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How can we test plastic pollution perceptions and behavior? A feasibility study with Danish children participating in “the Mass Experiment”

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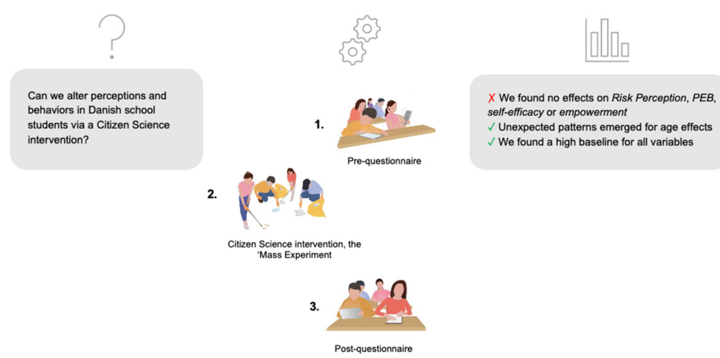
HIGHLIGHTS

- A feasibility study on children's environmental behaviors in relation to a comprehensive citizen science activity in Denmark.
- No main effects of the intervention were found, however the results revealed a high baseline concern for plastic pollution.
- Division in age groups proved to be an indicator for engagement in picking up litter before and after the intervention.

GRAPHICAL ABSTRACT



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ABSTRACT

Research suggests that behavior change programs can be fast and cost-effective solutions to plastic pollution alongside traditional environmental policy-making. Furthermore, encouraging change in perception and behavior can be a tool to change consumption and waste handling towards increased circularity, which is of high concern in the EU. Beyond *knowledge*, predictors of pro-environmental behavior include *concern*, *social norms*, *nature-connectedness, identity* and *self-efficacy*. Citizen Science (CS) as a way to raise awareness and potentially change behavior show promise within plastic litter monitoring. We tested the feasibility of evaluating a nation-wide citizen science intervention, ‘the Mass Experiment’ (ME), with school students (age 7-16) in Denmark. With more than 57,000 students signed up for ME, this is to our knowledge one of the largest CS activity on plastic debris targeting young people. As an addition to the core CS activity we developed a voluntary and anonymous questionnaire to study the perceptions and behaviors of the students. We hypothesized that the intervention would increase *risk perception*, *self-efficacy* and *empowerment* as well as *self-reported actions*. Through 931 pre-surveys and 838 post-surveys aggregated at the team level ($n = 48$), we found that the intervention had no significant overall effect on team, risk-perception, pro-environmental behaviors, nor self-efficacy or empowerment. However, unexpected patterns emerged for age effects, potentially advising some caution over the design of such CS activities particularly for younger children. We discuss methodological limitations, the high baseline for nearly all variables, the Danish context and the intervention itself and make recommendations for studying future CS interventions.

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1. Introduction

The prowess of plastic to sustain and enhance society throughout the 20th and into the 21st century is inarguable. Anthropogenic demands have driven plastic production to increase rapidly since the 1950s with an yearly average of 4% since the financial crisis in 2008, reaching 359 million metric tons in 2018 (PlasticsEurope, 2019). However, human behavior, actions and inactions, account for the fact that 79% of plastic materials end up in landfills or in the natural environment (Geyer et al., 2017; Pahl et al., 2017). Plastic pollution contaminates all environmental compartments. The impacts of micro- and nano-sized plastic litter to the environment and human health are continiously being studied (SAPEA, 2019) and the documented effects of macroplastics, plastic particles' vectoral properties for harmful substances etc. have caused concern among a broad array of actors in society (Bucci et al., 2020; Rochman et al., 2016). In order to prevent and mitigate plastic pollution, regulation addressing all phases of the value chain has been adopted at international, regional and national levels throughout the world (SAPEA, 2019). In Europe, the European Commission has published the *European Strategy for Plastics in a Circular Economy* (2018), aiming to guide all steps of the plastic value chain onto a circular path, including improved waste handling to increase recycling. More specifically, this has been the aim of regulations such as the *Single Use Plastic Directive*, proposed by the European Commission in 2018 as well as the EU Directive from 2015 targeting consumption of lightweight plastic bags. Nevertheless, recent research argues that reducing plastic pollution while simultaneously promoting a sustainable consumption may require an increased focus on understanding human behavior rather than solely relying on economic incentives and disincentives as it is traditionally seen (Benartzi et al., 2017; Jia et al., 2019; Pahl et al., 2017). Newfound public attention and risk perception of plastic pollution accentuate a momentum for studying how societal interventions, including Citizen Science projects, can shift human perceptions and behavior in the environmental domain (SAPEA, 2019).

In the fall of 2019, the annual Natural Science Festival arranged by the National Centre for Learning in Science, Technology and Health in Denmark (ASTRA) was launched. As a part of the festival a comprehensive Citizen Science (CS) project called The Mass Experiment (ME) is executed - each year with a new topic. Public and private schools across Denmark are encouraged to sign up for the activity though campaigns and during the annual natural science conference "Big Bang". Through the ME ASTRA strive to connect students' lives to actual research and gain knowledge by taking ownership of local issues. This is something CS can enable given the right circumstances including access to curiccular relevant learning materials (Jenkins, 2011).

In 2019, 57,000 Danish students participated in the ME, with plastic pollution as the topic. This was the first national scientific survey of plastic waste in the Danish environment (cf. Syberg et al., 2020). Here we present a complementory and voluntary study conducted in parallel with the ME, which examines plastic attitudes and behaviors in students 7-16 years of age participating in the ME. While Syberg et al. (2020) focused on the ME from a natural science perspective (how much plastic was found, where etc.), the present paper approaches the activity from a social science perspective (what were the participants' attitudes and behavioral intentions etc.). The aim was to test the feasibility of evaluating a large-scale CS initiative and gather first insights into the outcomes of this type of program. Through a voluntary pre- and post-questionnaire, we sought to explore key concepts linked to behavior change and hypothesized that the intervention would increase the school students' *risk perception*, *self-efficacy* and *empowerment*, as well as *self-reported actions*. In order to advance the hypothesis testing, minimize false positive findings and structure the research, we submitted a preregistration of the study prior to examination of the collected data in the fall of 2019 with Open Science Framework (OSF). [Reference removed for blind review but provided to editor.]

2. Theory

2.1. Pro-environmental behavior

Kurisu (2016) defines Pro-environmental Behaviors (PEB) as behaviors that *"actually contribute or are perceived to contribute to environmental conservation"*, while environmental conservation is described as either the reduction of negative impacts or increase of positive impacts on the environment (Kurisu, 2016, p. 3). It is essential to understand PEBs and ways to promote these with regards to environmental challenges for which there is a prevailing consensus that human action is the main contributor (such as climate change and plastic pollution) (Doran and Zimmerman, 2009; Maibach et al., 2014; Muncke et al., 2020). Literature finds that psychological as well as social factors can predict future pro-environmental patterns. These include, but are not limited to *risk perception* (Liobikiene and Juknys, 2016; Syberg et al., 2018), *self-efficacy* (Cheng and Monroe, 2012), *empowerment* (Turreira-García et al., 2018; Wali et al., 2017), *self-identity* (Carfora et al., 2017), *nature-connectedness* (nature-relevant experiences) (Cheng and Monroe, 2012), *personal* and *social norms* (Grønhøj and Thøgersen, 2012; Heidbreder et al., 2019), and *knowledge* (Kaiser and Fuhrer, 2003; Kurisu, 2016). Furthermore, Stevenson et al. (2014) argue that socio-demographics such as *ethnicity*, *school income level* and *geographical location* (Berenguer et al., 2005; Ifegbesan and Rampedi, 2018) have an impact on PEBs.

Syberg et al. (2018) describe important discrepancies between *perceived risk* and *actual risk* in regard to plastic pollution, and the consequences that are imminent if risk assessment in society – namely at policy level – is not based on a scientifically informed foundation about essential drivers and biases for risk perception. Their work discusses the distinctive risks related to plastic being a visible threat to the environment in contrast to other harmful substances such as endocrine disruptive chemicals, while on the other hand also being a common household necessity for most people. Among other things, they suggest that involvement of local stakeholders and engagement of residents through citizen science projects may increase a realistic risk perception of plastic pollution in the particular social context. Liobikiene and Juknys (2016) investigated the role of values, environmental risk perception, awareness of consequences, and readiness to perform environmentally-friendly behavior in a Lithuanian case sample. Via interviews and questionnaires in a target group of Lithuanians age 15-74 years old, they found that self-transcendence value orientation, environmental risk perception and the assumption of responsibility were the most prominent predictors of environmental behavior which are highlighted ad having policy implications for promoting PEBs.

