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The Journal of Climate Change and Health

journal homepage: www.elsevier.com/joclim

Research article

Evaluating the Public Climate School, a multi-component school-based program to promote climate awareness and action in students: A cluster-controlled pilot study

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ARTICLE INFO

Article History:

Received 1 September 2023

Accepted 24 November 2023

Available online 27 November 2023

Keywords:

Climate change

Behavioral intentions

Pro-environmental behavior

Climate awareness

Climate action

Education for sustainable development

School-based program

ABSTRACT

Introduction: Despite the potential of school-based programs targeting climate awareness and action to support students in addressing the climate crisis and to improve their mental health and well-being, there is limited evidence for their effectiveness. In preparation for a cluster-randomized controlled trial, we assessed the feasibility of evaluating the Public Climate School (PCS), a one-week school program in Germany, and its effects on theory-based behavioral and psychological outcomes.

Material and methods: We enrolled 158 students from 11 classes (grades 7–13) into a cluster-controlled pilot study. Four classes were allocated to the waitlist control group and 7 to the intervention group participating in the PCS in November 2021. Using online surveys, we assessed theory-based behavioral and psychological outcomes at baseline and follow-up. Two-level models were used to investigate changes in outcomes.

Results: 125 students completed the baseline and follow-up survey (dropout rate: 21 %). For most outcomes we observed no between-group differences, except for pro-environmental communication and engagement (e.g., posting on social media; $p=.040$) and perceptions of environmental norms ($p=.001$) in the anticipated direction.

Conclusion: This study confirmed the feasibility of evaluating the PCS and provides parameter estimates to guide sample size calculations and study design decisions for future research. Together with recent work on the association between collective action and mental health, the effect of the PCS on pro-environmental communication and engagement highlights the value of examining effects of education for sustainable development programs on student health and linking them to collective action in future work.

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1. Introduction

The climate crisis poses unprecedented threats to human livelihoods and health [1], requiring mitigation and adaptation measures at all levels of society. Today's young generation is particularly

affected by the detrimental consequences of the climate crisis [2,3] and suffers from adverse mental health effects, including climate anxiety [4–6]. In a recent multi-country survey among young people, 75 % of respondents perceived their future as frightening [4], with low levels of self-efficacy potentially aggravating climate anxiety [7,8]. Meanwhile, young people are a driving force behind the current climate protests (e.g., Fridays for Future) and can contribute to climate action in meaningful ways [9]. Recent work suggests that unlike individual actions, collective action such as joining or leading

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advocacy groups or participating in climate protests might be associated with beneficial effects on mental health and well-being in youth [10].

Schools can play an important role in promoting climate knowledge in young people by providing information on the climate crisis and its consequences as well as mitigation and adaptation strategies [11]. Moreover, they have the potential to foster student mental health in light of the accelerating climate crisis by promoting skills to take collective climate action [10]. However, the implementation of education for sustainable development (ESD) programs aimed at fostering climate awareness and action is currently limited in Germany and internationally [12,13]. Progress in the field is held back by limited and inconsistent evidence for the effectiveness of ESD programs [14]. Prior work showed positive effects on students' sustainability knowledge [15,16], attitudes [16,17], and behaviors [12], but also null effects were found for these outcomes [18].

Previous studies evaluating ESD programs rarely used theoretical frameworks to inform their research, limiting the ability to investigate mechanisms of behavior change based on the assessment of theory-informed mediators [19]. To close this gap, we used the Social Identity Model of Pro-Environmental Action (SIMPEA) [20] to guide the design of this pilot study and the selection of outcomes [14]. The SIMPEA has been used to explain social, psychological, and emotional determinants of climate action [21]. Specifically, the SIMPEA proposes that climate change-related cognitions (e.g., risk perceptions) and emotions (e.g., guilt) result from climate crisis appraisals, which in turn spur social identity-related processes (e.g., adherence to social norms, collective efficacy beliefs, and identification with groups). These processes, again, affect pro-environmental intentions and behaviors.

This pilot study contributes to the limited body of evidence on ESD programs by examining methodological and procedural aspects of evaluating the Public Climate School (PCS), a multi-component school-based program to improve climate awareness and action among school students in Germany. In preparation of future intervention studies assessing the effectiveness of the PCS and similar school-based programs, we investigated participant recruitment and retention, data quality as well as basic psychometric properties and parameter estimates of SIMPEA-based outcomes.

2. Material and methods

2.1. Study design

The pilot study was based on a parallel-group cluster-controlled design conducted in five schools in Germany with seven classes

participating in the PCS (henceforth *intervention classes*) and four classes serving as waitlist controls (henceforth *control classes*; Fig. 1). Control classes took part in the PCS after the pilot study. Data were collected one week before ('T': Time; T1) and one week after the PCS (T2), in close collaboration with *Klimabildung e.V.*, the NGO implementing the PCS. The study design and selection of outcomes was guided by the SIMPEA [20], described in detail in the study protocol [14].

