

Measuring socio-ecological handprints: Psychometric evaluation of a scale assessing school students' civic engagement for climate protection

Messung des sozial-ökologischen Handabdrucks: Psychometrische Evaluation einer Skala zur Erfassung des zivilgesellschaftlichen Engagements von Schüler:innen für den Klimaschutz

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Author statement

AS: Conceptualization, Methodology, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. SH: Conceptualization, Methodology, Project administration, Investigation, Writing - review & editing, Resources. PG: Methodology, Investigation, Resources, Project administration, Investigation. MH: Methodology, Writing - review & editing. PB: Methodology, Writing - review & editing. VF: Writing - review & editing. JK: Conceptualization, Methodology, Investigation, Project administration, Supervision, Writing - review & editing. SH used university budget of Freie Universität Berlin to conduct this study. Conflicts of interest: none.

Abstract

Civic engagement for climate protection initiates collective processes to pursue structural changes towards the mitigation of climate change. To our best knowledge, no validated scale on civic engagement for climate protection of school students exists. This study aims to examine the psychometric characteristics of a new measure. Baseline data from the Public Climate School study 2023 was used to assess item properties and factor structure of an 8-item scale. A total of $N = 360$ school students ($M_{\text{age}} = 14$ years, $SD = 1.19$, 49% female) from seven schools in Germany completed the measurement. Correlational analyses were conducted with theory-derived measures, including individual consumption behaviors to reduce one's ecological footprint, enactment of social influence, perceived knowledge about engagement options, risk perception, self- and collective efficacy beliefs, ingroup identification, and ingroup norms. All items of the civic engagement scale had right-skewed distributions. Exploratory factor analysis indicated one-dimensionality of the construct. The scale showed good reliability (McDonald's $\omega = .86$) and differed from other climate protection behaviors. Associations of civic engagement with related variables were consistent with theoretical assumptions. Results indicate applicability of the scale to measure propensity for civic engagement for climate protection, warranting replication in school contexts of other countries.

Keywords

civic engagement, climate protection behavior, collective action, environmental activism, school students

Impact statement

In this study, we investigated measurement characteristics of a scale that measures school students' civic engagement for climate protection with eight questions. The results indicate that the mean value of the scale can be interpreted as a reliable and meaningful measure of civic engagement for climate protection.

Civic engagement includes behaviors targeting systemic changes and is an important lever for climate protection that has so far been underrepresented in research and practice. The short scale evaluated here can be used to measure civic engagement in the target group of school students, identify variables related to civic engagement and quantify the success of interventions to increase civic engagement. When applying the scale to other target groups, we recommend the re-evaluation of the scale properties.

Zusammenfassung

Zivilgesellschaftliches Engagement für den Klimaschutz stößt kollektive Prozesse an, um strukturelle Veränderungen zur Eindämmung des Klimawandels zu erreichen. Nach unserem Kenntnisstand gibt es keine validierte Skala zum zivilgesellschaftlichen Engagement von Schüler:innen für den Klimaschutz. Ziel dieser Studie ist es, die psychometrischen Eigenschaften einer neuen Skala zu untersuchen. Anhand von Baseline-Daten der Public Climate School Studie 2023 wurden die Item-Eigenschaften und Faktorstruktur einer 8-Item-Skala analysiert. Insgesamt nahmen $N = 360$ Schüler:innen ($M_{\text{Alter}} = 14$ Jahre, $SD = 1.19$, 49% weiblich) aus sieben Schulen in Deutschland an der Messung teil. Korrelationsanalysen wurden mit theoriegeleiteten Maßen durchgeführt, darunter individuelles Konsumverhalten zur Verringerung des ökologischen Fußabdrucks, Ausüben von sozialem Einfluss, wahrgenommenes Wissen über Engagement-Optionen, Risikowahrnehmung, Selbst- und kollektive Wirksamkeitsüberzeugungen, Ingroup-Identifikation und Ingroup-Normen. Alle Items der Skala zum zivilgesellschaftlichen Engagement wiesen rechtsschiefe Verteilungen auf. Die explorative Faktorenanalyse wies auf die Eindimensionalität des Konstrukts hin. Die Skala zeigte eine gute Reliabilität (McDonald's $\omega = .86$) und unterschied sich von anderen klimaschützenden Verhaltensweisen. Die Assoziationen des zivilgesellschaftlichen Engagements mit verwandten Variablen stimmten mit theoretischen Erwartungen überein. Die Ergebnisse deuten hin auf die Anwendbarkeit der Skala zur Messung der Tendenz für zivilgesellschaftliches Engagement für den Klimaschutz und sprechen für eine Replikation in Schulkontexten anderer Länder.

Schlagwörter

zivilgesellschaftliches Engagement, Klimaschutzverhalten, kollektives Handeln, Umweltaktivismus, Schüler:innen

Impact-Statement

In dieser Studie haben wir die Messeigenschaften einer Skala untersucht, die mit acht Fragen das zivilgesellschaftliche Engagement von Schüler:innen für den Klimaschutz misst. Die Ergebnisse zeigen, dass der Mittelwert der Skala als zuverlässiges und aussagekräftiges Maß für zivilgesellschaftliches Engagement für den Klimaschutz interpretiert werden kann.

Zivilgesellschaftliches Engagement umfasst Verhaltensweisen, die auf systemische Veränderungen abzielen und ist ein wichtiger Hebel für den Klimaschutz, der bisher in Forschung und Praxis unterrepräsentiert ist. Die hier evaluierte kurze Skala kann verwendet werden, um zivilgesellschaftliches Engagement in der Zielgruppe der Schüler:innen zu messen, Variablen zu identifizieren, die mit zivilgesellschaftlichem Engagement zusammenhängen und den Erfolg von Interventionen zur Steigerung des zivilgesellschaftlichen Engagements zu quantifizieren. Bei der Anwendung der Skala in anderen Zielgruppen empfehlen wir eine erneute Überprüfung der Skaleneigenschaften.

1 Introduction

1.1 Civic Engagement for Climate Protection

Global climate change is caused by humans (Cook et al., 2016) and can be mitigated by human behavior (Lacroix, 2018). In addition to the key levers for climate protection that can be moved by governments and large companies, individual citizens can and must also take action to mitigate climate change. The most prevalently addressed and studied form of climate protection behaviors is the reduction of individual consumption in the private sphere, for example the use of energy or production of waste (Guillaume et al., 2020). These behaviors have a direct effect by preserving natural resources and, thus, reduce people's ecological footprint (Guillaume et al., 2020; Kranz et al., 2022).

