. Standard errors are in parentheses. ***, **, and * denote significance levels at the 1, 5, and 10% levels, respectively.

4.4 Robustness Checks

As indicated in section 3.1.3, EFA was conducted for knowledge, attitude and awareness to test my results due to the lack of external validity of my scales for these three outcome variables. I performed several other robustness checks to probe my results. First, I included the imbalanced covariates (Table 3) in the regression model and re-estimated the treatment effects on the six outcome variables. These control factors are used to make the model estimates more precise, given that the sample selection did not occur perfectly random. For knowledge, the treatment effect is slightly stronger after controlling for the imbalanced variables (increase from 0.27 to 0.31 standard deviations). For attitude, the coefficient falls from 0.13 to -0.29 standard deviations, making the effect on attitude questionable. While insights from interviews indicate that the attitude of some students has changed, this result would need to be investigated further with a larger sample size. The coefficient of awareness falls but stays positive (0.45 to 0.18), which is still consistent with my expectations. Similar effects occur in the regression with the factor scores (Table 4). The only difference that appears noteworthy is that the coefficient of "Importance of nature protection" increases from 0.47 to 0.49, indicating that there might indeed have been an effect on this aspect of student's attitudes. Both coefficient for diet preferences and WTD do not change considerably (from 0.295 to 0.27 and -0.21 to -0.30, respectively). The coefficient for wellbeing increased from 0.47 to 0.62, which is still the strongest treatment effect compared to the other five outcome variables. Most of the included control variables display coefficients that are not statistically insignificant and none of the treatment effects became significant, as expected. One significant result reveals that the time spent on social media seems to negatively influence wellbeing, which can be explained with theory (Ramesteiner, 2009).

To test for heterogeneity within my treatment group, I interact two outcome variables, i.e. knowledge and awareness with the covariates homework and proximity to the next forest, respectively (Table 5). Based on theory, spending more time on homework could be positively associated with the level of knowledge a student achieves. The coefficient of the interaction term between knowledge and treatment group is positive but very small and not statistically significant, hence negligible. Looking at the awareness outcome variable, the coefficient for the interaction term between whether a student can reach a forest by walking and the treatment, is in fact positive and significant at the 10% level.

This indicates that living closer to a forest and awareness positively correlate in the treatment group. The treatment effect amongst those that live close to a forest increases to 1.08 standard deviations. A possible explanation might be that those who live close to a forest care more for it and are more worried after they learned about forest-related issues. They could also have had greater opportunities to go in the forests to reflect on what they learned, as indicated by two students in the interview. This indicates that other factors could drive the treatment effects which could be investigated in future research.

Table 5: The impact of the forest school program on knowledge and awareness for students that spend more time on homework and live in walking distance to a forest

	(1) Knowledge	(2) Knowledge	(3) Awareness	(4) Awareness
Treatment	0.481*	0.299	-0.240	-0.889***
	(0.197)	(1.120)	(0.187)	(0.264)
Post	0.673	0.547	-0.223	-0.807***
	(0.641)	(0.832)	(0.361)	(0.211)
Post x Treatment	0.242	0.423	0.432	1.082**
	(0.288)	(1.140)	(0.318)	(0.370)
Time spent on homework	0.0827	0.0424		
	(0.201)	(0.274)		
Time spent on homework x Treatment		0.0610		
		(0.381)		
Can walk to next forest			0.0970	-0.508***
			(0.285)	(0.0999)
Can walk to next forest x Treatment				0.683*
				(0.328)
Constant	-0.843	-0.718	0.0845	0.669
	(0.618)	(0.814)	(0.293)	(.)
Observations	82	82	82	82
Adjusted R-squared	0.152	0.147	-0.013	-0.016

Notes: This table shows the treatment effects on knowledge and awareness controlling and with interaction terms for time spent on homework and whether a student can walk to the next forest, respectively. Column 1 shows the main treatment effect on knowledge controlling for time spent on homework. Column 2 shows the treatment effect on knowledge with an interaction term for time spent on homework. Column 3 shows the main treatment effect on awareness controlling for whether a student can walk to the next forest. Column 4 shows the treatment effect on awareness with an interaction term for whether a student can walk to the next forest. The dependent variables are standardized for ease of interpretation.
Standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.

5 Study Limitations and Discussion

Since the students in the treatment and control group go to the same school, it is reasonable to assume that information about the project was exchanged across the groups. My treatment effects are therefore likely to capture both network amplification and spillover effects (Nilsson et al., 2017). In order to better understand the potential size of the spillover effect, students were asked to indicate how many students they personally know from the other classes. The amount ranged from 10 to 21. However, the magnitude of spillover effects is assumed to be significantly smaller since students were taught remotely and less interaction took place amongst them, which was confirmed during interviews.

I further acknowledge that the quantitative results based on my research design are limited due to several factors. First, the relatively small sample size that was selected only from one school is unlikely to be representative and caused the power of my model to be very small. Since the nature of this field experiment required intensive cooperation with involved schools, increasing the sample size was not possible given the time and resources available for this research. Second, as indicated in section 3.1.1 students could not choose themselves whether they want to participate but the randomization occurred at the class instead of the individual level. Third, while non-compliance was not assumed to be an issue, it is difficult to know whether students were actually present during online interventions, since they did not turn on their cameras.