The study was prospectively registered with the German Clinical Trials Register (ID: DRKS00027021). School authorities at federal level and the Ethics Committee of the Department of Education and Psychology of the Freie Universität Berlin (036/2021) approved the study. Written informed consent was obtained from students and their parents. No financial incentives were offered for study participation.

2.2. Recruitment and group allocation

We invited teachers from approximately 7,500 schools in Germany to participate in the pilot study by providing study information via the PCS newsletter. Given the study's focus on adolescents aged 12–19 years, we recruited a convenience sample of classes covering grades 7–13 without specifying further exclusion criteria. We then invited all students in participating classes to take part in the baseline and follow-up surveys by distributing a leaflet on study content and procedures, without applying any exclusion criteria at student level.

Classes were allocated to the intervention or control group after recruitment. Due to logistical constraints, group allocation was performed locally by teachers that were instructed to assign their classes by tossing a coin. Given the type of intervention, it was not possible to blind the school community or the implementation team to the intervention status of the classes.

2.3. Intervention

The PCS targets all schools in Germany and aims at increasing students' knowledge about the climate crisis and empowering them to become change agents that initiate climate action. Given its aim to bridge the gap between knowledge and action, the PCS applies core ESD principles such as forward thinking, autonomous action, or participation in social decision-making processes [22]. It focuses on the climate crisis and related topics such as biodiversity loss, climate justice, climate communication, economic impact of the climate crisis, visions of a sustainable future, or climate and arts. The PCS comprised four components, including live online lessons, climate-related

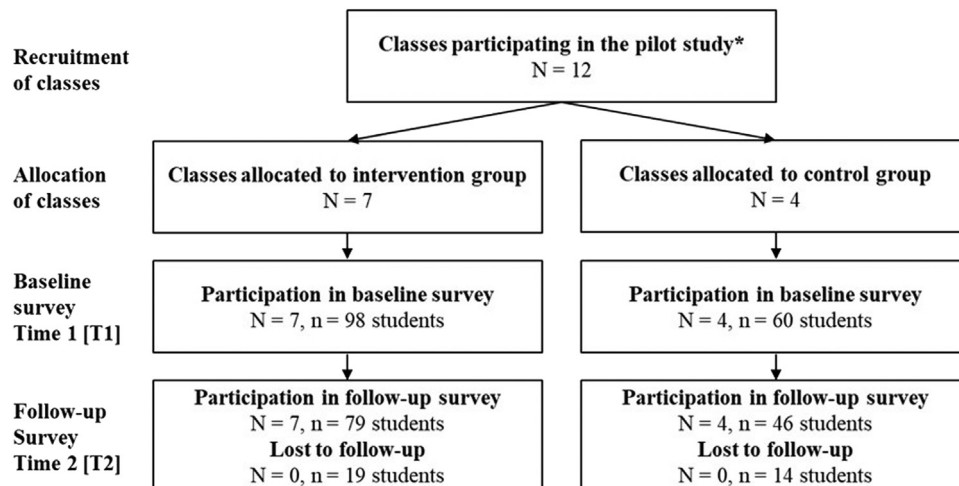


Fig. 1. Participant flow.

Note. * One class dropped out prior to group allocation.

challenges of the day, workshops, and peer exchange sessions. A detailed description of the PCS components is presented in the Supplemental Online Appendix (Table S1). This pilot study evaluates the PCS from 2021, conducted during a school week between November 22-26. Intervention material and further information are presented on the PCS website [23].

2.4. Data collection and measures

We invited students to complete online surveys before and after the PCS. Using a link or QR code on the invitation leaflet, students accessed the online surveys implemented in Unipark (QuestBack GmbH, Oslo, Norway) on their private devices during school hours.

As process measures, we assessed participant recruitment and retention, proportions of missing data, as well as basic psychometric properties of the scales. The selection of the primary and secondary outcomes was guided by the SIMPEA [20]. An overview of outcome measures is provided in the Supplemental Online Appendix (Table S2). Given a lack of validated German scales for outcome assessment, we translated and adapted items from international studies. When suitable items were not available, we created new items. Sociodemographic data were assessed at baseline and included grade level, gender, subjective social status (assessed with the German version of the MacArthur Scale [24]), parental educational attainment, and municipal size.