Another form of climate protection behavior is to influence close others to change their behavior within their scope of action and in turn reduce their ecological footprint, for example by convincing a family member to cycle to work instead of driving by car (Hamann & Masson, 2020). However, individuals as well as social groups are restricted by systemic conditions that might impede behavior change towards climate protection (Hamann & Masson, 2020). For example, a systemic barrier to switching from car to bicycle for the daily commute might be a lack of safe cycle paths in the municipality. Therefore, the reduction of individual consumption and the exertion of social influence do not constitute the full spectrum of possible mitigation behaviors (Szaguhn & Sippel, 2021).

A third form of climate protection behavior is civic engagement for climate protection, also referred to as collective action (Hamann & Masson, 2020; Kranz et al., 2022). Based on the framework by Hamann and Masson (2020), figure 1 gives an overview of the aforementioned forms of climate protection behaviors. Civic engagement describes an individual's behaviors that express a sense of responsibility for and identification with humanity in a global context, one component of which is climate protection (Abs et al., 2024). Civic engagement for climate protection can be defined as "intentional and conscious civic behaviors that are focused on systemic causes of environmental problems and the promotion of environmental sustainability through collective efforts" (Alisat & Riemer, 2015, p. 14). An exemplary civic engagement behavior could be to start a petition to build more safe cycle paths in the municipality. The impact that is generated by the transformation of systemic conditions towards the mitigation of climate change can be significantly higher than the impact of individual behavior change and is crucial for a socio-ecological transformation towards climate protection (Chater & Loewenstein, 2022).

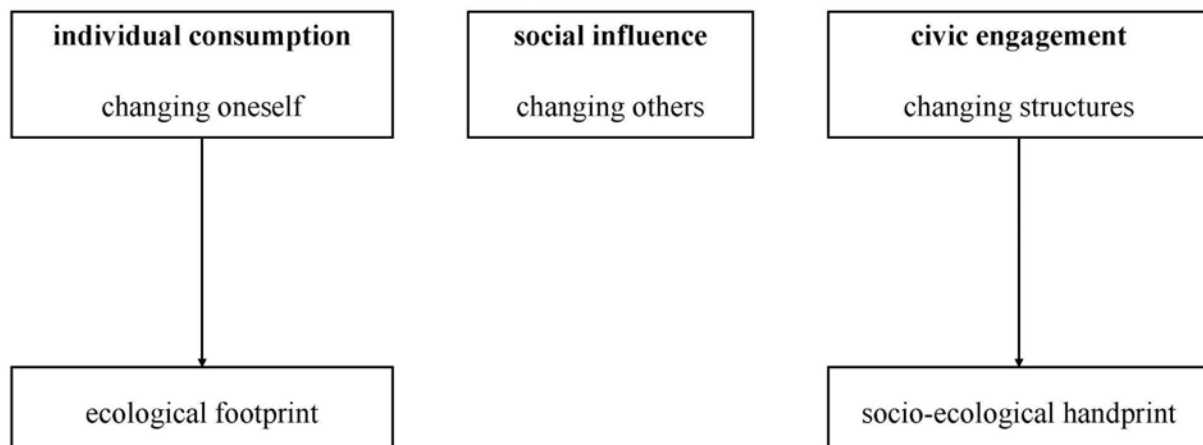
This impact is conceptualized as the socio-ecological handprint (Hamann & Masson, 2020). The socio-ecological handprint is a positive impact indicator that complements the negative impact measured by the ecological footprint (Guillaume et al., 2020) and was initiated as such by the Indian organization Centre for Environment Education (<https://www.handprint.in/>). The NGO Germanwatch has further developed the concept and established the focus on structural change and

transformative learning (Heitfeld & Reif, 2020; Reif & Heitfeld, 2015). A comprehensive education for sustainable development imparts competencies on both the implementation of proven effective climate protection behaviors in one's own life and critical reflection on which changes are relevant for climate protection at the societal level (Vare & Scott, 2007). The handprint concept is widely used in German-speaking countries, however to date, there is a lack of research on civic engagement for climate protection and its measurement.

The willingness for civic engagement for climate protection is especially high in adolescents and young adults (Bundesministerium für Umwelt, 2023). Many young people see themselves as part of the solution to climate change and have found ways of showing engagement for climate protection, for example organizing and participating in climate strikes (Thomaes et al., 2023). The Fridays for Future protests are a prominent example of civic engagement for climate protection enacted by adolescents that has influenced political action on a global level (Wallis & Loy, 2021). Most adolescents and young adults in Germany are convinced that climate change can be combated through joint engagement effectively and call for politicians to pay more attention to young people (Bundesministerium für Umwelt, 2022).

Figure 1

Forms of Climate Protection Behaviors Based on Hamann and Masson (2020)



1.2 Forms of Civic Engagement for Climate Protection

To understand how people show civic engagement for climate protection, it is essential to consider a variety of behaviors (Tindall et al., 2003). As these behaviors may differ greatly from one another, frameworks that further categorize civic engagement for climate protection have been developed. Stern et al. (1999) and more recently Hamann et al. (2021) distinguish different types of behaviors. Stern et al. (1999) proposed three different types of civic engagement for climate protection: committed public activism (e.g., climate strikes), non-activist supportive behavior

(e.g., supporting petitions for climate protection, donating to climate organizations, discussions with politicians) and acting in organizations (e.g., sustainable behavior in the workplace). Similarly, Hamann et al. (2021) distinguish protesting (i.e., putting pressure on decision makers) from volunteering in climate protection groups or organizations.

Alisat and Riemer (2015) found that civic engagement for climate protection includes two sub-factors that represent the role of an actor: participatory actions (e.g., participating in community events) and leadership actions (e.g., organizing a protest). Hamann and Masson (2020) subdivide civic engagement for climate protection into four categories according to the goals pursued by specific behaviors: political influence (e.g., voting, participating in protests), influence on the general public (e.g., educating others), direct influence on structures (e.g., creating sustainable alternatives) and maintenance of groups and organizations (e.g., membership, donations).