In addition, despite the use of a difference-in-difference method, it remains difficult to perfectly isolate the treatment effect from all possible confounders. For example, variations specific to the weather, group or assistants may have influenced survey responses across the treated students. Biology and geography teachers were contacted before the interventions to ensure that similar topics were not part of the class content during the treatment period. Another limitation of the model is that we cannot test the parallel trend assumption that is required for the differences-in-differences estimator since we only have data of two points in time (Figure 6). Given that students' perceptions are likely to change in the time of adolescence, this assumption is difficult to test (O'Brien, 2009).

With respect to the attitude and awareness outcome variables, I acknowledge that externally validated scales could have elicited more reliable results. The factor analysis I conducted serves as a first mean of comparison and indicated that the scales I have used were still appropriate for the purposes of this research. Indeed, future research could focus on the development and validation of scales with an appropriate systematic procedure to measure the effect of a comparable forest school program on secondary students (Leeming et al., 1995; Larson, 2011). I note that testing multiple hypotheses with one sample suggest the conduction of a Bonferroni Correction Tests (Stock and Watson, 2015). Since none of my results were statistically significant, this was not done but might be needed in future research with larger sample sizes and significant results.

Another potential concern are unreliable responses in the surveys. All survey scores were self-reported with the expectation that every child answered each item honestly and without external influences. However, biases might occur due to the order of the questions, lack of attention or students might not answer truthfully (Dillman et al., 2009). Especially because students filled out the surveys at home, it could not be made sure that they don't look up answers to knowledge questions. Further, since I conducted the interventions with the students myself, experimenter expectancy effects could have led to responses that might please me as the instructor and researcher (Leeming et al., 1993; Oerke and Bogner, 2013). Methods like cheap talk and comprehensive instructions were applied to help reducing these biases (Carlsson et al., 2005).

The time lag between the interventions and long interviews might have influenced the insights obtained. One student indicated in her in-depth interview, that she is more conscious about changes of her awareness and attitude than when she filled out the second survey, because she reflected about the project in the last weeks and needed time to "digest" the material. This allowed to get some first insight into the potential durability of treatment effects and raises an interesting aspect to be investigated in future research.

Further, the ongoing COVID-19 pandemic significantly hampered the communication with students and teachers and made the design and implementation of the new project more difficult and time consuming. Interventions could not take place in person, which might have reduced the treatment effects. On the other hand, the fact that students spent most of their time at home before the treatment, might have increased their happiness to

participate. Hence, this research needs to be considered as an advanced pilot study and all results need to be interpreted with caution. Future research might be able to test the robustness of my findings and shed more light on the potential of forest school programs at the secondary school level.

6 Conclusion

EE programs, like forest schools provide multiple benefits for participating students and offer an indispensable contribution to the long-term transformation towards a more sustainable future. While forest school programs are mostly applied in primary schools guided by the pedagogy of play, this research serves as an advanced pilot study that investigates the effect of a more advanced forest school program on secondary school students. Building on a wide range of concepts and theories within the EE literature, the project aims to create a long-term feeling of responsibility through the integration of students in the sustainable management of student's "own school forest". Using a field experiment with a treatment and control group, I studied how the program influenced secondary school student's a) knowledge, attitude and awareness about forests and climate change, b) environmental behavior and willingness to donate for forest protection and c) wellbeing. Semi-structured short interviews and in-depth interviews were used to gain additional insights into the mechanisms driving the potential changes. The results provide relevant insights about the role of responsibility, practical and scientific participation and interdisciplinarity to enhance the effectiveness of forest school programs for secondary school students.

Although this study could not reveal statistically significant results due to a small sample size, the direction of quantitative results as well as insights from interviews suggest that the program has improved student's understanding of how forests can contribute to combat climate change as well as the multiple consequences climate change can have on ecosystems, including forests. Through the comprehension of these interconnections, students appeared sensitized to the human role in the climate crisis and the urgency to act. This seems to have increased students' awareness of forest and climate change-related issues. The positive change in attitude is relatively small, but appears to imply a new appreciation of nature protection for some students. A key study insight is that more students wanted to reduce or forgo meat consumption in favor of the environment after

the project took place. Further, results suggest that the largest effect was an increase of wellbeing in the treatment group, by almost 1 unit (on a scale of 1-10) compared to the control group. Qualitative insights revealed that students specifically appreciated the varied types of interaction throughout the project and the concrete opportunity to collectively contribute to climate change mitigation and adaptation. The study also revealed factors influencing the effectiveness of forest school programs. The possibility to take over responsibility for the forest area in the long-term seemed to have increased student's human-nature connection and self-efficacy which is recognized as central to address the current ecological crisis (Latour, 2014). The scientific approach was perceived as a very positive aspect of the project, enhancing student's curiosity and opinion of science. Various students indicated that the project raised their interest in the topic and strengthened their future aspirations to help solving environmental challenges.

The insights of this study do not only speak to the literature on the implementation and effect of forest school programs employed at the secondary school level (Knight, 2016). It also contributes to the enhancement of sustainable land use practices and the required socio-cultural transformation away from a nature-human dichotomy towards a feeling of stewardship that we need for a successful sustainability transformation in the 21st century (Bai et al., 2019). Hence, the results of this dissertation are of equal interest for educators, academics and policy makers working within sustainability education, as well as practitioners and scientists in the field of sustainable forestry and land management.