2.5. Data analysis

In retention analyses, we investigated whether students providing data at both time points differed from students that only provided baseline data by assessing baseline differences via *t*- or χ^2 -tests and using a binary retention variable (0=not retained for analysis, 1=retained) [25]. For group allocation tests, corresponding procedures were conducted using a binary group allocation variable (0=control group; 1=intervention group). Parameter estimates for study outcomes at T2 were investigated in Mplus using separate random intercept two-level models with students nested in classes. The intervention group and grade level were included as class-level predictors. Student-level predictors were the baseline level of the outcome, students' gender (female=1), and subjective social status. Unless dichotomous, predictors were grand-mean centered. To account for missing data, we applied full information maximum likelihood procedures for model estimation. To assess the proportion of variance observed at student- and class-level, we investigated intra-class correlation coefficients (ICC) for all outcomes.

Data analyses were conducted with IBM SPSS 29 and Mplus (Version 8.1 [26]). For replication purposes, analysis codes are available upon request.

3. Results

3.1. Sample characteristics

Classes from five schools in three German federal states (Baden-Württemberg, Niedersachsen, and Schleswig-Holstein) participated in the study. While three study sites were high schools, the remaining two sites comprised a mix of school types including high school, secondary school, and vocational school. In total, twelve classes were recruited with one class dropping out before group allocation. In grade levels 7, 9, 10, 11, and 12, two classes participated in the study, respectively, while only one class in grade level 13 took part. In total, 158 students were enrolled in the study, translating to an average number of 14 participants per class (range: 7–26). Detailed sample characteristics are presented in Table 1.

Table 1
Sample characteristics by study group.

	Intervention group n = 98 M (SD) or n (%)	Control group n = 60 M (SD) or n (%)
Grade level (7-13)	10.66 (1.69)	9.73 (1.53)
Gender		
Female	42 (43 %)	27 (45 %)
Male	54 (55 %)	32 (53 %)
Diverse	2 (2 %)	1 (2 %)
Social status (1=lowest - 10=highest)	6.14 (1.78)	6.43 (1.79)
Parental education: at least 12 years of schooling		
Both parents	32 (36 %)	23 (45 %)
One parent	23 (26 %)	18 (35 %)
None	35 (39 %)	10 (20 %)
Municipal size		
< 5,000 inhabitants	15 (15 %)	8 (14 %)
5,000 – 19,999 inhabitants	19 (19 %)	8 (14 %)
20,000 – 99,999 inhabitants	19 (19 %)	23 (40 %)
100,000 – 999,999 inhabitants	37 (38 %)	12 (21 %)
≥ 1,000,000 inhabitants	8 (8 %)	7 (12 %)

Note. M: mean. SD: standard deviation. (x-y) refers to the response range of the variable.

3.2. Group allocation and participant retention

Seven (98 students) and four classes (60 students) were allocated to the intervention and control group, respectively. Group allocation tests revealed that baseline variables were similarly distributed in both groups, except for student grade level (intervention group: $M = 10.66, SD=1.69$; control group: $M = 9.73, SD=1.53$; $t(156)=-3.48, p<.001$).

In total, 125 students from 11 classes provided data for both time points (79 % retention). There was no evidence for differences in baseline variables between students providing data at both time points and students only providing baseline data, except for subjective social status (students providing baseline data only: $M = 5.48, SD=1.43$; students providing data at both time points: $M = 6.43, SD=1.82$; $t(148)=-2.62, p=.010$).

3.3. Observations during data collection

Students participated in the online surveys mainly via their private smartphones and needed on average 18 ($SD=6$, range: 7–46) and 13 minutes ($SD=4$, range: 6–24) to complete the questionnaire at T1 and T2, respectively. According to teacher reports, study material including a manual and checklist were highly valued by school staff and informed consent procedures were well accepted by students and parents. In lower grade levels, teachers had to support some students in completing the surveys.

3.4. Data quality and basic psychometric properties

At T1, data from 155 to 158 participants were available for each item (item-level proportion of missing data: $\leq 2\%$). At T2, data from 120 to 125 participants was received (item-level proportion of missing data: $\leq 4\%$).

Most items contributed to higher internal consistency of scales, except for two items that were excluded for scale computation (climate change-related positive emotion scale: 'convinced'; postmaterialistic values scale: 'One should now allow that measures to reduce carbon emissions are compromising wealth'). Final scales showed mostly acceptable or good internal consistency (Cronbach's alpha: 0.63–0.94; Table 2).

Table 2
Descriptive statistics and internal consistency for study outcomes per group.