Others argue that these forms of civic engagement for climate protection are not clearly distinct from each other (Sabherwal et al., 2021) and that all civic engagement behaviors map onto one latent construct (Dono et al., 2010; Sguin et al., 1998). Although these frameworks have considerable overlap, to date, there is no consensus whether forms of civic engagement represent different latent dimensions of civic engagement or rather levels of engagement in a one-dimensional construct.

1.3 Nomological Network of Civic Engagement for Climate Protection

Civic engagement for climate protection can be distinguished from other forms of climate protection behaviors (Hamann & Masson, 2020). Unlike the reduction of individual consumption and exertion of social influence, it initiates collective processes and pursues change on a societal level instead of an individual level (Hamann & Masson, 2020). Prior research suggests the consideration of both individual and collective variables in the investigation of civic engagement for climate protection by young people (Wallis & Loy, 2021).

Individual-level predictors of civic engagement for climate protection can be derived from the Norm Activation Model (Schwartz & Howard, 1981). The Norm Activation Model was developed to predict prosocial behavior and is commonly applied in research on climate protection behavior (Klößner, 2013). The Norm Activation Model is relevant for civic engagement for climate protection because it accounts for the uptake of behaviors that express a sense of responsibility for others, even in the face of personal cost (Seger & Böcker, 2023). Based on the Norm Activation Model, civic engagement for climate protection is driven by personal norm: a sense of personal responsibility to act. Multiple prerequisites must be met, so that an individual's personal norm to enact civic engagement for climate protection is activated (Klößner, 2013). First, the individual must be aware of a social problem, in this case the risk that climate change poses on humanity. Further, an individual must be aware of the consequences of their own behavior in the

context of this problem, e.g., knowledge on which behaviors are effective for climate protection. Lastly, an individual must assume responsibility and feel competent to perform these behaviors (Klößner, 2013).

The Social Identity Model of Pro-Environmental Action (SIMPEA, Fritsche et al., 2018) is based on the Social Identity Model of Collective Action (SIMCA, van Zomeren et al., 2008). SIMPEA focuses on collective variables that are associated with climate protection behavior. It has been successfully applied to explain civic engagement for climate protection amongst young people (Wallis & Loy, 2021). SIMPEA proposes that climate protection behavior is determined by ingroup identification, ingroup norms, and collective efficacy beliefs. This process is influenced by both personal and collective emotions and motivations. Ingroup identification describes how strongly an individual feels connected to their group (e.g., school students, climate activists). Ingroup norms represent attitudes and behaviors that an individual perceives as typical or desirable for ingroup members (e.g., the norm to protect the climate). Collective efficacy is an individual's perception of the group's capability to achieve its climate protection-related goals. Furthermore, collective efficacy may shape perceptions of self-efficacy for civic engagement for climate protection. According to SIMPEA, civic engagement is also related to an individual's appraisal of global climate change, their perception of which consequences global climate change will have for them and others.

1.4 Civic Engagement for Climate Protection in Adolescents

Adolescents will be more severely affected by the negative consequences of climate change when they are older than the adult generation nowadays (Wallis & Loy, 2021). Hence, dealing with the threat of climate change may cause fear and hopelessness among young people (Hickman et al., 2021; Ojala, 2012b). Associations have been found between the use of effective coping strategies, the activation of positive emotions and the engagement in climate protection behaviors (Ojala, 2012b). The engagement in collective climate protection behaviors, unlike individual climate protection behaviors, may be a protective factor for mental health of those young people concerned about climate change (Schwartz et al., 2023).

Compared to adults, adolescents face certain additional barriers for the enactment of civic engagement behaviors (Hickman et al., 2021; Wallis & Loy, 2021). For instance, voting for environmental parties is the most commonly shown form of civic engagement for climate protection in Germany (Bundesministerium für Umwelt, 2023). This is often no option for adolescents as they are mostly ineligible to vote (Wallis & Loy, 2021). On the other side, civic engagement behaviors might be influenced less by family habits than consumption behaviors regarding food or transportation (Ojala, 2012b). Therefore, in the target group of adolescents, civic engagement for climate protection might be especially relevant, but also challenging (Wallis & Loy, 2021).

1.5 Current Research

To our best knowledge, there is no validated scale to measure civic engagement for climate protection in the target group of adolescents as students from secondary schools. Our goal was to develop a scale that measures between-person and within-person differences over time in a self-reported construct reflecting the propensity to show naturally occurring civic engagement for climate protection in an adolescent's personal environment. Among the measurement approaches described by Lange (2025), the construct that the scale is intended to measure most closely resembles a person property — namely, the propensity to show civic engagement for climate protection. For the sake of readability, we refer to this construct as civic engagement for climate protection throughout the paper.

We aimed to examine psychometric properties of this newly developed scale leading to the following research questions:

1. Are the proposed items a consistent measure of civic engagement for climate protection?
2. What is the internal structure of civic engagement for climate protection?
3. Can distinctions between civic engagement for climate protection and other forms of climate protection behaviors (individual consumption and social influence) be found empirically?
4. Can theoretically proposed bivariate positive relations between civic engagement for climate protection and associated psychosocial constructs (perceived knowledge about options for civic engagement for climate protection, perceived risk of climate change, ingroup identification, ingroup norms, self- and collective efficacy beliefs) be found empirically?

2 Methods

2.1 Public Climate School 2023 Study: Participants and Procedures

Empirical data was collected as part of the baseline assessment of the Public Climate School study project, a one-week school program for climate education in Germany. This study project was preregistered in the German Clinical Trials Registry (DRKS-ID: DRKS00032981) and approved by the ethics committee of the Department of Education and Psychology at the Freie Universität Berlin. A total of 22 classes from seven schools in five German federal states were enrolled in the Public Climate School study by their teachers and completed the baseline assessment, which resulted in a sample of 360 secondary school students. Four of the study sites were grammar schools, two were comprehensive schools and one was an intermediate school. All participating school students and their legal guardians gave informed consent. Students completed an online questionnaire during a school lesson in November 2023. Classes from grade level 7 to 11 participated with a mean of 8.76 ($SD = 1.06$). Mean age of the participants was 14 years ($SD = 1.19$, range: 12-17). 49% of participants were female, 50% male and 1% diverse. The

mean perceived social status (see 2.3) of participants was 4.11 ($SD = 1.34$) on a scale of 1-10. Sociodemographic sample characteristics are summarized in table 1.