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Appendix 1: Treatment Interventions

1.1 Detailed Project Plan for Teachers and Assistants

The first intervention is an **introductory presentation** in which all students of the treatment group will be introduced to the main idea of the long-term forest school program, i.e. the possibility to sustainably manage and take on responsibility for "their own" school forest of 80 ha over various years. The presentation will include:

- information about old growth forests
- large-scale deforestation, e.g. for soy bean production to feed animals sold to Europe
- causes and consequences of climate change and the interaction of forests and climate change.

The workshops will be conducted in the three classes from the treatment group separately to allow for more interaction. The **first workshop** will include:

- a detailed explanation and calculation of the CO2 sequestration potential of different trees (Figures 1 and 2)
- an explanation of how to create an observational area, a research method from forest science that allows a detailed study of the development of forests
- ecological benefits of mixed forests compared to monocultures and the required management procedure to create a climate resilient mixed forest stand (Figure 3)
- brainstorming to collect ideas for a small project in the field of student's interest that can be related to the forest school program (I will present several suggestions how the project could be integrated into various different subjects, e.g. Biology, Geography, Mathematics, Chemistry, Sports, Arts, etc. to highlight the interdisciplinarity of forest-related topics)

The third intervention will be the **outdoor excursion** in which students will:

- create an observational area themselves in a 7 hectare forest stand, numbering trees, evaluating so called "social classes" as well as measuring and documenting tree heights and diameters
- participate in an interactive quiz testing student's knowledge referring to the introductory presentation
- have the opportunity to select their "own" tree
- receive a school forest ID where the number of the trees are noted and future visits can be registered (Figure 4)

In the **final workshop**:

- the data collected by students will be analyzed, resulting in the amount of CO2 the school forest stand sequestered in the last 100 years
- students will learn how long their family can drive by car to emit the amount of CO2 sequestered by their school forest in a year
- students will be informed about the data bank and website that was created for the project, in which all data can be stored and compared in the future
- each student will be asked to present their project idea about the school forest, to reflect and give feedback about the four interventions

1.2 Selected Material and Pictures from Interventions

Am Beispiel von vier Buchen

Baum-Nr.	Baumart	Bhd	Höhe	F2021 Holzvolumen incl. Ästen und Wurzeln	F2021 Holzmasse incl. Ästen und Wurzeln	F2021 gespeicherter Kohlenstoff C	F2021 im bisherigen Baumleben NETTO entnommenes CO2
		in cm	in m	in m^3	Tonnen Darr (ohne Wasser)	Tonnen reiner C	Tonnen CO2
1	Buche	20	18,2	0,7503	0,5402	0,2701	0,9903
2	Buche	35	23,2	2,1155	1,5232	0,7616	2,7925
3	Buche	50	32,1	4,7985	3,4549	1,7275	6,3340
4	Buche	65	35,0	8,3136	5,9858	2,9929	10,9739

Netto: CO2-Aufnahme minus CO2-Abgabe der Buche durch ihre eigene Zellatmung

Figure 1: Detailed calculation of CO2 sequestration potential of four different trees (first workshop, intervention 2).

Am Beispiel der stärksten Buche (Baum-Nr. 4)

	Baum-Nr.	Baumart	Bhd	Höhe	Holzvolumen incl. Ästen und Wurzeln	Holzmasse incl. Ästen und Wurzeln	gespeicherter Kohlenstoff C	im bisherigen Baumleben NETTO entnommenes CO2
			cm	m	m^3	Tonnen Darr (ohne Wasser)	Tonnen reiner C	Tonnen CO2
F2021	4	Buche	65,0	35,0	8,3136	5,9858	2,9929	10,9739
F2026	4	Buche	67,0	35,7	9,0106	6,4876	3,2438	11,8940
Differenz 5 J.								**0,9201**
mittlere Differenz pro Jahr								0,184

184 kg / 0,150 = **1227 km** (150g/km CO2-Ausstoß laut Fahrzeugschein V.7 auf der Vorderseite rechts)

Ihr könntet also vom Carolinum bis zu eurer Partnerschule nach Turin in Italien fahren!

Figure 2: Calculation of distance in which a car emits the amount that the widest tree (Figure 1) captures in one year (first workshop, intervention 2).