		Cronbach's α	Intervention group			Control group		
			M (SD)	Skewness	Kurtosis	M (SD)	Skewness	Kurtosis
Primary outcome								
Behavioral intentions for pro-environmental consumer behaviors (1-6)	T1	.77	4.27 (1.11)	-0.48	0.29	3.78 (1.30)	-0.27	-0.87
	T2	.87	4.34 (1.41)	-0.93	0.28	3.96 (1.28)	-0.30	-1.08
Secondary outcomes								
Behavioral intentions for pro-environmental communication and engagement (1-6)	T1	.82	2.73 (1.39)	0.56	-0.37	2.38 (1.12)	0.40	-1.01
	T2	.88	2.74 (1.53)	0.54	-0.83	2.26 (1.20)	0.61	-0.32
Pro-environmental consumer behaviors (1-6)	T1	.63	4.13 (0.95)	-0.12	0.13	3.82 (1.02)	-0.26	-0.89
	T2	.74	4.03 (1.22)	-0.67	0.02	3.77 (0.94)	0.12	-1.09
Pro-environmental communication and engagement behaviors (1-6)	T1	.72	2.57 (1.27)	0.59	-0.29	2.18 (1.00)	0.57	-0.71
	T2	.82	2.51 (1.41)	0.57	-0.91	1.87 (0.91)	0.71	-0.79
Climate change-related positive emotions (1-5)	T1	.69	2.16 (0.85)	0.98	1.10	2.48 (0.86)	0.60	0.27
	T2	.69	2.24 (0.90)	0.60	0.07	2.16 (0.78)	0.48	-0.12
Climate change-related negative emotions (1-5)	T1	.89	2.70 (0.83)	0.17	-0.77	2.46 (0.73)	0.41	0.02
	T2	.93	2.65 (0.92)	0.04	-0.71	2.49 (0.94)	0.21	-0.79
Climate change-related risk perception (1-5)	T1	.74	3.89 (0.66)	-0.74	0.89	3.66 (0.57)	-0.78	-0.11
	T2	.90	3.78 (1.02)	-1.65	2.25	3.66 (0.86)	-1.32	1.71
Climate change-related concerns (1-6)	T1	.80	4.70 (1.09)	-1.06	1.30	4.33 (1.11)	-0.73	0.71
	T2	.83	4.49 (1.18)	-1.27	2.08	4.12 (1.27)	-0.64	0.23
Tendency to deny the climate crisis (1-6)	T1	.80	1.68 (0.88)	1.75	2.36	1.98 (1.04)	2.22	6.15
	T2	.89	1.68 (1.07)	2.56	6.95	1.88 (1.10)	2.00	4.65
Climate change-related self-efficacy (1-6)	T1	.81	4.23 (1.12)	-0.67	0.34	3.72 (1.23)	-0.72	0.38
	T2	.87	4.16 (1.29)	-0.88	0.42	3.46 (1.42)	-0.38	-1.05
Climate change-related collective efficacy (1-6)	T1	.85	4.54 (1.10)	-0.92	1.10	3.94 (1.29)	-0.70	0.06
	T2	.91	4.39 (1.46)	-0.88	0.03	3.63 (1.52)	-0.41	-1.11
Climate change-related altruistic values (1-6)	T1	.76	5.62 (0.47)	-1.44	1.69	5.34 (0.90)	-2.50	8.74
	T2	.83	5.48 (0.95)	-3.30	12.03	5.37 (0.77)	-1.28	0.68
Climate change-related biospheric values (1-6)	T1	.83	5.44 (0.67)	-2.06	5.65	5.13 (0.99)	-2.31	6.51
	T2	.89	5.33 (1.04)	-2.68	8.03	5.00 (1.00)	-1.28	1.19
Climate change-related environmental norms (1-6)	T1	.92	3.74 (1.24)	-0.04	-0.39	3.29 (1.17)	0.07	-0.62
	T2	.93	3.81 (1.38)	-0.49	-0.25	2.99 (1.12)	-0.11	-1.11
Postmaterialistic values (1-5)	T1	.73	3.86 (0.97)	-0.47	-0.46	3.51 (1.11)	-0.51	-0.37
	T2	.82	3.84 (1.07)	-1.05	0.74	3.36 (1.15)	-0.52	-0.25
Identification with civic engagement groups involved in climate action (1-6)	T1	.88	3.86 (1.34)	-0.01	-0.77	3.40 (1.31)	0.02	-0.18
	T2	.94	3.88 (1.61)	-0.37	-0.87	3.16 (1.48)	0.21	-1.00
Climate knowledge (1-6)	T1	.83	4.46 (1.10)	-0.69	0.43	3.89 (1.18)	-0.54	0.18
	T2	.90	4.55 (1.19)	-1.34	2.15	3.88 (1.33)	-0.47	-0.44

Note. T1, intervention group: 97 ≤ n ≤ 98 students; T2, intervention group: 77 ≤ n ≤ 79 students. T1, control group: 58 ≤ n ≤ 60 students; T2, control group: 43 ≤ n ≤ 46 students due to missing values. M: mean. SD: standard deviation.