Table 1

Sociodemographic Characteristics of Participants

Characteristic		$M (SD)$ or $n (%)$
Grade level	7	54 (15.00%)
	8	79 (21.94%)
	9	139 (38.61%)
	10	74 (20.56%)
	11	14 (3.89%)
Age	12	45 (12.50%)
	13	74 (20.56%)
	14	117 (32.5%)
	15	92 (25.56%)
	16	25 (6.94%)
	17	7 (1.94%)
Gender	Female	175 (48.61%)
	Male	180 (50.00%)
	Diverse	4 (1.11%)
	Missing	1 (0.28%)
Municipal size	< 5,000 inhabitants	65 (18.05%)
	5,000 – 19,999 inhabitants	57 (15.83%)
	20,000 – 99,999 inhabitants	50 (13.89%)
	100,000 – 999,999 inhabitants	155 (43.06%)
	≥ 1,000,000 inhabitants	33 (9.17%)
Perceived social status	[1=lowest - 10=highest]	4.11 (1.34)
Country of birth	Germany	326 (90.56%)
	Other	34 (9.44%)
Country of growing up	Germany	347 (96.39%)
	Other	12 (3.33%)
	Missing	1 (0.28%)
Parental education: high school diploma	No parent	63 (17.50%)
	One parent	66 (18.33%)
	Both parents	158 (43.89%)
	I don't know	73 (20.28%)
Parental education: university studies	No parent	60 (16.67%)
	One parent	58 (16.11%)
	Both parents	123 (34.17%)
	I don't know	119 (33.06%)

Note. Percentages refer to the sample of $N = 360$ school students, [x-y] refers to the response range of the variable.

2.2 Procedures of scale development

A scale for the assessment of civic engagement for climate protection in secondary school students was developed. Two of the items (item 2 and item 6) were adopted from the 'communication and engagement behavior' scale developed for the Public Climate School study 2021 (Keller et al., 2024). The other items were newly developed and reflected behaviors that contribute to the socio-ecological handprint based on work by Reif and Heitfeld (2015), Heitfeld & Reif (2020), and Hamann and Masson (2020) by members of the Division of Health Psychology at Freie Universität Berlin and the Division of Clinical and Biological Psychology at Technische Universität Dortmund. In an iterative process comprising multiple online meetings, item selection and phrasing were refined with the feedback and suggestions of researchers and practitioners in education for sustainable development affiliated with Germanwatch and Institut Futur (Freie Universität Berlin). Items were selected with the aim of representing behaviors that are attainable and comprehensible for the target group of secondary school students. To this end, examples from the school context for two items (item 3 and item 7) and an extensive introductory text (see supplementary material A) prefacing the scale were added. Comprehensibility of the scale for the target group was checked by two school teachers, however, no pilot data from school students was collected.

Based on previous studies (e.g., Bundesministerium für Umwelt, 2022; Misch et al., 2021) it was expected that civic engagement behaviors are shown only by a minority of students and at a low average frequency. To allow for maximum variability in responses, a Likert-scale with six categories was chosen as a response format: 1 = *not true at all*, 2 = *hardly true*, 3 = *rather not true*, 4 = *rather true*, 5 = *fairly true*, 6 = *completely true*. Thus, a higher score represents a higher level of civic engagement. For the purpose of planned longitudinal analyses with the scale carried out in the overarching study project, a retrospective timeframe of 3 months was chosen for the scale. The final scale consists of eight items, which are shown in table 2 in German (original) and English (translation). These eight items were chosen to represent a broad variability of behavioral options. Items were not translated from German to English professionally, translations should therefore be interpreted with caution.

To gain more specific insights into civic engagement behaviors and explore behaviors that were potentially not included in the eight items, an additional open response question was added: "In the last three months, I have engaged in other ways for more climate protection. Please enter here how you have engaged for more climate protection." Participants were able to note up to three answers.

Items 7 and 8 address structural changes in default options and framework conditions. Here, the phrasing "my environment" was chosen.¹ A similar framing is often used in climate education programs for students (Kranz et al., 2022) and serves to provide plausible context.

¹ Derived from Reif and Heitfeld (2015), environment is explained in the introductory text (supplementary material A) as referring to the students' personal surroundings, such as their school, club, religious community, another local group, or place of residence.

Table 2

Scale Items in German (Original) and English (Translation)

Item	German (Original)	English (Translation)
	In den letzten 3 Monaten habe ich...	In the last 3 months I have...
1	...Verbündete gesucht, die sich mit mir für mehr Klimaschutz einsetzen möchten.	...looked for allies who would like to collaborate on climate protection.
2	...Kontakte zu einer Gruppe gehabt, die sich für den Klimaschutz engagiert.	...had contact with a group that is engaged in climate protection.
3	...Kontakte mit Entscheidungsträger*innen (z.B. Schulleitung, Lehrperson) aufgenommen, um mit ihnen über die Verankerung von Klimaschutz zu sprechen.	...contacted decision-makers (e.g., school management, teachers) in order to talk to them about embedding climate protection.
4	...Petitionen zu einem Klimaschutzthema unterstützt.	...supported petitions on a climate protection topic.
5	...Geld zur Unterstützung von nachhaltigkeitsbezogenen Projekten gespendet.	...donated money to support sustainability-related projects.
6	...an Aktionen oder Protesten für mehr Klimaschutz teilgenommen.	...participated in actions or protests in favor of more climate protection.
7	...versucht, klimafreundliches Verhalten in meinem Umfeld leichter oder naheliegender zu machen.	...tried to make climate-friendly behavior easier or more approachable in my environment.
8	...Veränderungen in den Rahmenbedingungen in meinem Umfeld (z.B. vegane Angebote in der Mensa) hin zu mehr Klimaschutz angestoßen.	...initiated changes in the overall conditions of my environment (e.g., vegan options in the canteen) towards more climate protection.

2.3 Measures

The items for study measures in German (original) and English (translation) are displayed in supplementary material B.

2.3.1 Civic Engagement for Climate Protection

The above described eight items measured civic engagement for climate protection in the last 3 months on a 6-point Likert scale ranging from 1 = *not true at all* to 6 = *completely true*. An aggregated measure was constructed from the mean of the eight ratings. McDonald's ω was .86.