Vom Altersklassen-Wald zum mehrschichtigen, ungleichaltrigen Mischwald

Alle Darstellungen nach Pretzsch (2019), Seiten 79, 180, 227

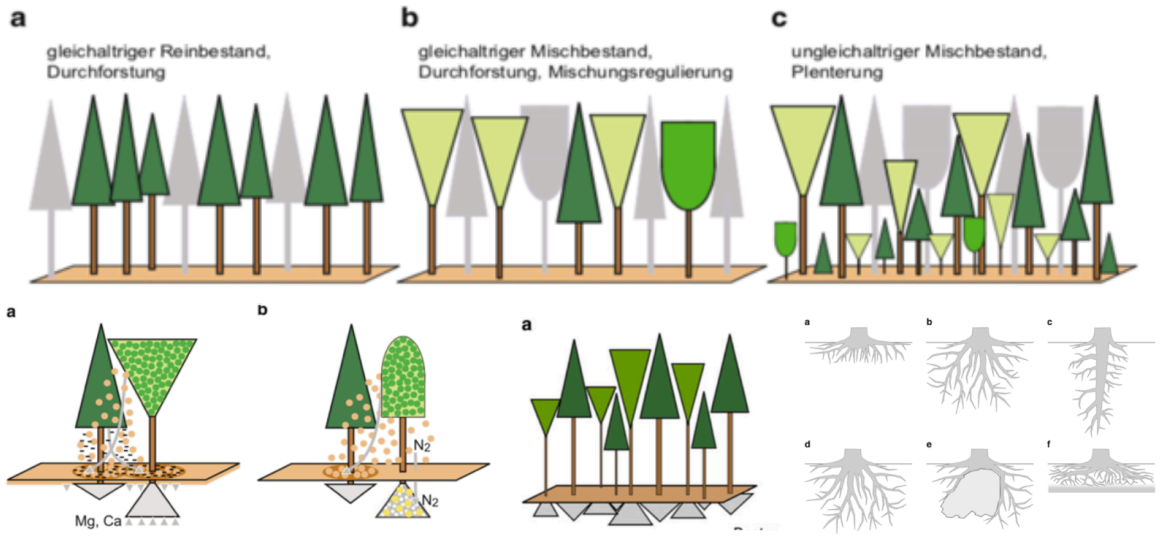

Figure 3: Explanation of ecological benefits of mixed-forests (first workshop, intervention 2).

Schulwald ID

Name: [redacted]

Klasse: 9/6

Schulwald: Wesenberg

Dauerbeobachtungsfläche WES_001

Projekt im Fach: Biologie

Titel: „Bodenqualität im Schulwald Wesenberg“

Gymnasium CAROLINUM

gemeinnützige Stiftung Wälder für Morgen

Ich trage Verantwortung für Baum/Bäume: .....

Besuch des Schulwaldes/meines Baumes am:

Datum	Bemerkungen	Mit ...	Anderes
30.01.2021	Windwurf, Spechthöhle, Borkenkäfer-schaden	Freundin	

Figure 4: Forest school ID for each student (outdoor excursion, intervention 3).

Figures 5 and 6: Students measuring the height and diameter of trees in “their” school forest (outdoor excursion, intervention 3).

Figure 7: Students during the interactive quiz (outdoor excursion, intervention 3).

Figure 8: Students after the outdoor excursion (intervention 3).

Appendix 2: Further Information about Variables

2.1 Outcome Variables (EFA)

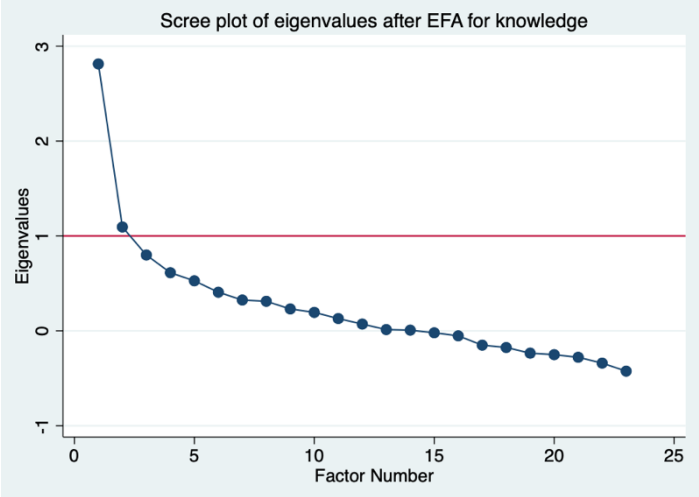

Figure 1: Scree plot of eigenvalues after EFA for knowledge

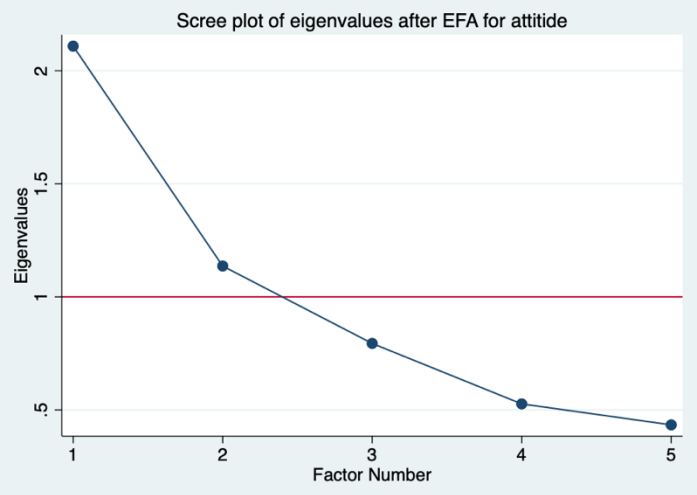

Figure 2: Scree plot of eigenvalues after EFA for attitude

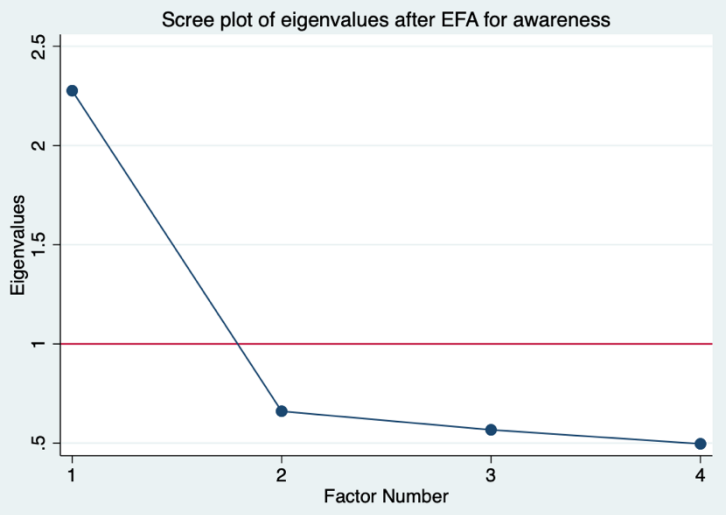

Figure 3: Scree plot of eigenvalues after EFA for awareness

2.2 Baseline Variables

The socio-demographic variables include: (i) gender dummy (1 if girl), (ii) age (14 to 16 years), (iii) favorite subject dummy, being 1 if it includes Biology or Geography (Table 1), weekly time allocation to homework, internet/social media, hobbies, computer games, going out with friends on a scale of 1 to 5 (0 hours, less than one hour, 1-5 hours, 5-7 hours, more than 7 hours).