Ajzen's theory of planned behavior (TPB) (Ajzen, 1991) accentuates key determinants for environmentally friendly behavior. Carfora et al. (2017) support this and add *self-identity* to the traditional TPB variables in the sense of having the ability to moderate the effect on perceived behavioral control on intentions and the effect of past behavior on intentions and future behavior. Similar to perceived behavioral control, *self-efficacy* seeks to encompass a more practical self-sense of how well one deems oneself capable of performing a particular behavior (Bandura, 1982). *Empowerment* through participation is strongly linked to conservation initiatives and behaviors, which Wali et al. (2017) find from studying data on conservation and quality of life initiatives in local Peruvian Amazon communities. Additionally, the concept of empowerment emerges as a prominent aim in literature on participation and engagement in environmental programs. However, through a systematic review on participatory environmental monitoring projects in peer-reviewed journals, Turreira-García et al. (2018) found that there are very limited measures included when accounting for empowerment of participants in praxis and that projects mainly are steered and controlled by professionals and researchers. Among several other factors, Cheng and Monroe (2012) investigated self-efficacy in relation to children's *connectedness to nature,* interests in nature-based activities and childrens' interest in PEBs. Through surveys on fourth-grade students, the main findings included self-efficacy as one key predictor for future environmentally friendly behaviors underlining Bandura's (1982) theories on self-efficacy: If individuals trust that they are capable of doing a certain action then they are more likely to do that action. Furthermore, existing research finds that engaging in nature-experiences at an early age increases the likelihood of holding PEBs as adults (Chawla, 2007; Nord et al., 1998).

Social norms in a family context is studied by Grønhøj and Thøgersen (2012) through survey responses from 601 Danish families with the aim of establishing to which extent adolescents' PEBs are affected by their own pro-environmental attitudes or if they are products of social influence of the immediate family. That study revealed that PEBs of the adolescents were heavily directed by family norms as well as influenced by how much they were expressed through their parents' behavior. Furthermore, in a litter behavior analysis Shimazu (2018) found social norms to be a specifically important predictor for the act of littering. Lastly, *knowledge* on how to perform PEBs is paramount for people to actually carry out the actions. In this regard it is evident that although doing PEBs might require knowledge on how to practically do so, holding that same environmental knowledge may not necessarily guarantee that people do it (Kaiser and Fuhrer, 2003).

The majority of literature on environmental behaviors and attitudes focuses on adults, while the development and predictors of PEBs in childhood are not quite as extensively documented (Bamberg and Möser, 2007; Wiernik et al., 2013). Nevertheless, exploratory studies suggest that age plays an essential role for performing PEBs, while also proposing a decreasing pattern with age in the childhood years through adolescence. For example, Collado et al. (2015) found that younger children (age 6-9) were more prone to behave in an environmentally conscious manner compared to older children (age 10-12). Interestingly, a recent study suggests that by exposing 10-year-olds to even very simple interventions, in this case by reading a short story about a dilemma on natural resources, had an immediate effect on sustainable behavior (Ebersbach and Brandenburger, 2020). Additionally, educating children on environmental issues at an early age has been shown to be beneficial for establishing and retaining future pro-environmental patterns while also having a positive influence on adult behavior (Damerell et al., 2013).

2.2. Citizen science

As a lever for introducing environmental awareness and engagement, participatory initiatives such as *citizen science* (CS) projects are promising (Pandya and Dibner, 2018). Evidence suggests that nature-specific activities, e.g. beach cleanups of marine litter, can have additional benefits including increased knowledge, awareness and PEB intentions. Wyles et al. (2017) conducted an experimental study to investigate the outcomes of beach clean-ups in terms of well-being, educational value and behavioral intentions. They found that beach clean-ups (compared to other coastal activities) had a positive effect on the individuals on all parameters and thus further underline the positive interplay between the natural environment and people for learning, understanding and environmental citizenship. It is worth noting that not all clean-ups yielding scientific data are designed as CS activities or qualified as such. Public participation in research has long been a tradition in various scientific fields such as astronomy, biology, environmental monitoring and public health with the common aim to engage participants and collect data of scientific value (Hecker et al., 2018). Today, the diverse methodological approach commonly referred to as CS, has gained momentum across disciplines yielding unique datasets and policy implications as well as the promise of empowerment and transformative results in communities (Haklay, 2015; Hidalgo-Ruz and Thiel, 2013; Pocock et al., 2017). Raised ecological awareness and empowerment from participation in environmental monitoring projects is widely considered as essential learning outcomes of CS, however these are highly dependent on the individual project designs and are not guaranteed (Pandya and Dibner, 2018). Bela et al. (2016) reviewed published research on CS and social learning, and commented on the need for an increased clarification of the concept in individual studies. They documented transformative outcomes as these in the literature are often assumed but rarely evaluated systematically. The growing evidence base on the development of science capital through CS, such as *scientific literacy*, *science-related values* and *science learning* out of school contexts, point to some positive feedback loops on science-related activities (including CS projects) along with development of *scientific identity* and *agency* (Ballard et al., 2018; Edwards et al., 2015; Pandya and Dibner, 2018). Although further systematic research on CS remains desirable, several studies suggest, several studies suggest increase in environmental understanding and pro-environmental intentions (Dawson et al., 2018; Edwards et al., 2019; Wyles et al., 2017). When engaging specificallt children in CS projects, the potential for for learning about the environment and triggering motivation for change are considerable as children are known to be innately curious and possess a willingness to learn, making them more open to supporting pro-environmental attitudes and behaviors (Hartley et al., 2018; Jenkins, 2011).

2.3. Plastic pollution in Denmark: current state & general concern

Even though Denmark is not among the most polluted countries in the world regarding plastic litter, annual waste collection campaigns have demonstrated that plastic litter is found throughout the country (Dansk Naturfredningsforening, n.d.). Of the annual 340,000 MT of plastic waste produced in Danish households and companies, approximately 36% is recovered for reuse while 36% is incinerated (Miljø- og Fødevareministeriet, 2018). The Danish Environmental Agency strongly encourages sorting of all waste including plastic, but the system for sorting, collection and management of plastic waste is the individual municipality's responsibility (The Danish Ministry of Environment and Food, n.d.). This leads to differences in household waste separation depending on where people live in the country. In Denmark, concern about environmental issues is relatively high with 83% of the surveyed population considering climate change to be anthropogenic driven and 80% being concerned about the environmental impact of plastic bags, plastic packaging and single-use plastics (Ipsos, 2019). Moreover, a recent study from the European Food Safety Authority consolidates that Danish citizens generally, and compared to the other EU member states, holds a high *awareness* as well as *risk perception* of various aspects of food safety, including the presence of microplastic particles in food (EFSA, 2019).

3. Methods

3.1. Recruiting from the Mass Experiment cohort

Each year in week 39, ASTRA (National Center for Learning in Science, Technology and Health in Denmark) facilitates a Natural Science Festival (Danish: Naturvidenskabsfestivallen) for children and adolescents. ASTRA and their collaborators aim to strengthen natural science subjects in the education system through three main activities reoccurring every year: School visits from researchers and experts, an open database with 200 protocols for science experiments and analytical exercises; and a large-scale two-day experiment with students called the Mass Experiment (ME). The overall theme of the ME 2019 was plastic pollution in nature and consisted of a comprehensive CS activity (Syberg et al., 2020). Approximately 57,000 participating students were signed up by their teachers and took part in the obligatory monitoring activity, while students from 5th grade and up had access to doing voluntary predefined tests for polymer identification in their school laboratories. Sign-up for the ME opened in the spring of 2019 for all educational institutions in Denmark including elementary schools (public and private) and high schools. Participating school classes were provided with educational materials for use before, during or after the clean-up. These included reading material, exercises and discussion points related to the theme of the ME: Plastic production, consumption and after-life. The clean-up activity followed a protocol adapted from the Joint Research Center (JRC) marine litter protocol which allowed the participants to choose their location from 7 different nature types and categorize their findings into the 22 most common and scientifically interesting plastic litter categories (Galgani et al., 2013; Syberg et al., 2020).

Each team conducted a clean-up collecting and identifying plastic waste from a 100 m area, defining one transect. Each teacher responsible for a team received a kit for conducting the CS activity, including gloves, trash bags and a large cloth depicting the 22 selected plastic types for the students to divide their plastic litter upon while counting the items (Syberg et al., 2020). The ME resulted in 3548 separate CS clean-ups corresponding to a distance of 354.8 km covering 94 out of 98 Danish municipalities (ASTRA, 2020; Syberg et al., 2020). Out of the 3548 samples only 66 did not contain any plastic, illustrating that plastic litter is present throughout the Danish environment (Syberg et al., 2020). The social science study reported here was not a mandatory part of the ME, rather it was presented as a scientific, albeit voluntary, addition. The respective team-coordinators could sign up their teams for participation and then receive guidelines and links for the online questionnaire prior to the ME and during the week after. In January 2020, the results from the CS activity were available to the participants and presented to the public, i.e. after the post-questionnaire were completed.