2.3.2 Individual Consumption

Four items measured the propensity for individual consumption behaviors relevant for the reduction of one's ecological footprint in the last 7 days on a 6-point Likert scale ranging from 1 = *not true at all* to 6 = *completely true*. (e.g., "...followed a climate-friendly diet", "...consumed less overall in favor of climate protection"). Items were based on everyday behaviors measured by Ojala (2012a, 2012b). An aggregated measure was constructed from the mean of the four ratings. In this study, McDonald's ω of the scale was .66.

2.3.3 Social Influence

Four items measured the propensity for social influence behaviors related to climate protection (e.g., "...drawn attention to climate protection content on social media", "...talked to family members, friends or acquaintances about climate protection.") in the last 3 months on a 6-point Likert scale ranging from 1 = *not true at all* to 6 = *completely true*. Items were based on communication behaviors measured by Ojala (2012a, 2012b) and indirect pro-environmental behaviors measured by Hamann & Reese (2020). An aggregated measure was constructed from the mean of the four ratings. In this study, McDonald's ω of the scale was .79.

2.3.4 Perceived Risk of Climate Change

We measured perceived risk of climate change using six items based on van der Linden (2015) on a 6-point Likert scale ranging from *very unlikely* to *very likely* (e.g., "In your opinion, how great a threat does climate change pose to nature?"). An aggregated measure was constructed from the mean of the six ratings. In this study, McDonald's ω (hierarchical) of the scale was .69.

2.3.5 Perceived Knowledge about Options for Civic Engagement for Climate Protection

Participants rated their agreement to the item „I know what I can do to advocate for more climate protection in my environment” on a 6-point Likert scale ranging from 1 = *not true at all* to 6 = *completely true*. This measure was developed in a previous Public Climate School study (Keller et al., 2024).

2.3.6 Self-Efficacy Beliefs for Civic Engagement for Climate Protection

Three items measured self-efficacy beliefs for civic engagement for climate protection (e.g., "I have the skills to engage for climate protection in my environment.") on a 6-point Likert scale ranging from 1 = *not true at all* to 6 = *completely true*. Items were developed following work by Gardner and Neuber (2021), Hamann and Reese (2020), and Ojala (2013). An aggregated measure was constructed from the mean of the three ratings. In this study, McDonald's ω of the scale was .85.

2.3.7 Ingroup Identification

Ingroup identification with others engaging for climate protection was measured using a three-item scale by Bamberg et al. (2015) adapted by Wallis & Loy (2021)

(e.g., “I identify with others who engage in climate protection.”) on a 6-point Likert scale ranging from 1 = *not true at all* to 6 = *completely true*. An aggregated measure was constructed from the mean of the three ratings. In this study, McDonald’s ω of the scale was .88.

2.3.8 Ingroup Norms

Based on the biospheric values scale by Ojala (2012a), environmental norms in the group of school students were measured with four items (e.g., “The majority of my classmates are committed to climate protection.”) on a 6-point Likert scale ranging from 1 = *not true at all* to 6 = *completely true*. An aggregated measure was constructed from the mean of the four ratings. In this study, McDonald’s ω of the scale was .88.

2.3.9 Collective Efficacy Beliefs

Four items measured collective efficacy beliefs for climate protection referring to the group of school students (e.g., “We as students can make a contribution to climate protection.”) on a 6-point Likert scale ranging from 1 = *not true at all* to 6 = *completely true*. Items were developed following work by Gardner and Neuber (2021), Hamann and Reese (2020), and Ojala (2013) and van Zomeren (2013). An aggregated measure was constructed from the mean of the four ratings. In this study, McDonald’s ω of the scale was .90.

2.3.10 Sociodemographic Variables

Participants completed several sociodemographic questions including grade level, age, gender, municipal size, perceived social status (assessed with the German version of the MacArthur Scale; Hoebel et al., 2015), country of birth, country of growing up and parental educational attainment.

2.4 Data Analysis

Data analysis was performed using R (RCoreTeam, 2024) and the packages psych (Revelle, 2024) and TAM (Robitzsch et al., 2024). To address research question 1, item characteristics were evaluated using elements of classical test theory (means, standard deviations, item total correlations, skewness, and kurtosis) and item response theory (polytomous Rasch model). The rating scale model was applied to the items of the civic engagement scale and item difficulty and mean square fit statistics (MNSQ) were reported (Yamashita, 2022). To assess the latent structure of the underlying construct of civic engagement for climate protection, exploratory factor analysis was conducted (research question 2). For research question 3, the Heterotrait-Monotrait ratio of correlations (HTMT; Henseler et al., 2015) was assessed. The HTMT ratio was calculated as the average of the correlations between items belonging to different constructs (heterotrait-heteromethod correlations) relative to the average of the correlations between items within the same construct (monotrait-heteromethod correlations). Further, we computed a Rasch rating scale measurement model in which all items measuring climate protection behaviors (i.e., civic engagement, social influence, and individual consumption) reflect

one latent factor. Principal component analysis was performed based on the residuals from this model to test one-dimensionality. Bivariate correlations between the civic engagement for climate protection scale and theoretically positively related psychosocial variables were examined (research question 4).

The empirical data had a nested structure, including a student level, a class level and a school level. Intra class correlation coefficients (ICCs) were calculated for the civic engagement for climate protection scale to assess the proportion of variance observed at the student level, the class level, and the school level in civic engagement for climate protection. The scale is intended to be used as a measure of individual differences between adolescents irrespective of their grouping in clusters. Hence, factor analyses will be conducted on a subject level only (Stapleton et al., 2016). There are multiple suggestions on required sample sizes to conduct exploratory factor analysis in the literature (e.g., Zygmunt & Smith, 2014), which are mostly met by our sample of $N = 360$.

3 Results

3.1 Item Analysis

Missing data was rare for all scales (range: 0% - 1.93% missing values per item) and tested to be missing completely at random ($\chi^2(948) = 990, p = .17$, Little, 1988). Missing values were imputed using predictive mean matching (Goretzko, 2021).

For all items of the civic engagement scale, all six answer categories were used. However, all items showed a right-skewed distribution (skewness = 0.6; item 7 - 2.7; item 6) with kurtosis ranging from -0.8 (item 7) to 4.2 (item 1). Item means were low for all items (1.5; item 1 and item 6 to 2.4; item 7). Standard deviations of the items ranged from 0.9 (item 1) to 1.5 (item 2). Part-whole corrected item-total correlations were positive and within the recommended range between .40 - .70 (Moosbrugger & Kelava, 2007) for all items (between .49; item 3 and .69; item 8), which indicates that each item makes an appropriate contribution to the construct to be measured by the instrument as a whole.