Favorite subject	Control (29)	Treatment (53)
Mathematics, Chemistry, Physics, Informatics	34,5% (10)	47,2% (25)
Languages (German, English, French, Spanish, Latin, Russian)	41,4% (12)	39,6% (21)
Art and Music	44,8% (13)	26,4% (14)
Philosophy and Religion	10,3% (3)	22,6% (12)
History, Politics, Economics	37,9% (11)	37,7% (20)
Sports	48,3% (14)	43,4% (23)
Geography	**6,9 % (2)**	**9,4% (5)**
Biology	**24,1% (7)**	**13,2% (7)**

Table 1: Distribution of most favorite subjects across treatment and control group.

Further independent variables were included to learn about student's daily contact with nature. One variable measures student's perception on the amount of nature in their neighborhood (Very little, little, moderate, much, extremely much) and dummies indicate whether students can walk to the next forest, whether they have access to a garden and whether they have a view of nature from their room at home. To learn about student's experiential relation with nature I have used the "Nature Experience" index (NEI) and an environmental education index adapted from Skianis (2013). The index considers all dimensions of student's empirical connectedness to nature, i.e. direct, indirect and vicarious experience (Kahn and Kellert, 2002). The items have been reduced to for the purpose of this study. Cronbach alpha is a=0.77, indicating acceptable levels of internal consistency.

8-item NEI indicator about student's participation in nature-related activities		
Time spent in forests in the last four weeks	Never, Once, 2-5 times, more than five times, Don't know	Direct experience
Time spent in forests in the last 12 months	Never, 1-5 times, 6-10 times, 11-30 times, more than 30 times, I don't know	Direct experience
Being in nature (last 3 years)	Never, 1-5 times, 6-10 times, 11-30 times, more than 30 times, don't know	Direct experience
Doing arts in nature (last 3 years)	Never, 1-5 times, 6-10 times, 11-30 times, more than 30 times, don't know	Direct experience
Planting trees (last 3 years)	Never, 1-5 times, 6-10 times, 11-30 times, more than 30 times, don't know	Direct experience
Watching nature movie or documentation (last 3 years)	Never, 1-5 times, 6-10 times, 11-30 times, more than 30 times, don't know	Vicarious experience
Reading books or articles about nature (last 3 years)	Never, 1-5 times, 6-10 times, 11-30 times, more than 30 times, don't know	Vicarious experience
Visiting a National Park or protected area (last 3 years)	Never, 1-5 times, 6-10 times, 11-30 times, more than 30 times, don't know	Indirect experience
Visiting an environmental education center (last 3 years)	Never, 1-5 times, 6-10 times, 11-30 times, more than 30 times, don't know	Indirect experience

Appendix 3: Questionnaire

Teenager's relationship with forests and its interrelation with climate change

The main goal of this study is to better understand teenager's relationship to nature, particularly forests. For the purposes of the analysis, we would like to ask you to complete the following questionnaire. It consists of four main parts: (A) **Background information**, (B) **Behavior** (C) **Knowledge and Attitudes** and (D) **Well-Being**. The questionnaire has been reviewed and approved by the LSE Research Ethics Committee. Please note:

1. It should take no more than 20 minutes to complete.

2. The completion of the questionnaire is anonymous and voluntary. The results will remain confidential and will be used solely for the purposes of this research.

3. Only part (C) of the survey includes some questions about your knowledge of forests and climate change. Your answers will not affect you in any way. In the rest of the survey there are no correct or wrong answers. We are interested in your opinions and experiences.

4. By filling out this questionnaire, you will have the chance to win a real 25€ Amazon voucher. Please tick the box if you would like to be part of the draw.

The success of the study is highly dependent on your contribution; therefore, your participation is very valuable. Please feel free to answer the questions with honesty and spontaneity.

A Background Information

A.1 What is your name? (Your name will only be seen by the researcher).

A.2 You are:
Girl Boy

A.3 What is your age?

A.4 What class are you in?

A.5 How many students do you know from classes … *(depending on whether the student is in the treatment or control group)***?**

A.6 Please tick your three favorite school subjects:
Mathematics, Chemistry, Physics, Informatics, 2nd language, Art, Music, Philosophy, Religion, History, Politics, Economics, Sports, Geography, Biology

A.7 How much nature would you say exist in the area you live in?
(Very little, little, moderate, much, extremely much)

A.8 If you wanted to visit a forest, how could you get there?

- I could walk.
- I would need to take the bicycle.
- I would need to take the bus or ask someone to drive me with the car.
- The next forest is so far away that nobody would drive me there.

A.9 Do you have access to a garden, or balcony with flowers at your home? *(Yes, No)*

A.10 Do you have a view of nature from your room at home? *(Yes, No)*

A.12 Think about a usual week. How often, approximately, are you involved in the following activities each week?