3.2. Participants and study design

The study was observational with no blinding. Hence all participants were aware of the fact that they were completing the questionnaires and were taking part in a research study. For ethical reasons, the students were anonymized and no individual IDs were recorded at any point, however through the ME each team received a unique team-id for reporting the clean-up data, enabling comparisons before and after the intervention. Since the aim was to compare the students' responses before and after the ME, we matched the respective team-ids in our two response data sets and found 48 team pairs (cf. section *Data selection protocol*). The surveys yielded 930 and 830 individual responses (pre and post, respectively), divided between the 48 groups at both time points. The total number of responses received after the interventions were lower than prior to the intervention. In-group variations for team numbers between the two time points occurred and was accounted for by reporting results in means rather than values for all concepts but one, which was reported as proportion scores. For the pre-intervention group the minimum group size was 9 participants and the maximum 62 ($M_{size} = 19$), and the post-intervention group had a minimum group size of 6 and a maximum of 43 ($M_{size} = 17$). Furthermore, the pre-intervention group consisted of 51.5% 'Female', 46.9% 'Male', 1.6% 'Other', with a M_{age} of 12.7, whilst the post-intervention groups had 51.2% 'Female', 46.7% 'Male', 2.1% 'Other' and a M_{age} of 12.6. The study has a repeated measures design, which allows us to study the change over time with the identical questionnaires before and after the intervention. The current study is specifically addressing the four variables included in the hypothesis: *Risk perception*, *reported behaviors*, *self-efficacy* and *empowerment* (see Pre-registration [removed for blind review but provided to editor]). The additional four measures are explained in Appendix A.

3.3. Questionnaire

To grasp and hold the attention of the young target group, a simple and short questionnaire was developed (including a pilot stage) for filling in and submitting online. The pre-questionnaire for T1 consisted of 15 questions, while the post-questionnaire (T2) was a direct replicate with three additional questions evaluating the experience of the ME. The initial page of the questionnaire explained that the study was anonymous, optional and was not a knowledge test. Contact information for the study was provided. All students had internet-access via a personal or school-provided laptop, tablet or smartphone from which they could use the survey-link provided by their team-leader. The students completed the survey in-class ($M_{response\ time} = 5.4$ min.) under adult supervision and were encouraged to raise their hand if assistance was needed.

3.4. Measures – the concepts of interest

We measured the students' behaviors (Hartley et al., 2015) and perceptions, focusing on four concepts introduced above: *Risk perception* (Liobikiene and Juknys, 2016), *self-reported behavior*, *self-efficacy* (Bandura, 1982) and *empowerment* (Turreira-García et al., 2018).[1] The post-survey consisted of four additional questions: Two on practical issues related to whether the students had participated in *all*, *some* or *just a few* of the ME activities and if they had gone to the lab to do polymer analyses (*yes* or *no*); and two questions assessing how they perceived the intervention (*fun*, *meaningful* or *boring*) and how it made them feel (*hopeful*, *powerful*, *scared* or *angry*). Additionally, we had the students respond to typical descriptive questions on age and gender (*boy, girl* or *other*). They registered with a unique team-id provided by ASTRA for reporting the collected plastic litter. This team-id was also registered for the present study allowing us comparison on a team level at the two time points before and after the ME: T1 and T2.

3.4.1. Risk perception

We measured the students' risk perception of three environmental issues to see any change over time, as well as the patterns of the issues pre- and post-intervention to study potential interrelated spill-over or suppression. We asked: a) *Do you think plastic in nature is a problem?* b) *Do you think climate change is a problem?* and c) *Do you think loss of biodiversity is a problem?* The students responded on a 5-point scale: 1) *Yes, it is a very big problem,* 2) *Yes, it is a small problem,* 3) *I am unsure whether it is a problem,* 4) *No, it does not matter*, and 5) *No, it is not a problem at all.* We calculated mean scores for each issue for each team, resulting in three scores for analysis at T1 and three scores at T2.

3.4.2. Self-reported behavior

We further asked whether the participants had performed specific pro-environmental behaviors in the previous week and compared the responses before and after the intervention (T1 and T2 respectively). Based on Hartley et al. (2015), behavior was measured by the questions: *"In the previous week, have you..?"* with eight response options (multiple selections were possible); 1) *Picked up litter from the ground,* 2) *Separated waste at home,* 3) *Separated waste at school,* 4) *Bought items with less packaging,* 5) *Avoided plastic bags in the supermarket,* 6) *Used reusable cups or food containers,* 7) *Encouraged friends or family to do some or all of the above*, and 8) *Littered on the ground.* Proportion scores were calculated for each behavior and team, indicating how many children in each team reported engaging in the behavior at T1 and T2, respectively, resulting in 16 scores in total.

3.4.3. Self-efficacy

Adapted from the New General Self-efficacy Scale (Chen et al., 2001) we measured whether the students considered themselves as capable of contributing to reduction of plastic pollution by asking them: *Do*

[1] We also included *nature-connectedness* (Cheng and Monroe, 2012), *fate/pathways* for two types of plastic bags, *social norms* (Grønhøj and Thøgersen, 2012) *and self-identification* (Carfora et al., 2017), see Appendix A, but focus here on the four core outcomes.

you think that you can reduce plastic pollution in nature? The response options ranged from: 1) *Yes, I definitely think I can,* to 5) *No, not at all.* We calculated means for each team at T1 and T2, resulting in two scores.

3.4.4. Empowerment

The students' sense of positive emotions in relation to plastic reducing behavior was studied by asking *If you pick up plastic litter from the ground, do you feel like you make a difference for the environment?* The response options ranged from 1) *I make an important difference,* to 5) *I do not make a difference at all.* We calculated means for each team at T1 and T2, resulting in two scores.

3.5. Data selection protocol

We followed a careful procedure to arrive at our final sample (Fig. 1). All responses from the pre- ($n = 3747$) and post-questionnaire ($n = 2355$) were collected from the survey-provider (SurveyXact) and incomplete responses were immediately excluded from the dataset. Ages ≥ 17 were omitted with reference to the focus on primary and secondary school students (pre: $n = 3395$ and post: $n = 2148$) – simultaneously, ages noted with a 0.5 were rounded up to the next year (e.g., 10.5 became 11 to facilitate categorization by age). Next, mistyped and therefore unmatchable team-ids were excluded (pre: $n = 3119$ and post = 2034). Teams with less than 5 students were omitted (pre: $n = 3030$ and post: $n = 1983$) and finally only matching teams from the pre- and post-dataset were kept for inclusion in the present study (matching teams: $n = 48$. Students: pre: $n = 931$ and post: $n = 838$).

3.6. Statistical analysis

We ran a GLM mixed ANOVA on each variable to test if there was a change between the two time points and whether this was the same for different items (e.g., perceived risk of plastic, climate change and biodiversity). We followed up main effects with post-hoc testing and included *age categories* (7-12 and 13-16 years of age) and level of *participation* (high and low) for exploratory purposes.

4. Results

4.1. Risk perception

Student perceptions of three environmental risks, *plastic pollution in nature, climate change* and *loss of biodiversity*, was generally high for both time points T1 and T2 and across issues (means between 4.17 and 4.82) (Fig. 2). We observed a significant difference between risk perception of the three issues, $F(2,88) = 59.84$, $p < 0.001$, partial eta sq. = 0.58, following the order from most to least concern: *Plastic pollution*, *climate change* and *loss of biodiversity*. This order applies to the pre as well as the post ME data, which indicates that the students perceived plastic pollution as the most important issue of the three. However, a decline in risk perception was found between the first and the second collection of data, $F(1,44) = 8.12$, $p = 0.007$, partial eta sq. = 0.16. Paired *t*-tests showed that this was driven by a drop in concern for *plastic pollution* ($t(47) = -2.25$, $p = 0.029$), whereas no decline for *climate change* ($t(47) = -1.82$, $p = 0.076$) or *loss of biodiversity* ($t(47) = -1.67$, $p = 0.101$) was noted (Fig. 2).

The analysis further showed a significant interaction between age and environmental issue, $F(2,88) = 3.21$, $p = 0.045$, partial eta sq. = 0.07. Independent *t*-tests showed that this was driven by a higher risk perception in the youngest age group regarding *loss of biodiversity*, $t(46) = -2.20$, $p = 0.033$ (Fig. 3); the age effect was not significant for plastic or for climate change, $p = 0.39$. Moreover, we found a main effect of participation level, $F(1,44) = 9.31$, $p = 0.004$, partial eta sq. = 0.18, Ms. = 4.60 (high participation) and 4.32 (low participation), indicating that those who participated in more of the activities had a higher level of concern (but we cannot say if this is a causal effect or potentially indicative of reverse causality).