3.5. Parameter estimates for study outcomes

Most outcome variance was observed at the student level (ICC: 0.01–0.13; Table 3 and Supplemental Online Appendix, Table S3). An ICC of 0.04 (e.g., pro-environmental communication and engagement; Table 3) means that 4 and 96 % of the variance was accounted for by the class and student level, respectively. Changes in behavioral intentions for pro-environmental consumer behaviors (primary outcome) did not differ between the intervention and control groups (b = 0.14, 95 % CI [-0.42;0.71], p=.622). Changes in secondary outcomes did not differ between groups either, except for pro-environmental communication and engagement behaviors (b = 0.44, 95 % CI [0.02;0.85], p=.040) and perceptions of environmental norms (b = 0.50, 95 % CI [0.20;0.80], p=.001), both showing higher levels in the intervention group.

4. Discussion

This pilot study aimed at investigating participant retention, data quality as well as basic psychometric properties and parameter estimates of outcome measures to inform future effectiveness studies of the PCS and similar ESD programs.

4.1. Feasibility of evaluating the Public Climate School

Despite a comprehensive recruitment strategy involving 7,500 schools in Germany, only 11 classes from 5 schools participated in

the pilot study. Limited participation likely reflects disruptions in school systems associated with the COVID-19 pandemic including partial school closures and increased burden of school staff, but also highlights the added value of developing targeted recruitment strategies for evaluating ESD programs. Decentral group allocation by teachers resulted in an unbalanced number of classes in the intervention and control group pointing to the need for a centralized randomization procedure implemented by research staff, possibly using stratified randomization [27,28]. In total, 79 % of students provided data for both surveys reflecting an acceptable dropout rate. Higher loss to follow-up among students from lower socio-economic backgrounds highlights the importance of developing strategies to increase retention rates in this group when evaluating ESD programs [29].

Observations during data collection indicate high acceptability of online surveys that students flexibly complete on their private smartphones or school-provided devices. Future studies should consider liaising with school staff prior to study commencement regarding technical requirements in order to enable each student to participate. Providing teachers with a manual and checklist for assessment sessions were important tools to facilitate data collection. To further reduce teacher burden, research teams should consider attending assessment sessions and assisting teachers with data collection in future studies.

Low proportions of item-level missing data at both time points suggest survey acceptability and reasonable participant burden. The majority of scales showed at least good internal consistency at

Table 3
Parameter estimates for behavioral outcomes at follow-up (T2).

	Estimate	SE	p-value	95 % CI
Primary outcome				
Behavioral intentions for pro-environmental consumer behaviors (ICC=0.01)				
Student-level predictors				
Intercept at T2	4.07	0.36	<.001	3.36; 4.77
Baseline level of outcome	0.76	0.14	<.001	0.48; 1.04
Female (vs. not)	0.08	0.34	.811	−0.58; 0.74
Social status	0.06	0.07	.387	−0.08; 0.20
Class-level predictors				
Intervention (vs. control)	0.14	0.29	.622	−0.42; 0.71
Grade level	— ^a	— ^a	— ^a	— ^a
Secondary outcomes				
Behavioral intentions for pro-environmental communication and engagement (ICC=0.05)				
Student-level predictors				
Intercept at T2	2.30	0.18	<.001	1.95; 2.66
Baseline level of outcome	0.74	0.08	<.001	0.59; 0.89
Female (vs. not)	0.32	0.19	.097	−0.06; 0.69
Social status	0.01	0.05	.988	−0.10; 0.10
Class-level predictors				
Intervention (vs. control)	0.14	0.19	.485	−0.25; 0.52
Grade level	0.16	0.06	.006	0.05; 0.27
Pro-environmental consumer behaviors (ICC=0.09)				
Student-level predictors				
Intercept at T2	3.74	0.17	<.001	3.41; 4.08
Baseline level of outcome	0.51	0.09	<.001	0.33; 0.70
Female (vs. not)	0.37	0.19	.051	−0.01; 0.74
Social status	−0.02	0.05	.765	−0.12; 0.09
Class-level predictors				
Intervention (vs. control)	−0.01	0.21	.979	−0.41; 0.40
Grade level	0.19	0.06	<.001	0.08; 0.29
Pro-environmental communication and engagement behaviors (ICC=0.04)				
Student-level predictors				
Intercept at T2	2.14	0.19	<.001	1.76; 2.51
Baseline level of outcome	0.67	0.09	<.001	0.49; 0.84
Female (vs. not)	−0.23	0.22	.300	−0.66; 0.20
Social status	−0.02	0.05	.748	−0.12; 0.09
Class-level predictors				
Intervention (vs. control)	0.44	0.21	.040	0.02; 0.85
Grade level	— ^a	— ^a	— ^a	— ^a