	0 hours per week	**Less than 1 hour per week**	**1-5 hours per week**	**5-7 hours per week**	**More than 7 hours per week**	**Don't know**
Homework						
Spending time on social media (Instagram, snapchat, twitter, facebook, etc)						
Hobbies (music, painting, dancing, reading, etc)						
Playing computer and other electronic games						
Going out with friends						

B Behavior

B.1. Frequency of engagement with nature

B.1.1 In the last 4 weeks, how often have you spent time in the forests?

- Never
- Once
- 2-5 times
- More than five times
- Don't know

B.1.2 In the last 12 months, how often have you spent time in the forests?

- Never
- 1-5
- 6-10
- 11-30
- More than 30
- I don't know

B.1.3 Would you have spent approximately more, less or equal amount of time in the forests without COVID-19 restrictions?

- Less
- Approximately the same amount
- More
- I don't know

B.1.4 How often have you engaged in the following activities in the last three years (for example with friends, family, your school or an environmental organization)?

	Never	1-5	Approximately 6-10	Between 11 and 30	More than 30 times	Don't know
Spending time in nature because you wanted to enjoy or experience it (by walking, cycling, canoeing)						
Doing art in nature (painting, photography, etc)						
Tree planting						
Watching a film or documentary about nature						
Reading articles or books about nature						

Visiting National Parks and reserves (e.g. Müritz National Park)						
Visiting an Environmental Education Centre (e.g. Steinmühle)						
Participating in an environmental education activity (project, seminar, fieldwork, excursion etc)						

B.2. Activism and willingness to donate

B.2.1 Have you ever looked up information about an environmental or conservation organisation because you where interested in it (e.g. NABU, WWF, Greenpeace) because you were interested in it? (*Yes, No)*

B.2.1.a Are you a member of an environmental or conservation organization (e.g. NABU, WWF, Greenpeace)? *(Yes, No)*

B.2.2 Remember that you have the chance to win a real 25€ by filling out this questionnaire. Now, you have the chance to donate some of this amount to an environmental organization which supports the protection or sustainable management of forests. This is an environmental organisation that engages in the protection of forests and biodiversity in Germany. If you win, please indicate how much of the 25€ you would be willing to donate for the protection of forests. The amount will be deducted from your voucher in case you are selected.

Sliding scale from 0.50€, up to 25€ (in 0.50€ steps)

B.3 Diet

B.3.1 Which of the following best describes your diet:

- I eat no animal products at all (vegan)
- I eat no meat and no fish (completely vegetarian)
- I eat no meat, but fish (pescatarian)
- I eat meat, but only with an eco label, if possible.
- I eat meat, but try to reduce it
- I eat meat even if it does not have an eco label
- Other:

B..3.1a If you do not eat (certain types of) meat or animal products, why?

- Parental preferences
- Religious reasons
- Health issues
- Concern for animal rights
- Concern for the environment
- Other:

C Knowledge and Attitude

C.1 Your relation and attitude towards nature

Please tick the option that best reflects your attitude.
("strongly disagree" - "disagree" - "neutral" - "agree" - "strongly agree")

C.1.1 Nature suffers from our modern lifestyles.

C.1.2 Should humans treat nature well in your opinion. Please select all that apply:

- No, I don't think humans have to treat nature well.
- Yes, because nature's value is unique; nobody has the right to damage it.
- Yes, because nature provides the basis for human's life.
- Yes, because nature must be maintained in favor of future generations.
- Yes, because humans have a responsibility to care for nature.
- I don't know.
- Other:

C.1.3 Nature protection creates benefits for humans, for example their health, quality of life, happiness or recreation.

C.1.4 Every human being should stand up for nature and the environment.

C.1.5 How important is nature to you personally? (*"not at all important" - " not important" - "neutral" - "important" - "very important")*

C.2 Forests

C.2.1 How important are forests to you? *("not at all important" to "very important")*

C.2.2 When you think about a forest, do you feel ...

- Interest
- Awe
- Happiness
- Calmness
- Responsibility
- Boredom

- Disgust
- Nothing at all
- I don't know
- Other:

C.2.3 In which condition would you say German forests are at the moment?

- very good
- Good
- Neither
- Bad
- Very bad
- I don't know

C 2.4 How much do you think you know about forests?

- I don't know anything about forests.
- I know a little bit about the functions of forests and problems that could negatively affect forests.
- I am confident in explaining the functions of forests and problems that could negatively affect forests.
- I am a young forest expert. I regularly read about forests and gather new information.

C.2.5 Would you like to learn more about forests? *(Yes, No, Maybe, Don't Know)*

C.2.6 Germany's forest cover is roughly …

50% 30% 20% 15% 10%

C.2.7 How much percent of today's area of Germany was covered with forests before human started to settle there?

C.2.8 Please select the response that best fits your knowledge.

	Definitely wrong	Probably wrong	Probably correct	Definitely correct	I don't' know
Forests are not important for our drinking water	○	○	○	○	○
Forests capture carbon from the atmosphere.	○	○	○	○	○
Trees can store carbon in the long-term.	○	○	○	○	○
Forest soils can store carbon in the long-term.	○	○	○	○	○
The ability to clean and store drinking water is the same in every forest, independent of the trees in it.	○	○	○	○	○
Broad leaved forest improve the soil quality of forests over time.	○	○	○	○	○
Forests do not have a large impact on climate change.	○	○	○	○	○

C.2.9 As a result of climate our forests could change. Which changes in your opinion are already noticeable in many forests?