4.2. Reported behavior

The overall mixed-ANOVA on the eight behaviors showed a main effect of behavior, $F(7,308) = 46.49$, $p < 0.001$, partial eta sq. = 0.51, with the most frequent behaviors being *sorting waste at home* and *picking up*

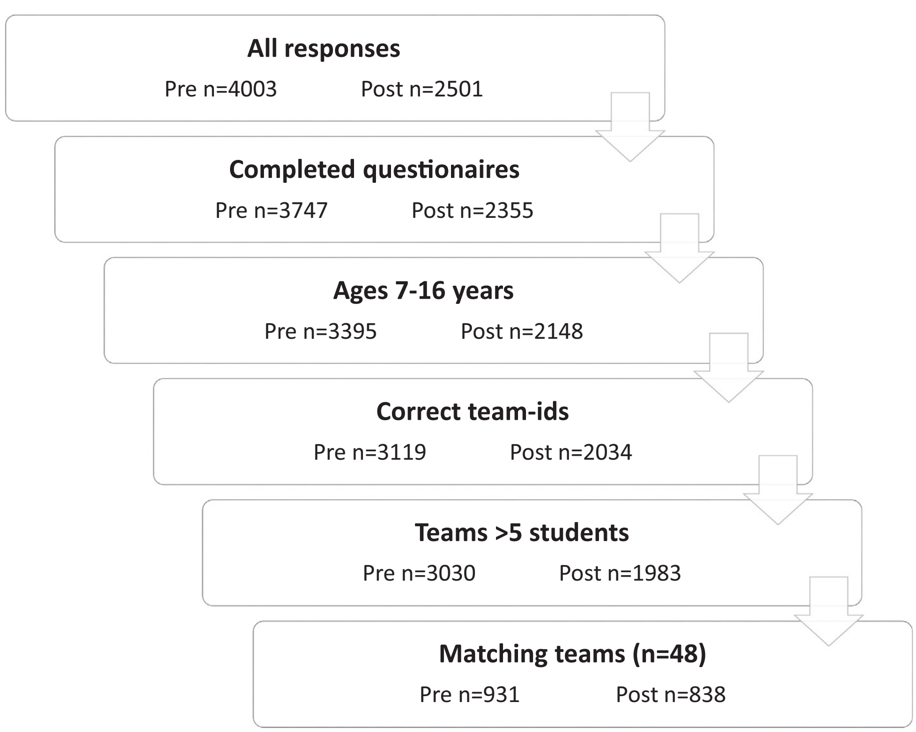

Fig. 1. Data selection process.

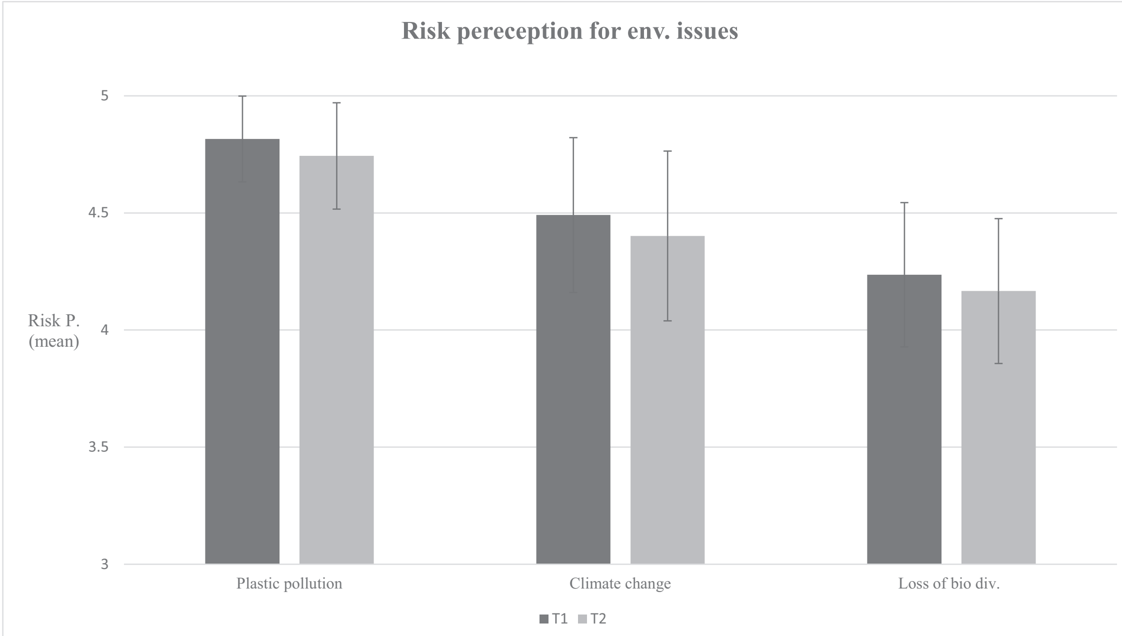

Fig. 2. Before (T1) and after (T2) responses to perceived risk of three environmental issues: Plastic pollution, climate change and loss of bio diversity. Response options range from 1 = "It is not a problem at all" to 5 = "It is a very big problem" Data are shown as means ± standard deviations.

litter from the ground, and the least common being *throwing litter on the ground* (Table 1). This main effect was further qualified by an interaction with age category, $F\,(7{,}308) = 3.44$, $p < 0.001$, partial eta sq. = 0.07 and a three-way interaction between behaviors, age category and time, $F\,(7{,}308) = 2.86$, $p = 0.007$, partial eta sq. = 0.06. Because our hypotheses centered on the change over time, we concentrated on the three-way interaction, which we followed up with separate tests on each behavior. Significance values for the main effects of time and age respectively are also given in Table 1.

We found an age category by time interaction only for two out of the eight behaviors: *Picking up litter*, $F(1{,}46) = 6.85$, $p = 0.012$, and *encouraging others*, $F(1{,}46) = 5.59$, $p = 0.022$. This interaction demonstrated no change for the older children over time but a drop in *picking up litter* for the younger children and a similar pattern for *encouraging others*. Although the behavior scores overall show a mixed pattern, the only two significant results indicate a decrease in pro-environmental behavior after compared to before the ME, contrary to our hypothesis.

4.3. Self-efficacy

The younger group (age category 1) had a significantly higher level of self-efficacy than the older group (age category 2) at T1 (main effect of age, $F\,(1{,}44) = 11.99$, $p < 0.001$, partial eta sq. = 0.214), even though both groups' self-efficacy was high (Fig. 4). A significant drop was observed for both groups between T1 and T2 (main effect of time, $F(1{,}44) = 13.05$, $p < 0.001$, partial eta sq. = 0.229), with the

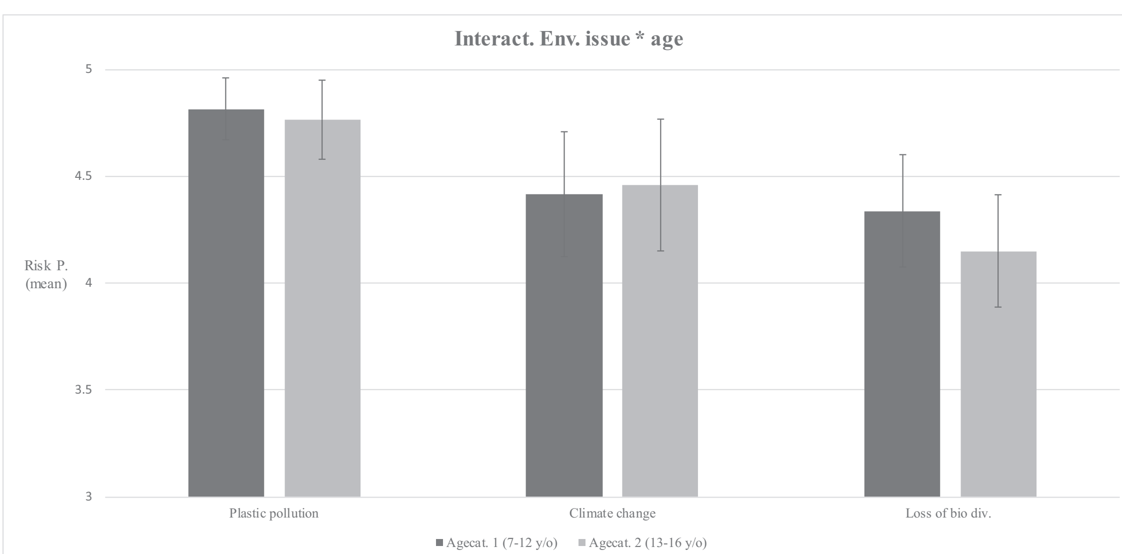

Fig. 3. Interaction between perceived risk for the three environmental issues and the two age categories. Response options range from 1 = "It is not a problem at all" to 5 = "It is a very big problem". Data are shown as means ± standard deviations.