Note. CI: confidence interval; ICC: intra-class correlation; SE: standard error. a: Predictor was excluded due to model non-convergence. Unstandardized coefficients are reported. Significant parameter estimates in bold. Model estimates refer to 120 ≤ n ≤ 121 students from 11 classes due to missing values. Average cluster size: 11 students per class.

baseline, except for pro-environmental consumer behaviors [30] and climate change-related positive emotions [31]. To support the rigorous assessment of ESD programs, there would be value in refining available scales to improve their psychometric properties and to develop new validated scales in case no high-quality instruments are currently available.

4.2. Preliminary parameter estimates

Dropout rates, average cluster sizes as well as estimates for parameters and intraclass correlation coefficients from this pilot study can be used to inform study design decisions and sample size estimations in future work [32]. Based on a sample of approximately 120 students, an average cluster size of 11 students per class and small intraclass correlation coefficients, recent evidence from simulation studies suggests that the pilot study was only powered to detect medium-sized level-2 (i.e., class-level) effects [32], highlighting the need for larger samples to detect smaller, yet meaningful effects. Non-significant between-group differences in study outcomes could thus be related to limited statistical power, precluding definitive conclusions regarding the effectiveness of the PCS.

Interestingly, we identified a significant between-group difference for students' pro-environmental communication and engagement (e.g., post on social media or talk with family members about climate protection), pointing towards the potential of the PCS to not only address consumer behaviors, but also civic actions aimed at mobilizing other individuals [33]. This result adds value to recent research on the potential of collective actions, as opposed to individual behaviors, to attenuate adverse effects of climate change anxiety on mental health in young people [10,34]. Based on these results, we currently plan a study with an additional 12-week follow-up survey assessing associations between civic action and well-being after PCS participation.

Taken together, our results and recent advances in the literature suggest that the PCS and other ESD programs should provide opportunities for collective action to strengthen students' impact (e.g., socio-ecological handprint [33]) and to promote their health and well-being. In the context of the PCS, the *climate-related challenges of the day* currently provide untapped potential to further strengthen opportunities for collective action by refocusing the selection of challenges on civic actions. Complementing existing program components, the PCS could be used as a platform to link students to civic organizations, providing low-threshold opportunities for collective climate action [33].

Moreover, we observed higher levels of perceived environmental norms, a determinant of pro-environmental behaviors, in intervention classes [20,35]. However, it has to be noted that both between-group differences reflected a decrease in the control group with stable outcome levels in the intervention group. This result could be explained by 'Black Friday' on November 26, 2021 (i.e., right before the follow-up survey), a national sales event with discounts in many stores [36]. Possibly, the PCS might have attenuated otherwise worsening levels of students' pro-environmental communication and engagement and environmental norms.

4.3. Strengths, limitations, and future directions

Despite several strengths, including the assessment of an innovative and highly relevant school-based program aimed at promoting climate awareness and action as well as foundational work on multiple feasibility components, we acknowledge several limitations. First, this pilot study lacks statistical power to detect small effects in study outcomes. This highlights the need for refined recruitment strategies addressing school- and student-level barriers for study participation to enroll sufficient schools and classes for a future effectiveness trial [28]. Second, we observed an acceptable, but selective dropout rate, indicating that students from lower socioeconomic backgrounds were more likely to drop out. Future research should include incentives to increase overall participation rates and follow up with non-retaining students to hear about their reasons. Third, group allocation procedures were not optimal, leading to unequal numbers of intervention and control classes that could be addressed by a-priori randomization performed by research staff and the inclusion of stratification variables (e.g., grade level). Fourth, information about the student-received "intervention dose" of the PCS program was not gathered. In a future trial, the degree of participation and interaction with program components should be assessed.

Given the intricate association between human health and the accelerating climate crisis, future iterations of the PCS will build on current health-related content including climate change-related emotions and effects of the climate crisis on sports. Moreover, refined versions will additionally focus on system-level factors to successfully adapt to the climate crisis including the interplay between health workforce shortages and crisis preparedness of healthcare systems.

5. Conclusions

This cluster-controlled pilot study confirmed the feasibility of a theory-based evaluation of the PCS and can inform recruitment, data collection as well as sample size estimations in future studies assessing the effectiveness of ESD programs. Together with recent work on the association between collective action and mental health, the potential effect of the PCS on pro-environmental communication and engagement highlights the value of examining effects of ESD programs on student health and linking them to measures of collective action.

Funding

This research received no external funding.