- Trees die due to extreme weather conditions, storms and dry periods
- Animals cannot live where they lived before anymore
- Damaging insects destroy trees to a much higher extent
- Trees capture less CO2 when it is dry for very long periods
- None of the above.
- I don't know

C.3. Environmental problems

C.3.1 How worried are you about the following environmental problems?

	Not at all worried	A little bit worried	Indifferent	Worried	Very worried
Destruction of forests					
Forest fires					
Water pollution (oceans, lakes and rivers)					
Air pollution					
Too much garbage					
Climate change					
Ozone hole					
Species extinction (plants and animals)					

How much do you agree with the statement? *("strongly disagree" to "strongly agree")*

C.3.2 I feel responsible for finding solutions to environmental problems.

C.3.3 Do you think you can help reducing environmental problems by changing your consumption behavior (e.g. flying less by plane, using less plastic, eating less meat, etc.)?

- No, this does not have any impact.
- Yes, but only a small impact.
- Yes, this can have an impact.
- Yes, this definitely has an impact.
- I don't know.

C.3.4 Do you think you can help reducing environmental problems when you become active for the environment (e.g. through your profession, a campaign or political activism)?

- No, this does not have any impact.
- Yes, but only a small impact.
- Yes, this can have an impact.
- Yes, this definitely has an impact.
- I don't know.

C.3.5 How much do you think you know about climate change?

- I don't know anything about climate change.
- I know a little bit about the causes of climate change and its potential consequences for nature and humans.
- I am confident in explaining the causes of climate change and its potential consequences for nature and humans.
- I am a young climate change expert. I regularly read about climate change and gather new information.

C.3.6 Would like to learn more about climate change? *(Yes, Maybe, No, Don't know)*

How much would you agree with the following statements? *("strongly disagree" to "strongly agree")*

C.3.7 Climate change is caused by human activities.
C.3.8 Climate change affects the daily life of people around the world already.
C.3.9 Climate change threatens my future.

C.3.10 Please indicate which of the following contribute to causing climate change:

- Ozone hole
- Burning of fossil fuels and carbon dioxide emissions from industry
- The greenhouse effect
- Destruction of forests
- Animal mass production
- Plastic pollution in the oceans
- I don't know

3.11. Please indicate how much you think the following may be a consequence of climate change in the near future

- Regional loss of tree species
- More regular and severe extreme weather events, like floods and droughts
- Sea level rise
- Increase of the ozone hole
- Refugees from environmental disaster
- Increase of plastic in the oceans

C.12 Where do you hear about climate change?

- I don't hear much about climate change.
- I hear about it through family and friends.
- I hear about climate change at school.
- I read articles or listen to the radio or podcasts that I come across in my daily life.
- I actively search for information through various news sources.

C.4. Future environmental aspirations

How important will the following be in the future for you: *("not at all important" to "very important")*

C.4.1 Contribute finding a solution to solve environmental problems.

C.4.2 Would you like to find a job in which you can work in or for nature/environment? If yes, please select all areas that you consider.

- Forestry
- Agriculture
- Gardening and landscape management
- Nature protection (e.g. in a National Park)
- Law (e.g. lawyer)
- Natural science (e.g. Biology and Physics, etc.)
- Technology (e.g. engineer for renewable energy and electric vehicles)
- Economics (e.g. in a sustainable business, a "green" bank or in economic research)
- Environmental NGO (e.g. WWF or Greenpeace)
- Politics
- Education (e.g. teacher in environmental education)
- Development aid
- I don't know it yet
- Other:
-

C.5 Changes in Knowledge and Attitude (Only for the second survey)

How much would you say you have changed your attitude towards the following since the last survey? *("Not at all" – "A little" – "A lot" – "Don't know")*

- Nature
- Forests
- Climate change

If a change has occurred, why do you think you have changed your attitude since the first survey?

- I have learned new things that made me reflect about my attitude.
- I have talked to other students.
- I have talked to my parents.
- I have started to become involved with an environmental organisation.
- I have participated in an environmental project at my school.
- Other:

D Wellbeing

D.1 All things considered, how happy/satisfied are you with your life as a whole?
(0 = extremely dissatisfied 10 = extremely satisfied)

D.2 How happy are you right now?

D.3 How anxious are you right now?

E School Forest Carolinum (Only for the second survey and the treatment group)

Did you attend the school forest project at your school? *(Yes, No)*

How often did you visit the school forests outside the activities organized by your school? *("Never", "once", "2-5 times", "more than 5 times")*

How much did you enjoy participating? *("Not at all" – "A little" – "A lot" – "Don't know")*

Did you learn something new? *("Not at all" – "A little" – "A lot" – "Don't know")*

Would you say that the project affected your attitudes and/or behaviour towards forests? *("Not at all" – "A little" – "A lot" – "Don't know")*

When thinking about the school forest, do you feel:

Pride	Responsibility	Disgust
Happiness	Excitement	Boredom

Thank you very much for your participation!

Appendix 4: Questions for In-Depth Interviews

Welcome / Introduction

"Thanks for participating in this interview! I have prepared several questions that can guide us though this interview, but I would also like to leave some room for you to talk about aspects that are important for you, but potentially did not come up in my questions. The goal of this interview is to get a more nuanced understanding of your relation to forests and climate change. Several questions will be about your participation in the forest school program. I will pick up some questions from the two surveys you have already filled out in January and March. Please answer as honest and as detailed as possible.