Table 1
Students' reported behavior (means of proportions indicating yes) for both time points (T1 and T2). The reported behaviors are answers to the question "In the last week did you..?". Effects over time, rank pre and post and the time and age cat. interactions are presented. Age category 1 (7-12 y/o) and age category 2 (13-16). Means for significant interactions are highlighted in bold.

Reported behavior	Time			Rank		Age cat. 1 (7-12)		Age cat. 2 (13-16)			
	T1 M of proportion (SD)	T2 M of proportion (SD)	P (for time effect)	T1	T2	T1 M of proportion (SD)	T2 M of proportion (SD)	T1 M of proportion (SD)	T2 M of proportion (SD)	P (for age effect)	P (for interaction time × age)
Pick up litter from the ground	0.52 (0.18)	0.50 (0.17)	0.036	1	2	**0.68 (0.16)**	**0.57 (0.15)**	**0.46 (0.15)**	**0.47 (0.17)**	0.001	0.012
Sort waste at home	0.52 (0.22)	0.55 (0.22)	0.115	2	1	0.42 (0.22)	0.49 (0.17)	0.56 (0.22)	0.57 (0.23)	0.094	0.191
Sort waste at school	0.30 (0.26)	0.33 (0.26)	0.543	5	5	0.32 (0.26)	0.30 (0.18)	0.30 (0.27)	0.34 (0.29)	0.946	0.182
Buy items with less plastic packaging	0.20 (0.11)	0.23 (0.11)	0.157	6	6	0.24 (0.13)	0.27 (0.12)	0.18 (0.10)	0.21 (0.11)	0.049	0.840
Avoid plastic bags in the super market	0.42 (0.16)	0.42 (0.14)	0.988	3	3	0.38 (0.17)	0.38 (0.14)	0.44 (0.15)	0.44 (0.14)	0.137	0.847
Use reusable cups or food containers	0.39 (0.17)	0.37 (0.16)	0.885	4	4	0.32 (0.16)	0.35 (0.11)	0.41 (0.16)	0.37 (0.18)	0.179	0.274
Encourage friends and family…	0.16 (0.12)	0.17 (0.10)	0.573	7	7	**0.25 (0.16)**	**0.20 (0.13)**	**0.13 (0.09)**	**0.15 (0.09)**	0.008	0.022
Throw litter on the ground	0.06 (0.08)	0.08 (0.08)	0.053	8	8	0.03 (0.05)	0.06 (0.09)	0.07 (0.09)	0.09 (0.08)	0.149	0.894

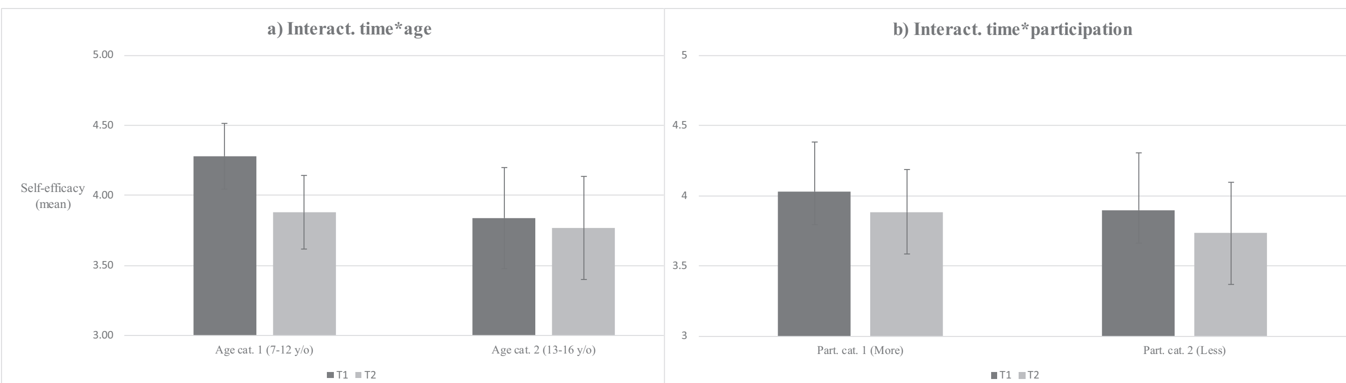

Fig. 4. a) The interaction of time and age cat. on self-efficacy. b) Interaction of time and participation cat. on self-efficacy. Response options range from 1 = "No, not at all" to 5 = "Yes, I definitely think I can. Data are shown as means ± standard deviations.

biggest drop observed among the younger students (interaction time by age $F(1,44) = 6.49$, $p = 0.014$, partial eta sq. = 0.129) telling us that the intervention did not increase the students' feeling that that they themselves were capable of reducing plastic pollution in nature, but rather the contrary. The students who participated to a greater extent in the ME had higher self-efficacy than those who participated to a

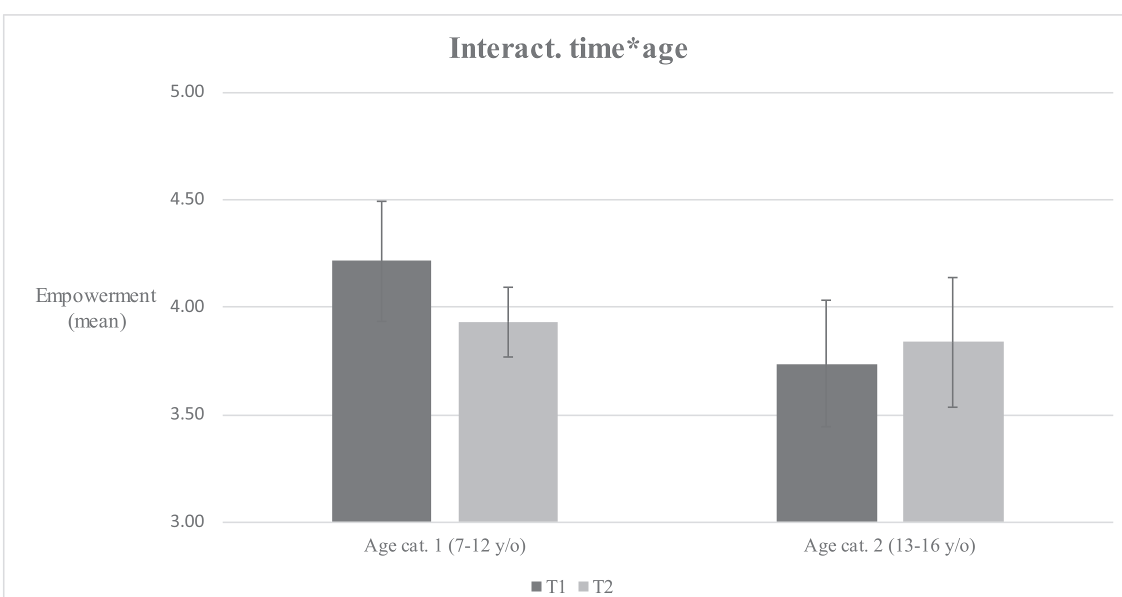

Fig. 5. Interaction of time and age cat. on empowerment. Response options range from 1 = "I do not make a difference at all" to 5 = "I make an important difference". Data are shown as means ± standard deviations.

lesser extent, indicating that students who entered into the ME with higher self-efficacy tended to be more engaged in the exercise.

4.4. Empowerment

Overall, *empowerment* did not differ between before and after the intervention (main effect of time, $F(1,44) = 3.06$, $p = 0.087$, partial eta sq. $= 0.065$). However, we did find a significant effect of *age category* ($F(1,44) = 16.18$, $p < 0.001$, partial eta sq. $= 0.269$) as well as interaction of *time* and *age category* ($F(1,44) = 12.24$, $p < 0.001$, partial eta sq. $= 0.218$, Fig. 5), further underlining the same pattern as for *self-efficacy* – the younger age group (age category 1) held a higher baseline compared to the older students (age category 2) and experienced a decrease post intervention.

5. Discussion

Plastic pollution has attracted a substantial amount of public interest, and interventions for changing behaviors are important to address the issue. However, evidence for the impact of such initiatives is currently insufficient. The present study emerged as a unique opportunity to examine the participants of the Mass Experiment (ME), an interdisciplinary national Citizen Science (CS) project aimed at children. The work is an important contribution to the existing literature which holds scarce evidence regarding evaluation on large-scale interventions, but it also highlights challenges in conducting such research.