Institutional review board statement

The study was approved by the Ethics Committee of the Department of Education and Psychology, Freie Universität Berlin (036/2021).

Author agreement

All the listed authors consent to their names on the manuscript and contributed significantly to the manuscript regarding the following criteria: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, and (3) final approval of the version to be submitted.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Jan Keller: Conceptualization, Data curation, Formal analysis, Methodology, Project administration, Writing – original draft, Writing – review & editing. **Michael Eichinger:** Conceptualization, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. **Myriam Bechtoldt:** Conceptualization, Methodology, Writing – review & editing. **Shuyan Liu:** Conceptualization, Methodology, Writing – review & editing. **Michael Neuber:** Conceptualization, Methodology, Writing – review & editing. **Felix Peter:** Conceptualization, Methodology, Writing – review & editing. **Carina Pohle:** Conceptualization, Data curation, Investigation, Methodology, Resources, Writing – review & editing. **Gerhard Reese:** Conceptualization, Writing – review & editing. **Fabian Schäfer:** Conceptualization, Investigation, Resources, Writing – review & editing. **Stephan Heinzl:** Conceptualization, Methodology, Project administration, Software, Supervision, Writing – original draft, Writing – review & editing.

Acknowledgments

The authors wish to thank all students, teachers, school principals, and practice partners for participating in and implementing this study.

Supplementary materials

Supplementary material associated with this article can be found in the online version, at [doi:10.1016/j.joclim.2023.100286](https://doi.org/10.1016/j.joclim.2023.100286).