A Rasch rating scale model was fit to the data using marginal maximum likelihood estimation. Difficulty scores on a logit scale ranged from 0.76 (item 7) to 1.70 (item 1). Lower scores indicate that respondents were more likely to give a higher rating for this item. MNSQ fit statistics for all items were within the range of 0.6 and 1.4 (Bond & Fox, 2015). This indicates alignment between respondents' traits and their response patterns. Mean infit MNSQ was 1.09 ($SD = 0.26$) and mean outfit MNSQ was 0.98 ($SD = 0.20$). Item characteristics are shown in table 3.

Correlations between the items were positive, mostly moderate and ranged from $r(358) = .18, p < .001$ (item 3 and item 5) to $r(358) = .54, p < .001$ (item 7 and item 8). The mean inter-item correlation was $r = .36$, which falls within the recommended range of .20 - .40 (Piedmont, 2014). Ratings for item 7 were significantly higher than ratings for the other items ($W = 28727, p < .001$). The correlation matrix is shown in table 4.

Table 3

Item Means, Standard Deviations, Item Total Correlations, Skewness, Kurtosis, Standardized Factor Loadings, Difficulty, Infit MNSQ and Outfit MNSQ of the Items

Item	Classical test theory					Item response theory			
	<i>M</i>	<i>SD</i>	Item total correlation	Skewness	Kurtosis	Factor loading	Difficulty	Infit MNSQ	Outfit MNSQ
1	1.5	0.9	.66	2.0	4.2	.67	1.70	0.70	0.68
2	1.9	1.5	.61	1.7	1.6	.62	1.18	1.20	1.07
3	1.7	1.3	.49	2.0	3.0	.49	1.37	1.36	1.26
4	1.7	1.3	.53	1.9	2.9	.52	1.33	1.25	1.14
5	1.7	1.3	.48	2.0	3.0	.49	1.40	1.37	1.08
6	1.5	1.1	.62	2.7	7.1	.62	1.67	1.15	0.81
7	2.4	1.4	.67	0.6	-0.8	.68	0.76	0.81	0.98
8	1.8	1.3	.69	1.7	2.0	.71	1.30	0.88	0.80

Note. Parameters refer to the sample of $N = 360$ school students. Factor loadings extracted from exploratory factor analysis.

Table 4

Inter-Item Correlations

Item	1	2	3	4	5	6	7	8
1	1							
2	.48***	1						
3	.37***	.36***	1					
4	.32***	.30***	.25***	1				
5	.34***	.22***	.18***	.28***	1			
6	.38***	.41***	.31***	.43***	.26***	1		
7	.42***	.40***	.29***	.37***	.39***	.37***	1	
8	.45***	.41***	.34***	.30***	.39***	.45***	.54***	1

Note. Parameters refer to the sample of $N = 360$ school students, *** $p < .001$.

3.2 Analysis of Open Responses

A total of 400 responses were given by the participants on the free text item: “In the last three months, I have engaged in other ways for more climate protection. Please enter here how you have engaged for more climate protection”. In an exploratory analysis, responses were sorted into three primary categories corresponding to the three forms of climate protection behaviors: individual consumption, social influence, and civic engagement for climate protection. Most answers ($n = 327$, 82%) were related to the reduction of individual consumption. 28 answers (7%) described social influence, including the use of social media, and serving as a role model. 45 (11%) answers represented forms of civic engagement. Out of these,

37 answers could be mapped onto the items of the civic engagement scale (e.g., item 1: “Talked to friends about what we can change”). Answers that addressed changes in the standard options and framework conditions (items 7 and 8) often referred to the school environment. Four answers described preparatory behaviors for the enactment of civic engagement (e.g., “informed myself”). The remaining four answers were unspecific and could not be categorized more precisely (e.g., “through projects”).

3.3 Dimensionality and Scale Properties

The assumption of substantial correlation between the items was tested with the Kaiser-Meyer-Olkin test of sampling adequacy (0.87), and the Bartlett’s test of sphericity ($\chi^2(28) = 743.61, p < .001$), both of which yielded satisfactory results. Two criteria were applied to determine the number of factors: Parallel analysis and the Empirical Kaiser Criterion (Braeken & Van Assen, 2017). Both criteria suggested the retention of one factor with an eigenvalue of 2.92.

To identify factor loadings for each item, an exploratory factor analysis was performed. Following recommendations for non-normally distributed data, weighted least squares estimation was used as an extraction method (Goretzko et al., 2021). Standardized factor loadings ranged from .49 (item 3 and item 5) to .71 (item 8). The variance that could be explained by the factor in the overall item variance is 36%. Standardized factor loadings for each item are shown in table 3.

In addition, one-dimensionality of the scale was assessed by performing principal component analysis on Rasch residuals on the Rasch rating scale model with the eight civic engagement items. The first component of the principal component analysis on Rasch residuals had an eigenvalue of 1.53, which does not exceed the upper threshold of 2.0 suggested to meet the assumption of one-dimensionality (Linacre, 2022).

The mean civic engagement score was calculated for participants across all eight items. The mean response was 1.8 (range: 1-5.3, $SD = 0.8$). The distribution was skewed towards the right (skewness = 1.3) with a kurtosis of 1.4. The reliability of the scale was good (McDonald’s $\omega = .86$).

In a three-level model, the ICC for the school level is 0 and the ICC for the class level is 0.087. Hence, no variance was observed at the school level, 8.7% of variance was observed at the class level and 91.3% of variance was observed at the student level. Hence, no substantial bias due to the multi-level structure of the data is expected.

3.4 Correlations with Other Variables

The mean score of civic engagement for climate protection did not differ between female and male students ($t(163.28) = 0.86, p = .39$) and students from differently sized municipalities ($F(4, 355) = 2.24, p = 0.06$). There was no significant correlation between civic engagement for climate protection and perceived social status ($r(358) = 0.03, p = .58$). There were small, but significant negative correlations between civic engagement for climate protection and grade level ($r(358) = -.19, p < .001$) and age ($r(358) = -.17, p < .001$), indicating that younger school students

from lower grades give higher ratings for civic engagement for climate protection on average.