Evidently, the results of the study led us to reject our hypothesis, which expected to see an increase of *risk perception*, *self-efficacy*, *empowerment* and pro-environmental *reported actions* when comparing pre and post responses from the students participating in the ME 2019. There were few or no main effects of the intervention on the four measured items from the hypothesis. Nevertheless, we found scores that were considerably high for both time points, which indicates high PEBs and risk perceptions for all participants regardless of the intervention. Furthermore, we observed patterns for the two age groups that point to diverse impacts of the ME and possibly a higher degree of change in the younger compared to the older age group. Notably, some effects for the younger children suggest adverse outcomes, e.g., behaviors such as encouraging others to act and also self-efficacy decreased compared to before the intervention. Lastly, the Danish context, in terms of societal factors such as general knowledge on and perceptions of plastic, may have had a greater impact on our study than initially expected.

5.1. High baseline

The present study's overall high baseline for measures such as *perceived risk of plastic pollution* (See Fig. 2) corresponds to the general perception in Denmark, where 80% of the surveyed population report a concern for the impact of plastic items on the environment (Ipsos, 2019). Research in Australia and Chile on plastic in the environment shows similar high concerns (Amenábar Cristi et al., 2020; Dilkes-Hoffman et al., 2019). In several studies *environmental concern* was positively related to attitude and a positive predictor of recycling behaviors (Chao et al., 2021; Jekria and Daud, 2016). Therefore, the high initial risk perception could reflect enthusiasm for the upcoming participation in the ME and being prepared for the curriculum on plastic pollution, which in turn may have compelled the students to answer in a more positive manner in the pre-questionnaire (T1), in anticipation of the activity. This is known as the *ceiling effect*, where studies that report high pre-scores are likely to observe no or little positive effects between two timepoints because the available room for improvement is limited. Liefländer & Bogner (2018) report a ceiling effect in a similar intervention study on school children with focus on the relationship between environmental attitudes and environmental knowledge and suggest that it can have cause biased correlations and limited the validity of their outcome. The particularly high initial baseline in this study might be at least partly responsible for the general lack of changes from T1 to T2 invoked by the actual participation in the ME. For *risk perception* of climate change as well as for loss of biodiversity, *self-efficacy*, *empowerment*, and all but two *reported behaviors* no significant changes were observed when comparing scores pre and post the ME.

Additional detailed analyses of prior perceptions, attitudes and behaviors in relation to plastic pollution would be highly relevant and could provide useful reflections to this very prominent aspect of our study. This could include additional variables explaining and elaborating on which psychological characteristics could explain the high baseline. In particular, analysis at the level of the individual might illuminate this finding further. In the present study, we were not allowed to identify individuals for matching purposes due to ethical reasons. Additionally, it would be relevant to study whether the high baseline also applies for the general Danish youth not participating in the ME (e.g. as a control group). The particular teachers motivated to integrate a comprehensive CS intervention into their curriculum, may belong to a segment of resourceful employees with an inherent environmental enthusiasm, which could have a catching effect on the general teaching content.

5.2. The role of age

As previous research has established, age is a prominent predictor of pro-environmental behavior (PEB) (Klineberg et al., 1998; Kurisu, 2016). Similarly, we found several interesting interactions with age in our study. For instance, we observed drops for the behaviors *picking up litter* and *encourage others* for the pre- vs. post-responses for the youngest students (age 7-12), which could either indicate that this group is more (negatively) affected by the ME compared to the older students or a manner of experience-discrepancy applied for the younger children in terms of stronger anticipation for the ME activities. This predisposition is suggested in the scarce literature on children's environmental behavior where knowledge and comprehension of environmental problems are pivotal for PEBs For instance, in an older study, Miller (1975) found that half of the studied second graders (age 7-8 years) fathomed pollution was due to individuals purposefully throwing litter on the ground, wheras 60% of eight graders (age 13-14 years) understood pollution as a combination of production and consumption (Miller, 1975). Further research is needed to establish or deny the same trend some 40 years later, however based on the results presented in Table 1 for the measure on reported behaviors, the youngest students were engaged in picking up litter prior to the intervention while afterwards they reported less of this behavior. The older participants held a more stable pre-post score for the same two items, which could potentially indicate that they already understand various aspects of plastic pollution including actions to carry out in order to reduce litter in nature, albeit at a lower level than the younger children.

Prior studies of littering behavior have shown that young adults are more likely to litter than older adults (Durdan et al., 1985; Krauss et al., 1978; Schultz et al., 2013). Kahn et al. (1999, 2002) find that moral reasoning for environmental issues including littering in nature also changes with age. While younger children reason in an anthropogenic manner (related to personal interests) for the age group 6-8 years while, older children from 11 years and up used biocentric reasoning (the notion that nature has intrinsic value). Kahn et al. also underline that even though the older children use biocentric reasoning they rarely act upon it (Kahn, 1999; Kahn and Lourenço, 2002). Our study is in line with the important role of age, as we found differences between 7 and 12 and 13-16-year-olds, which suggested a “lower limit” for the littering behavior of adolescents/children. Further research should investigate whether a CS activity which is strongly focused on scientific observations and analysis might actually undermine children's motivation to perform PEBs. This interpretation is currently highly speculative but worth keeping in mind for designing interventions for behavior change, which might benefit from motivational - in addition to informational - content.

5.3. Tackling plastic pollution in Denmark

The intervention showed no overall positive effect on the measures *self-efficacy* or *empowerment*. Again, with reference to the high baseline, these results ought to not be translated directly as though the participants were disengaged with or discouraged by the intervention itself. Instead, it is possible that the ME has provided the students with realistic insights into the state of plastic pollution in the Danish environment. Images of plastic pollution in mainstream media tend to portray a state and pollution level much more severe than, and in continents much different from, the natural environment in Denmark. The Danish environmental policy-making is in general viewed upon as ambitious regarding compliance to and even outperformning the OECD average on most of the Sustainable Deveelopment Goals. Furthermore, Denmark is ranked number six in the most recent Climate Change Performance Index evaluating the ambitiousness of national climate change policies (Burck et al., 2021). While still facing serious environmental challenges including air quality, minimizing single-use plastic products and loss of biodiversity, Denmark has accomplished to successfully decoupled emissions of green house gasses with the growth in gross domestic product largely because of the Danish energy sector (OECD, 2019). In December 2018 the Danish government issued an official report on the effort to avoid plastic waste and instead focus on recirculating plastic materials (Miljø- og Fødevareministeriet, 2018).

If the students have associations with plastic pollution from highly impacted environments e.g. media coverage of pollution in Southeast Asia or at sea in the Great Pacific Garbage Patch, the CS activity in their local community may appear uninteresting to them. We speculate that it is plausible that the ME provided the participating students with an assumption that picking up litter in nature is not a useful instrument for tackling plastic pollution in the Danish setting. On the contrary, the results on sorting behavior may reflect an (non-significant) increased understanding of how to handle plastic waste within the frame of the Danish societal approach and waste infrastructure which has an emphasized focus on sorting recycling plastic waste (Miljø- og Fødevareministeriet, 2018). The current study's results, in combination with the results from the natural science paper on the CS project on the plastic fractions found throughout the Danish realm, can effectively inform Danish decision-makers on where to focus regulatory efforts in order to reduce plastic waste in nature. Vaughan et al. (2003) illustrate that environmental education programmes for children have positive effects on parents and other third-party adults' environmental learning which stresses the importance and potentials of CS activites for students and children in Denmark and in general. Future research could investigate children's perceptions of different types of intervention and approaches to the problem.

5.4. Limitations and suggestions for future research

The current study made use of a unique opportunity to partner with a national citizen science initiative. This held several opportunities but also constraints on the design and measurement. While we preregistered the study approach and expectations, in the end it is best classed as a feasibility study, which is more open-ended and holds several aspects for further exploration including the additional variables on self-identity, nature connectedness, social norms, and knowledge on pathways.

For future studies in a similar setting, we suggest: (a) Individual IDs for the participants, which would allow for a more straight-forward paired analysis process and yield more data points to better test the effect of the intervention (of course abiding by stringent data protection rules and ethical guidelines); (b) Control groups if possible to account for the baseline and provide more confidence on causality attributed to the intervention; (c) Involvement in the design process of the intervention by for instance making the evaluation-research an integrated part of the exercise from the start with regards to timing of pre- and post-questionnaires, exposure to teaching material, age groupings etc.; (d) Planning and executing efforts to encourage more responses on the follow-up questionnaire. This would enable access to a larger proportion of the unvisited yet existing data of un-matched questionnaires, which could effected the study's outcome in several ways; e) Including behavior-change based content rather than exclusively science-based content and ideally test different content modules, to understand and maximise the motivational and behavior change potential of citzen science.