Abbreviations

ESD: education for sustainable development
PCS: Public Climate School

References

- [1] Skea J, Shukla P, Reisinger A, Slade R, Pathak M, Al Khouridajie A, et al. Summary for policymakers. Climate change 2022: mitigation of climate change. Contribution of working group III to the sixth assessment report of the Intergovernmental Panel on Climate Change. Cambridge, UK and New York, NY, USA: Cambridge University Press; 2022.
- [2] Sanson AV, Van Hoorn J, Burke SEL. Responding to the impacts of the climate crisis on children and youth. *Child Dev Perspect* 2019;13(4):201–7.
- [3] Crandon TJ, Scott JG, Charlson FJ, Thomas HJ. A social–ecological perspective on climate anxiety in children and adolescents. *Nat Clim Chang* 2022;12(2):123–31.
- [4] Hickman C, Marks E, Pihkala P, Clayton S, Lewandowski RE, Mayall EE, et al. Climate anxiety in children and young people and their beliefs about government responses to climate change: a global survey. *Lancet Planet Health* 2021;5(12):e863–e73.
- [5] Burke SEL, Sanson AV, Van Hoorn J. The psychological effects of climate change on children. *Curr Psychiat Rep* 2018;20(5):35.
- [6] Vergunst F, Berry HL. Climate change and children's mental health: a developmental perspective. *Clin Psychol Sci* 2022;10(4):767–85.
- [7] Innocenti M, Santarelli G, Lombardi GS, Ciabini L, Zjalic D, Di Russo M, et al. How can climate change anxiety induce both pro-environmental behaviours and eco-paralysis? The mediating role of general self-efficacy. *Int J Environ Res Public Health* 2023;20(4):3085.
- [8] Ágoston C, Csaba B, Nagy B, Kóváry Z, Düll A, Rác J, et al. Identifying types of eco-anxiety, eco-guilt, eco-grief, and eco-coping in a climate-sensitive population: a qualitative study. *Int J Environ Res Public Health* 2022;19(4):2461.
- [9] De Moor J, Wahlström M, Wennerhag M. Protest for a future II - composition, mobilization and motives of the participants in Fridays for Future climate protests on 20–27 September 2019, in 19 cities around the world. 2020.
- [10] Schwartz S, Benoit L, Clayton S, Parnes M, Swenson L, Lowe S. Climate change anxiety and mental health: environmental activism as buffer. *Curr Psychol* 2022;42(3).
- [11] Mochizuki Y, Bryan A. Climate change education in the context of education for sustainable development: rationale and principles. *J Educ Sustain Dev* 2015;9(1):4–26.
- [12] Kerret D, Orkibi H, Bukchin S, Ronen T. Two for one: achieving both pro-environmental behavior and subjective well-being by implementing environmental-hope-enhancing programs in schools. *J Environ Educ* 2020;51(6):434–48.
- [13] Holst J, Brock A. Bildung für nachhaltige Entwicklung (BNE) in der Schule: Strukturelle Verankerung in Schulgesetzen, Lehrplänen und der Lehrerbildung. Berlin, Germany; 2020.
- [14] Eichinger M, Bechtoldt M, Bui ITM, Grund J, Keller J, Lau AG, et al. Evaluating the Public Climate School - a school-based programme to promote climate awareness and action in students: protocol of a cluster-controlled pilot study. *Int J Environ Res Public Health* 2022;19(13):8039.
- [15] Boeve-de Pauw J, Van Petegem P. The effect of Flemish eco-schools on student environmental knowledge, attitudes, and affect. *Int J Sci Educ* 2011;33(11):1513–38.
- [16] Boeve-de Pauw J, Gericke N, Olsson D, Berglund T. The effectiveness of education for sustainable development. *Sustainability* 2015;7(11):15693–717.
- [17] Boeve-de Pauw J, Van Petegem P. The effect of eco-schools on children's environmental values and behaviour. *J Biol Educ* 2013;47(2):96–103.
- [18] Olsson D, Gericke N, Boeve-de Pauw J, Berglund T, Chang T. Green schools in Taiwan – Effects on student sustainability consciousness. *Glob Environ Chang* 2019;54:184–94.
- [19] Bartholomew LK, Mullen PD. Five roles for using theory and evidence in the design and testing of behavior change interventions. *J Public Health Dent* 2011;71(s1):S20–33.
- [20] Fritsche I, Barth M, Jugert P, Masson T, Reese G. A Social Identity Model of Pro-Environmental Action (SIMPEA). *Psychol Rev* 2018;125(2):245–69.
- [21] Mackay CML, Schmitt MT, Lutz AE, Mendel J. Recent developments in the social identity approach to the psychology of climate change. *Curr Opin Psychol* 2021;42:95–101.
- [22] What is education for sustainable development? 2021. [cited 2023 Nov 21] Available from: https://www.bne-portal.de/bne/en/esd-for-2030/esd-for-2030_node.html
- [23] Klimabildung e.V. Public Climate School. 2023. [cited 2023 Nov 21] Available from: <https://publicclimateschool.de>
- [24] Hoebel J, Müters S, Kuntz B, Lange C, Lampert T. Measuring subjective social status in health research with a German version of the MacArthur Scale. *Bundesgesundheitsblatt Gesundheitsforsch Gesundheitschutz* 2015;58:749–57.
- [25] Graham JW. Missing data analysis: making it work in the real world. *Annu Rev Psychol* 2009;60:549–76.
- [26] Muthén LK, Muthén BO. Mplus user's guide. 8th ed. Los Angeles, CA: Muthén & Muthén; 2017.
- [27] Ivers NM, Halperin JJ, Barnsley J, Grimshaw JM, Shah BR, Tu K, et al. Allocation techniques for balance at baseline in cluster randomized trials: a methodological review. *Trials* 2012;13(1):120.
- [28] Gellert P, Bethke N, Seybold J. School-based educational and on-site vaccination intervention among adolescents: study protocol of a cluster randomised controlled trial. *BMJ Open* 2019;9(1):e025113.
- [29] Tsiampalis T, Faka A, Kouvari M, Psaltopoulou T, Pitsavos C, Chalkias C, et al. The impact of socioeconomic and environmental determinants on Mediterranean diet adherence: a municipal-level spatial analysis in Athens metropolitan area, Greece. *Int J Food Sci Nutr* 2021;72(2):259–70.

- [30] Ojala M. How do children cope with global climate change? Coping strategies, engagement, and well-being. *J Environ Psychol* 2012;32(3):225–33.
- [31] Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS Scales. *J Pers Soc Psychol* 1988;54.
- [32] Arend MG, Schäfer T. Statistical power in two-level models: a tutorial based on Monte Carlo simulation. *Psychol Methods* 2019;24(1):1–19.
- [33] Hamann KRS, Masson T. Kollektives nachhaltiges Handeln und Psychologie. In: Genkova P, editor. *Handbuch Globale Kompetenz*. Wiesbaden: Springer Fachmedien Wiesbaden GmbH; 2022. p. 1–16.
- [34] Hamann K.R.S., von Agris A.S., Markus L. Investigating the predictors of collective action intensity and health. *PsyArXiv*; 2023. [cited 2023 Nov 21] Available from: [10.31234/osf.io/qev28](https://doi.org/10.31234/osf.io/qev28)
- [35] Masson T, Jugert P, Fritsche I. Collective self-fulfilling prophecies: group identification biases perceptions of environmental group norms among high identifiers. *Soc Infl* 2016;11(3):185–98.
- [36] Statista. Planen Sie am Black Friday Sale 2021 teilzunehmen? [Do you plan to shop on Black Friday 2021?] 2021. [cited 2023 Nov 21] Available from: <https://de.statista.com/statistik/daten/studie/1064046/umfrage/geplanter-einkauf-an-black-friday-in-deutschland>