To assess whether the scale measures civic engagement for climate protection equally across age groups, we estimated a multiple-group Rasch rating scale model with five age groups (12 years, 13 years, 14 years, 15 years and ≥ 16 years), combining school students 16 years or older into one group due to the small number of older students. Root mean square differences (RMSD) quantify the distance between group-specific item characteristic curves and joint item characteristic curves. Differential item functioning (DIF) must be assumed if RMSD exceeds .12 (Baghaei & Robitzsch, 2025). None of the items were flagged for differential item functioning in either age group. Thus, measurement invariance across age groups can be assumed.

The mean score of civic engagement for climate protection was correlated moderately with individual consumption ($r(358) = .44, p < .001$) and strongly with social influence ($r(358) = .64, p < .001$). The HTMT ratio for civic engagement for climate protection and individual consumption was 0.62. The HTMT ratio for civic engagement for climate protection and social influence was 0.83. HTMT ratios for both pairs of variables are below the recommended threshold of 0.85 (Henseler et al., 2015), indicating that the correlations of the items within the same construct are stronger than the correlations between items measuring different constructs (Henseler et al., 2015).

Principal component analysis on Rasch residuals was performed on a Rasch rating scale model of all items included in the civic engagement, individual consumption and social influence scales. The first component of the principal component analysis on Rasch residuals had an eigenvalue of 2.11, which exceeds the upper threshold of 2.0 suggested to meet the assumption of one-dimensionality (Linacre, 2022). The principal component analysis suggests a clustering of residuals of the items of the civic engagement scale. In this joint model, some items were outside the suggested range of 0.6 to 1.4 for MNSQ fit statistics (Bond & Fox, 2015; see supplementary material C1).

Correlations between the mean score of civic engagement for climate protection and psychosocial variables were positive and ranged from moderate to high (table 5). The strongest association was found between civic engagement for climate protection and ingroup identification with others engaging for climate protection ($r(358) = .62, p < .001$).

Table 5

Means, Standard Deviations and Correlations of Study Variables with the Civic Engagement for Climate Protection Scale Mean

Variable	<i>M</i>	<i>SD</i>	Correlation with civic engagement for climate protection [95 % CI]
Individual consumption	3.3	1.0	.44*** [.35, .52]
Social influence	2.2	1.1	.64*** [.57, .69]
Perceived risk of climate change	3.5	0.8	.32*** [.23, .42]
Perceived knowledge about options for civic engagement	1.2	1.3	.31*** [.21, .40]
Self-efficacy beliefs for civic engagement	3.0	1.2	.47*** [.38, .54]
Ingroup identification	2.4	1.2	.62*** [.55, .67]
Ingroup norms	2.8	1.0	.43*** [.34, .51]
Collective efficacy beliefs	3.7	1.3	.36*** [.27, .45]

Note. *** $p < .001$.

4 Discussion

A scale to measure school students' civic engagement for climate protection was developed and its psychometric properties were assessed. Dimensionality of the scale and associations of civic engagement for climate protection with similar and related constructs were analyzed. Results are an initial indication of the one-dimensional structure of civic engagement for climate protection, allowing the interpretation of a scale mean. The reliability of the scale was good. Civic engagement was distinguishable from other climate protection behaviors, and its associations with related variables aligned with theoretical expectations. In the following, convergence and differences of these results with prior empirical work will be discussed.

High item difficulties show that civic engagement for climate protection is enacted by a small group of school students. On average over all scale items, 12% of participating students gave a somewhat positive rating (*rather true, fairly true, or completely true*). This aligns with results of the German Environmental Awareness study, in which 15% of a somewhat older age group of 14-29 years stated to be part of the environmental movement (Bundesministerium für Umwelt, 2023). In addition to research on participation in civic engagement for climate protection, the proposed scale may benefit the research on non-participation, which has been studied less so far (Cologna et al., 2021).

The scale on civic engagement for climate protection referred to behaviors in the last 3 months, which was chosen as part of the overarching research questions of the study project, but potentially increased item difficulty. Future research could increase this timeframe in order to improve item difficulty and skewness parameters. The 6-point response scale may have not matched the actual occurrence of and variability in behavior. Depending on the scope of research, future studies could consider to alternatively choose a binary response scale (i.e., behavior shown vs. not shown) or a frequency scale (e.g., behavior frequency per month).

Item 6 (“...participated in actions or protests in favor of more climate protection.”) was rated with the lowest scores on average. Item 6 represents committed activism, which might be associated with publicity and risk (Stern et al., 1999). Although climate protection is a broadly accepted goal amongst the German public, activists may face severe backlash (Bundesministerium für Umwelt, 2023). As recently as 2021, over 40% of young people surveyed in Germany indicated they participated in Fridays for Future protests (Bundesministerium für Umwelt, 2022). The public attention that young climate activists receive often tends to be negatively biased (Bergmann & Ossewaarde, 2020; Mayes & Hartup, 2022), especially since 2021 (More in Common, 2023). The negative media coverage may have recently hindered adolescents from participating in protests. A second explanation why participants reported a low rate of protesting could be that large protest actions (e.g., Fridays for Future’s Global Climate Strike) only take place rarely. Thus, the timeframe of 3 months applied in the scale may have been a limitation.

Item 7 (“...tried to make climate-friendly behavior easier or more approachable in my environment.”) received significantly higher ratings than the other items. It should be noted that due to the general wording of this item, respondents might have referred to individual consumption or social influence behaviors in addition to the intended civic engagement behaviors when responding to this item.

Item 5 (“...donated money to support sustainability-related projects.”) had the lowest correlations with the other scale items. In contrast to the other civic engagement behaviors, donating is based on monetary (vs. time) resources which limits accessibility for adolescents (Han et al., 2023).