6. Conclusion

Plastic litter in the natural environment is ubiquitous and various policy measures are implemented at international and local levels to handle pollution. Participatory interventions such as CS activities are gaining a footing within the field of environmental sciences, however evaluation of actual changes in behaviors and perceptions are scarcely documented. This study focused on one specific CS intervention, the ME, and its impact on the *risk perceptions*, *reported behavior*, *self-efficacy* and *empowerment* of Danish school students. Unexpectedly, we found no main effects of the intervention in the data analyses of the responses to our pre- and post-questionnaires. Nevertheless, we learned that the participating students held a high baseline for all four measures, potentially reflecting very high motivation in the pre-responses and a narrow prospect for improvement. In addition, we speculate that the Danish circumstances marked by a general high concern for plastic pollution can partially account for the lack of change in the four measures. Age occurred as a predictor of the students' reported behavior, where for instance the younger age group (7-12 years) reported a decrease in *picking up litter from the ground*, while the older age group held a consistently high engagement for the same behavior measured prior to the intervention and after. These results suggest an advantage of increased attention to the role of age when designing and measuring this type of intervention.

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CRediT authorship contribution statement

Nikoline G. Oturai: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization. **Sabine Pahl:** Methodology, Formal analysis, Writing – review & editing. **Kristian Syberg:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision, Funding acquisition.

Declaration of competing interest

We declare no potential conflicts of interest with respect to the research, authorship, or publication of this article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.scitotenv.2021.150914.

References

Ajzen, I., 1991. The theory of planned behavior. Organ. Behav. Hum. Decis. Process. 50 (2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T.

Amenábar Cristi, M., Holzapfel, C., Nehls, M., De Veer, D., Gonzalez, C., Holtmann, G., Honorato-Zimmer, D., Kiessling, T., Muñoz, A.L., Reyes, S.N., Nuñez, P., Sepulveda, J.M., Vásquez, N., Thiel, M., 2020. The rise and demise of plastic shopping bags in Chile – Broad and informal coalition supporting ban as a first step to reduce single-use plastics. Ocean Coast. Manag. 187 (December 2019). https://doi.org/10.1016/j.ocecoaman.2019.105079.

ASTRA, 2020. Plastforurening i Danmark - Resultatrapport for Masseeksperiment 2019 doi:2488917148.

Ballard, H.L., Harris, E.M., Dixon, C.G.H., 2018. Science Identity and Agency in Community and Citizen Science : Evidence & Potential.

Bamberg, S., Möser, G., 2007. Twenty years after Hines, Hungerford, and Tomera: a new meta-analysis of psycho-social determinants of pro-environmental behaviour. J. Environ. Psychol. 27 (1), 14–25. https://doi.org/10.1016/j.jenvp.2006.12.002.

Bandura, A., 1982. Self-efficacy mechanism in human agency. Am. Psychol. 37, 122–147 (0.1037/0003-066X.37.2.122).

Benartzi, S., Beshears, J., Milkman, K., Sunstein, C.R., Thaler, R.H., Shankar, M., Tucker-Ray, W., Congdon, W.J., Galing, S., 2017. Should governments invest more in nudging? Psychol. Sci. 28 (8), 1041–1055. https://doi.org/10.1177/0956797617702501.

Berenguer, J., José, A.C., Rocío, M., 2005. Rural-urban differences in environmental concern, attitudes, and actions. Eur. J. Psychol. Assess. 21 (2), 128–138. https://doi.org/10.1027/1015-5759.21.2.128.

Bucci, K., Tulio, M., Rochman, C., 2020. What is known and unknown about the effects of plastic pollution: a meta-analysis and systematic review. Ecol. Applications, eap.2044 https://doi.org/10.1002/eap.2044.

Burck, J., Hagen, U., Bals, C., Höhne, N.A., Nascimento, L., 2021. Climate Change Performance Index Results 2021. https://www.germanwatch.org/en/CCPI.

Carfora, V., Caso, D., Sparks, P., Conner, M., 2017. Moderating effects of pro-environmental self-identity on pro-environmental intentions and behaviour: a multi-behaviour study. J. Environ. Psychol. 53, 92–99. https://doi.org/10.1016/j.jenvp.2017.07.001.

Chao, C.M., Yu, T.K., Yu, T.Y., 2021. Understanding the factors influencing recycling behavior in college students: the role of interpersonal altruism and environmental concern. Int. J. Sustain. High. Educ. https://doi.org/10.1108/IJSHE-07-2020-0232.

Chawla, L., 2007. Childhood experiences associated with care for the natural world: a theoretical framework for empirical results. Child. Youth Environ. 17 (4), 144–170. http://www.jstor.org/stable/10.7721/chilyoutenvi.17.4.0144.

Chen, G., Gully, S.M., Eden, D., 2001. Validation of a new general self-efficacy scale. Organ. Res. Methods 4 (1), 62–83. https://doi.org/10.1177/109442810141004.

Cheng, J.C.H., Monroe, M.C., 2012. Connection to nature: children's affective attitude toward nature. Environ. Behav. 44 (1), 31–49. https://doi.org/10.1177/0013916510385082.

Damerell, P., Howe, C., Milner-Gulland, E.J., 2013. Child-orientated environmental education influences adult knowledge and household behaviour. Environ. Res. Lett. 8 (1). https://doi.org/10.1088/1748-9326/8/1/015016.

Dansk Naturfredningsforening (n.d.). Affaldsindsamlingen. Retrieved July 9, 2020, from https://www.affaldsindsamlingen.dk/om/.

Dawson, A.L., Kawaguchi, S., King, C.K., Townsend, K.A., King, R., Huston, W.M., Nash, S.M.B., 2018. Turning microplastics into nanoplastics through digestive fragmentation by Antarctic krill. Nat. Commun. 9 (1), 1–8. https://doi.org/10.1038/s41467-018-03465-9.

Dilkes-Hoffman, L.S., Pratt, S., Laycock, B., Ashworth, P., Lant, P.A., 2019. Public attitudes towards plastics. Resour. Conserv. Recycl. 147 (January), 227–235. https://doi.org/10.1016/j.resconrec.2019.05.005.

Doran, P.T., Zimmerman, M.K., 2009. Examining the scientific consensus on climate change. Eos Trans. AGU 3. https://doi.org/10.1029/2009EO030002.

Durdan, C.A., Reeder, G.D., Hecht, P.R., 1985. Litter in a university cafeteria: demographic data and the use of prompts as an intervention strategy. Environment and Behavior. vol. 17, Issue 3. Sage Publications, pp. 387–404. https://doi.org/10.1177/0013916585173007.

Ebersbach, M., Brandenburger, I., 2020. Reading a short story changes children's sustainable behavior in a resource dilemma. J. Exp. Child Psychol. 191, 104743. https://doi.org/10.1016/j.jecp.2019.104743.

Edwards, R., Phillips, T., Bonney, R., Mathieson, K., 2015. Citizen Science and Science Capital - A Tool for Practotioners. University of Stirling.

Edwards, R., Kirn, S., Hillman, T., Kloetzer, L., Mathieson, K., McDonnell, D., Phillips, T., 2019. Learning and developing science capital through citizen science. In: Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., Bonn, A. (Eds.), Citizen Science - Innovation in Open Science, Society and Policy. UCL Press, pp. 381–390 https://doi.org/10.14324/111.9781787352339.

EFSA, 2019. 2019 Eurobarometer on Food Safety in the EU - Fact Sheet Denmark (Issue April).

Galgani, F., Hanke, G., Werner, S., De Vrees, L., 2013. Marine litter within the European Marine Strategy Framework Directive. ICES J. Mar. Sci. 70 (6), 1055–1064. https://doi.org/10.1093/icesjms/fst122.

Geyer, R., Jambeck, J.R., Law, K.L., 2017. Production, use, and fate of all plastics ever made. Sci. Adv. 3 (7), 25–29. https://doi.org/10.1126/sciadv.1700782.

Grønhøj, A., Thøgersen, J., 2012. Action speaks louder than words: the effect of personal attitudes and family norms on adolescents' pro-environmental behaviour. J. Econ. Psychol. 33 (1), 292–302. https://doi.org/10.1016/j.joep.2011.10.001.

Haklay, M., 2015. Citizen Science and Policy: A European Perspective.

Hartley, B.L., Thompson, R.C., Pahl, S., 2015. Marine litter education boosts children's understanding and self-reported actions. Mar. Pollut. Bull. 90 (1–2), 209–217. https://doi.org/10.1016/j.marpolbul.2014.10.049.

Hartley, B.L., Pahl, S., Holland, M., Alampei, I., Veiga, J.M., Thompson, R.C., 2018. Turning the tide on trash: empowering european educators and school students to tackle marine litter. Mar. Policy 96 (February), 227–234. https://doi.org/10.1016/j.marpol.2018.02.002.

Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., Bonn, A., 2018. Citizen Science - Innovation in Open Science, Society and Policy. UCLPRESS.

Heidbreder, L.M., Bablok, I., Drews, S., Menzel, C., 2019. Tackling the plastic problem: a review on perceptions, behaviors, and interventions. Sci. Total Environ. 668, 1077–1093. https://doi.org/10.1016/j.scitotenv.2019.02.437.

Hidalgo-Ruz, V., Thiel, M., 2013. Distribution and abundance of small plastic debris on beaches in the SE Pacific (Chile): a study supported by a citizen science project. Mar. Environ. Res. 87–88, 12–18. https://doi.org/10.1016/j.marenvres.2013.02.015.

Ifegbesan, A.P., Rampedi, I.T., 2018. Understanding the role of socio-demographic and geographical location on pro-environmental behavior in Nigeria. Appl. Environ. Educ. Commun. 17 (4), 335–351. https://doi.org/10.1080/1533015X.2017.1419102.

Ipsos, 2019. Danskerne og klimaforandringerne. https://www.ipsos.com/da-dk/ny-undersogelse-danskerne-og-klimaforandringerne.

Jekria, N., Daud, S., 2016. Environmental concern and recycling behaviour. Procedia Econ. Finance 35 (October 2015), 667–673. https://doi.org/10.1016/s2212-5671(16)00082-4.

Jenkins, L.L., 2011. Using citizen science beyond teaching science content: a strategy for making science relevant to students' lives. Cult. Stud. Sci. Educ. 6 (2), 501–508. https://doi.org/10.1007/s11422-010-9304-4.

Jia, L., Evans, S., van der Linden, S., 2019. Motivating actions to mitigate plastic pollution. Nat. Commun. 10 (1), 9–11. https://doi.org/10.1038/s41467-019-12666-9.

Kahn, P.H.J., 1999. The Human Relationship With Nature: Development and Culture. The MIT Press.

Kahn, P.H.J., Lourenço, O., 2002. Water, air, fire, and earth: a developmental study in Portugal of environmental moral reasoning. Environ. Behav. 34 (4), 405–430. https://doi.org/10.1177/00116502034004001.

Kaiser, F.G., Fuhrer, U., 2003. Ecological behavior's dependency on different forms of knowledge. Appl. Psychol. 52 (4), 598–613. https://doi.org/10.1111/1464-0597.00153.

Klineberg, S.L., McKeever, M., Rothenbach, B., 1998. Demographic predictors of environmental concern: it does make a difference how it's measured. Soc. Sci. Q. 79 (4), 734–753.

Krauss, R.M., Freedman, J.L., Whitcup, M., 1978. Field and laboratory studies of littering. Journal of Experimental Social Psychologyvol. 14, Issue 1. Elsevier Science, pp. 109–122. https://doi.org/10.1016/0022-1031(78)90064-1.

Kurisu, K., 2016. Pro-environmental behaviors. 2015. https://doi.org/10.1007/978-4-431-55834-7.

Liobikiene, G., Juknys, R., 2016. The role of values, environmental risk perception, awareness of consequences, and willingness to assume responsibility for environmentally-friendly behaviour: the Lithuanian case. J. Clean. Prod. 112, 3413–3422. https://doi.org/10.1016/j.jclepro.2015.10.049.

Maibach, E., Myers, T., Leiserowitz, A., 2014. Climate scientists need to set the record straight: thereis a scientific consensus that human-caused climate change is happening. Earth's Future 2, 295–298. https://doi.org/10.1002/2013EF000226.Received.

Miljø- og Fødevareministeriet, 2018. Plastik Uden Spild (Issue December). doi:978-87-93635-99-9.

Miller, J.D., 1975. The development of pre-adult attitudes toward environmental conservation and pollution. Sch. Sci. Math. 75 (8), 729. https://doi.org/10.1111/j.1949-8594.1975.tb09899.x.

Muncke, J., Andersson, A.M., Backhaus, T., Boucher, J.M., Carney Almroth, B., Castillo Castillo, A., Chevrier, J., Demeneix, B.A., Emmanuel, J.A., Fini, J.B., Gee, D., Geueke, B., Groh, K., Heindel, J.J., Houlihan, J., Kassotis, C.D., Kwiatkowski, C.F., Lefferts, L.Y., Maffini, M.V., Scheringer, M., 2020. Impacts of food contact chemicals on human health: a consensus statement. Environ. Health Glob. Access Sci. Source 19 (1), 25. https://doi.org/10.1186/s12940-020-0572-5.

Nord, M., Luloff, A.E., Bridger, J.C., 1998. The association of forest recreation with environmentalism. Environ. Behav. 30 (2), 235–246. https://doi.org/10.1177/0013916598302006.

OECD, 2019. OECD environmental performance reviews: Denmark 2019. OECD Environmental Performance Reviews https://doi.org/10.1787/1eeec492-en.

Pahl, S., Wyles, K.J., Thompson, R.C., 2017. Channelling passion for the ocean towards plastic pollution. Nat. Hum. Behav. 1 (10), 697–699. https://doi.org/10.1038/s41562-017-0204-4.

Pandya, R., Dibner, K.A., 2018. Citizen science as an opportunity for science learning. Learning Through Citizen Science: Enhancing Opportunities by Design. National Academies of Sciences, Engineering, and Medicine, pp. 1–183 https://doi.org/10.17226/25183.

PlasticsEurope, 2019. Market data. https://www.plasticseurope.org/en/resources/market-data.

Pocock, M.J.O., Tweddle, J.C., Savage, J., Robinson, L.D., Roy, H.E., 2017. The diversity and evolution of ecological and environmental citizen science. PLoS ONE 12 (4), 1–17. https://doi.org/10.1371/journal.pone.0172579.

Rochman, C.M., Browne, M.A., Underwood, A.J., Van Franeker, J.A., Thompson, R.C., Amaral-Zettler, L.A., 2016. The ecological impacts of marine debris: unraveling the demonstrated evidence from what is perceived. Ecology 97 (2), 302–312. https://doi.org/10.1890/14-2070.1.

SAPEA, 2019. A Scientific Perspective on Microplastics in Nature and Society. https://doi.org/10.26356/microplastics.

Schultz, P.W., Bator, R.J., Large, L.B., Bruni, C.M., Tabanico, J.J., 2013. Littering in context: personal and environmental predictors of littering behavior. Environ. Behav. 45 (1), 35–59. https://doi.org/10.1177/0013916511412179.

Syberg, K., Hansen, S.F., Christensen, T.B., Khan, F.R., 2018. Risk perception of plastic pollution: importance of stakeholder involvement and citizen science. 58, 1–23. https://doi.org/10.1007/978-3-319-61615-5.

Syberg, K., Palmqvist, A., Khan, F.R., Strand, J., Vollertsen, J., Clausen, L.P.W., Feld, L., Hartmann, N.B., Oturai, N., Møller, S., Nielsen, T.G., Shashoua, Y., Hansen, S.F., 2020. A nationwide assessment of plastic pollution in the Danish realm using citizen science. Sci. Rep. 10 (1). https://doi.org/10.1038/s41598-020-74768-5.

The Danish Ministry of Environment and Food, n.d.The Danish Ministry of Environment and Food. (n.d.). Tip om sortering af affalnd. Retrieved April 8, 2020, from https://mst.dk/affald-jord/affald/saerligt-for-borgere-om-affald/sortering-af-affald/.

Turreira-García, N., Lund, J.F., Domínguez, P., Carrillo-Anglés, E., Brummer, M.C., Duenn, P., Reyes-García, V., 2018. What's in a name? Unpacking "participatory" environmental monitoring. Ecol. Soc. 23 (2). https://doi.org/10.5751/ES-10144-230224.

Vaughan, C., Gack, J., Solorazano, H., Ray, R., 2003. The effect of environmental education on schoolchildren, their parents, and community members: a study of intergenerational and intercommunity learning. J. Environ. Educ. 34 (3), 12–21 (10.1080/00958960309603489).

Wali, A., Alvira, D., Tallman, P.S., Ravikumar, A., Macedo, M.O., 2017. A new approach to conservation: using community empowerment for sustainable well-being. Ecol. Soc. 22 (4). https://doi.org/10.5751/ES-09598-220406.

Wiernik, B.M., Ones, D.S., Dilchert, S., 2013. Age and environmental sustainability: a meta-analysis. J. Manag. Psychol. 28 (7), 826–856. https://doi.org/10.1108/JMP-07-2013-0221.

Wyles, K.J., Pahl, S., Holland, M., Thompson, R.C., 2017. Can beach cleans do more than clean-up litter? Comparing beach cleans to other coastal activities. Environ. Behav. 49 (5), 509–535. https://doi.org/10.1177/0013916516649412.