1. Environmental Attitudes

How would you describe your attitude to nature and specifically forests? Attitude in this context captures what you think about nature and forests, which value you assign to them and whether/why you think they should (or should not) be protected.

Did this attitude change due to your participation in the forest school program? If yes, why?

2. Responsibility

In what way, would you say, is spending time in a normal forest different from spending time in the school forest?

What do you associate with the school forest?

Do you feel some kind of responsibility for the school forest? If yes, why?

3. Awareness

How would you describe your awareness about environmental problems in general? Which ones do you worry most about? How worried are you about climate change and the conditions of forests compared to other environmental problems?

Did this change due to your participation in the forest school program? If yes, why?

4. Knowledge

What do forests have to do with climate change and what does climate change have to do with forests?

Where did you learn this from? Did you learn any of this during the forest school program?

Where you aware of the interconnectedness between forests and climate change before participating in the school forest project?

Is there anything you learned through the school forest project, which we did not talk about so far?

5. Interdisciplinarity

According to your response in the survey from January, your most favorite subjects are… Could you find topics in the school forest project which fit to your personal interests? Did you see interconnections to other areas which you find interesting but did not expect?

6. Project design

How did you like the project overall and what did you like most?

Was there something you missed in the project?

7. Mechanisms

We have now talked a lot about the forest school program you participated in. Would you say, that your participation caused any kind of change in your life?

Why do you think did these changes occurred?

8. Wellbeing

Would you say your participation in the school forest project contributed to your wellbeing? If yes, why?

9. Future Aspirations

Would you like to work in or for the environment in your future?

Did your future aspiration change after your participation in the school forest project?

Would you say the school forest project can have a positive impact on the environment? Would you say, *you* can have a positive impact on the environment through your participation in the school forest project?

10. WTD

Why did you choose the amount you indicated to donate to an environmental organization that protects forests?

11. Spillovers / Communication

Did you speak to students from class 9/2 or 9/5 about the project?

With whom did you talk about the project?

Table 5.1: Main regression table with non-standardized outcome variables

	(1) Knowledge	(2) Knowledge	(3) Attitude	(4) Attitude	(5) Awareness	(6) Awareness	(7) Diet	(8) Diet	(9) WTD	(10) WTD	(11) Wellbeing	(12) Wellbeing
Treatment	2.418*	2.222	0.0691	0.351**	-0.214	0.00864	-0.0618	-0.0369	0.309	1.016	0.203	-0.110
	(1.104)	(1.200)	(0.139)	(0.124)	(0.147)	(0.165)	(0.109)	(0.118)	(1.797)	(2.032)	(0.447)	(0.486)
Post	2.241	1.686	-0.0552	1.976*	-0.267	1.399	-0.0690	-0.0651	-1.103	0.959	-0.505	-2.002
	(1.236)	(5.738)	(0.141)	(0.999)	(0.195)	(1.208)	(0.123)	(0.352)	(1.919)	(6.623)	(0.516)	(1.451)
Post x Treatment	1.476	1.672	0.0891	-0.193	0.376	0.154	0.295	0.270	-1.614	-2.321	0.947	1.261
	(1.581)	(1.662)	(0.201)	(0.193)	(0.262)	(0.275)	(0.154)	(0.162)	(2.461)	(2.655)	(0.653)	(0.686)
Female		-0.995		0.203		0.0806		0.175		3.901		-0.979*
		(1.155)		(0.112)		(0.163)		(0.101)		(2.014)		(0.436)
Can walk to next forest		-0.934		0.129		0.210		0.0785		-2.870		-0.103
		(1.975)		(0.210)		(0.264)		(0.149)		(3.040)		(0.769)
Time spent on homework		0.762		0.267		0.338		-0.00882		1.233		0.369
		(1.109)		(0.146)		(0.175)		(0.0785)		(1.384)		(0.370)
Time spent on social media		-0.691		-0.00550		-0.0370		-0.0979		-0.617		-0.643*
		(0.679)		(0.0943)		(0.112)		(0.0531)		(0.995)		(0.291)
Time spent on hobbies		0.345		0.278**		0.143		0.0527		0.116		0.150
		(0.768)		(0.0974)		(0.121)		(0.0601)		(1.073)		(0.273)
Constant	10.03***	10.59	3.972***	1.941	4.336***	2.670*	0.345***	0.341	11.28***	9.213	6.643***	8.140***
	(0.827)	(5.662)	(0.0961)	(0.994)	(0.0821)	(1.195)	(0.0894)	(0.342)	(1.358)	(6.479)	(0.340)	(1.397)
Observations	82	82	82	82	82	82	82	82	82	82	82	161
Adjusted R-squared	0.156	0.143	-0.011	0.125	-0.007	0.027	0.027	0.032	0.005	0.026	0.021	0.052

Notes: This table shows the main regression results for the impact of the forest school treatment on the six main outcome variables. Column 1-2 show the main treatment effect on knowledge about forests and climate change; column 3-4 show the effect on attitude towards nature and forests; column 5-6 represent the effect on awareness about forest and climate change related issues; column 7-8 elicit the effect on whether meat was reduced or forgone for environmental reasons; column 9-10 state the effect on willingness to donate (WTD) for an organization that protects forests and column 11-12 elicit the effect on wellbeing. The dependent variables in columns 1-6 and 9-12 are *not* standardized.
Standard errors are in parentheses. ***, **, and * denote significance at the 1, 5, and 10% levels, respectively.