Exploratory analysis of responses to the free-text item showed that most answers described individual consumption behaviors, indicating that these are the more frequently shown behaviors for climate protection among adolescents. Even when asked about civic engagement behaviors, adolescents tend to give answers related to individual consumption (Reuter & Frick, 2024). Compared to individual consumption behaviors, laypeople consider the effort required for civic engagement behaviors high while underestimating their environmental impact (Bundesministerium für Umwelt, 2022; Truelove & Gillis, 2018). Those responses related to civic engagement mostly mapped onto the behaviors represented in the proposed items. They were specifications of the behaviors included in the scale rather than additional behaviors that have been left out of the scale. Although it must be taken into consideration that answers might have been influenced by the previous presentation of the scale in the questionnaire, this supports content validity of the scale. On the other hand, those responses might suggest that school students had difficulties in assigning their activities to the items. Educating oneself on topics

related to climate change was mentioned in the responses. This has been included in other measures of civic engagement (e.g., Alisat & Riemer, 2015). However, educating oneself alone does not contribute to a person's socio-ecological handprint without subsequent engagement. We consider it as an expression of contemplation rather than goal-oriented preparation or enactment of civic engagement for climate protection.

The goal of item development was to describe behaviors that are not limited by age requirements and are therefore attainable for school students. In favor of this, we did not find that older students were more engaged in civic engagement for climate protection. On the contrary, we found that younger students rated their civic engagement for climate protection slightly higher than older students. A possible explanation might be that younger students in our sample were more likely to display higher social desirability (Ng et al., 2024) or did not comprehend the items fully. Our analysis indicates that the scale is applicable for adolescents of different ages. In contrast to previous research (Piyapong, 2019), gender was not related to civic engagement.

The present data provides initial evidence that our measure of civic engagement for climate protection is not excessively correlated with other forms of climate protection behaviors (i.e., individual consumption, social influence). The moderate positive association between civic engagement and individual consumption behaviors should be interpreted cautiously due to the low reliability of the individual consumption scale, but is in line with previous studies (Alisat & Riemer, 2015; Reuter & Frick, 2024). Students who show civic engagement for climate protection are more likely to align their individual consumption with the goal of climate protection and vice versa. However, motivations and prerequisites between the two forms of behavior may differ. Individual consumption behaviors might also be motivated by personal goals other than climate protection. For example, healthy food choices are also perceived as more environmentally sustainable (Sproesser et al., 2023). Social influence and civic engagement are strongly related. These forms of behavior are distinguished by the pursued goal rather than the specific action. While social influence aims to address close others, civic engagement aims for systemic changes. For example, using social media to raise awareness can be an act of social influence when directed at peers, but also a form of civic engagement when aimed at broader political or societal impact. Therefore, high correlations on a behavioral level do not necessarily contradict the differentiation of constructs. Moreover, the presence of both types of behaviors might represent a common motivation to “do more” for climate change mitigation.

The positive relationships between the civic engagement measure and perceived knowledge about options for civic engagement for climate protection, perceived risk of climate change, ingroup identification, ingroup norms, self- and collective efficacy beliefs were in accordance with theoretical expectations from the Norm Activation Model and the SIMPEA model and show starting points through which civic engagement for climate protection may be addressed in interventions. Positive relations between the civic engagement scale and collective efficacy beliefs, ingroup norms, and especially ingroup identification underline the significance of social aspects and peer interactions for the civic engagement of adolescents

(Fritsche et al., 2018; Wallis & Loy, 2021). Further, the perceived risk of climate change, perceived knowledge about options for civic engagement for climate protection, and self-efficacy beliefs may be strengthened through action-oriented and empowering education for sustainable development. These findings emphasize the role of schools as places for education, formation of social bonds, and opportunities to show civic engagement for climate protection for school students.

A strength of this study is the unique focus on school students as a target group which extends prevailing research on university students (e.g., Cologna et al., 2021). Further strengths of the study include a comprehensive assessment of theoretically related constructs and the consideration of behavioral examples listed by participants.

However, some limitations need to be acknowledged. A selective sample was investigated as volunteering teachers were the basis for class recruitment potentially leading to examining students with a higher motivation towards climate protection. School students are more likely to show civic engagement for climate protection if this is supported by their school (Kranz et al., 2022). Thus, present findings do not generalize to the population of all school students in Germany. The fact that students completed the questionnaires in connection with participating in the Public Climate School project may also have led them to respond in a particularly socially desirable way. Future research could additionally assess objective data, for example the number of students engaging in climate protection groups, workshops, or events at school. Also, results cannot be transferred to cultural contexts in which school students might face other barriers regarding civic engagement for climate protection, such as higher social stigma (Chang, 2022). A further limitation is the lack of pilot testing with members of the target group.

Results on one-dimensionality of the scale are limited to the selected items tailored to the context of school students. For example, leadership actions (Alisat & Riemer, 2015) were underrepresented in this scale in comparison to studies in adult populations, as leadership actions are harder to realize for adolescents. Due to the low base rate and the small number of items, it cannot be ruled out that multidimensionality of civic engagement for climate protection remained undetected. Using a validation sample, this studies' exploratory results should be validated with confirmatory factor analysis. A sample with a higher base rate of civic engagement for climate protection (e.g., participants at a climate protest) could be assessed to validate the results on one-dimensionality of the scale. The rating scale model was applied to the data for its robustness against a small amount of observations in some response categories (Linacre, 2000), however its restrictions on item thresholds might have led to extreme values in the fit indices. It should be noted that many of the scales used to describe the nomological network were developed for the Public Climate School study project. They have not yet been validated in the relevant sample and their relation to civic engagement for climate protection has not been tested previously.

In contrast to individual consumption behavior for climate protection (contributing to the ecological footprint), which has been studied in great detail, the assessment of civic engagement (contributing to the socio-ecological handprint) has been rare. Civic engagement of individuals is considered as a vital lever for socio-

ecological transformation, yet it is underrepresented not only in research, but also in the action orientation of adolescents, in political action and media coverage (Reuter & Frick, 2024). The initial findings presented here lay groundwork for further development of a short and practical scale as a valuable tool for future research on school student engagement in climate action, contributing to an increased socio-ecological handprint.

5 Open science statement



As explicit participant consent for open data sharing has not been obtained in the sample, the individual-level data are not publicly available. Group-level data can be provided upon request. The analysis code used in this study is publicly available on the Open Science Framework (OSF) and can be accessed at <https://osf.io/eg-bnk>. Questionnaire items for all measures in this study can be found in the supplementary material B. The overarching study project with its primary outcome 'civic engagement for climate protection' was registered in the German Clinical Trials Registry (<https://drks.de/search/de/trial/DRKS00032981/details>). Sample size calculations were related to examining intervention effects in the longitudinal dataset, but not for the analysis reported here. We confirm that we have reported all measurements, conditions and data exclusions.

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