The effect of a citizen science project conducted in the classroom on students age 9-13 on attitudes towards science and connection to nature.

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Abstract

In this study the effect of a citizen science project is investigated on students' attitudes towards science and connection to nature. To measure the effects an adapted version of the MATS questionnaire is being used. The research population consists of students aged between nine and thirteen, who participated in the 'Nederland Zoemt' ("the Netherlands Buzzes') citizen science project. The focus of this research was on the effect contributing data to scientific research might have on the students' attitudes towards science. This was investigated using a quasi-experimental study. The results did not show a significant effect of the intervention on the research population. This study does show that the questionnaire is viable to use on Dutch primary school children. The abundance of opinions from the students gathered through the questionnaire and interviews gives a lot of information for further research in the field of informal and formal science education.

Introduction

Citizen science makes the act of conducting science possible for basically everyone. The data collection of science projects is greatly enhanced through the recruitment of volunteers.
This kind of science started around 1900 with the Christmas Bird Count in the USA (Silvertown, 2009), where volunteers counted the birds present in their gardens. Since then, citizen science has grown abundantly especially in ecology research. For example, in 2008, 60 articles were published on citizen science in ecology (Nadkarni & Stevenson, 2009). The increase of this kind of research is mainly caused by the availability of technical tools such as the internet and software to collect data.

Citizen science in general is a proven method for gathering data, and it has increased our knowledge on nature and biodiversity (Bonney et al., 2015). However, citizen science could be more. Only recently, research has been focusing on including volunteers more effectively and thereby for example enhancing their scientific literacy (Bela et al., 2016). Other research on citizen science has talked about different educational outcomes like attitude towards science, appreciation of nature and public engagement. A CAISE report of 2009 (Bonney et al., 2009) reviews public participation in scientific research (PPSR). In this report the authors discuss potential effects of PPSR on different aspects such as awareness, knowledge, understanding, engagement, interest, skills, attitudes and behavior. This report shows the potential beneficial effects of PPSR projects like citizen science on the aspects mentioned above. According to the CAISE report, the effects on attitudes and behaviors have not yet been documented extensively. In the CAISE report, different PPSR projects have been investigated and only one of them documented on attitudes. The birdhouse network did not find any changes in attitudes, possibly because the participants are already interested in science. There are other qualitative studies that show improvements in volunteers regarding scientific literacy and attitudes towards science (Cronje et al., 2011).

Brossard (2005) reported on the effect of the birdhouse network citizen science project. They believed that the educational material would activate the participants to enroll in a thoughtful process, which would persuade them to change their attitude. They found that the participants would be undecided in their answers on questions about attitude. This made them conclude that the measurement of attitudes is complex, which means scales should be developed to make clearer distinctions between different answers. As mentioned above, a problem in testing the effects of participating in a citizen science project is that participants are generally already interested in science (Rotman et al., 2012). This makes it hard to test the effect of enrolling in a citizen science project. Another problem is that only people who actually enroll in the citizen science project can be observed and tested. This means that the pretest of each participant is used as the control for their posttest. This makes it hard to limit the effects of co-factors that might influence the participants. While studies based on finding effects on volunteers who participate in citizen science show promising results, this does not mean that these effects will occur everywhere, where people participate in citizen science projects (Lorentz et al., 2016).

For this reason, the current study aimed at taking a (quasi-)experimental approach, in which the self-selection bias of participants is annulled. For this reason we targeted a citizen science project with school children, for which participation was non-voluntary and because potential benefits of citizen science in addressing scientific literacy and attitudes could be very applicable in formal education. The school children were members of classes which participated as a whole. This will result in a diverse study population. Students with different interests in science and nature will be present in each class. Several studies have investigated student participation in citizen science and reported anecdotal evidence that participation can influence student attitudes toward science and scientific literacy (Patterson, 2012).

Learning through participation in citizen science projects can be seen as a part of Informal Science Education (ISE). ISE research is focused on how to explain science to the public and how to promote the public understanding of science among the population (Bonney et al., 2009). An important finding in educational research is that relevance of the content can increase the motivation for students to learn (Falk, 2010). This could be an opportunity for ISE to implement this knowledge in the citizen science project. When the research is made relevant for the participants, the participants will be motivated to learn from the project. This will hopefully lead to an increase in the participants' attitude towards science.

Some research has already been done on using citizen science in a classroom setting, such as by Hiller et al. (2014). One of the main research goals was to look at Science, Technology, Engineering and Mathematics (STEM) career motivation before and after participating in a citizen science project. The intervention group scored higher on the posttest than the control group, which means there is a positive influence from the citizen science project on STEM career motivation. The authors however discuss the limitations of this study with only 86 participants and would like to see longitudinal studies being performed to further improve or knowledge on STEM career motivations.

The knowledge we have on children in primary education and their ideas about scientists are mainly based on the Draw-a-scientist test (DAST), developed by Chambers (1983). Through this test, we have learned that a lot of children would draw seven characteristics of scientists: eyeglasses, facial hair, lab coat, scientific instruments, books, technology and relevant captions. This gives a very stereotypical image of a scientist. But Finson (2002) showed that these stereotypical images can be altered by using role models, by keeping in mind the gender and the race of the role model. When exposed to female or minority scientists the children will develop an image of scientists as being more like regular people. The exposure to different types of people who work as scientists should be well organized and should occur for a longer period of time. According to Kahle (1987) the perception of scientists that children have is an aspect of their attitude towards science, which is why it is important to focus on this aspect in the science curriculum.

This specific research focuses on the factor of contributing data to a real scientific project. We wanted to test for this specific part of citizen science because it is a pivotal part of citizen science. Contributing data to actual scientific research might motivate students to try hard and get more positive feelings about science because they can be part of it. The research question of this study is: What is the effect of contributing data (through a citizen science project) on primary school students' (age 9-13) attitude towards science and connection to nature? To get an answer to this question, different steps will have to be taken.

First, it was important to obtain a viable instrument to measure the attitude towards science from the desired target audience. Two recently developed questionnaires were available for the desired target audience; BRAINS questionnaire from Summers & Abd-El-Khalick (2017) and the MATS questionnaire from Hillman et al. (2016). The MATS questionnaire was considered to be the best fit, because of the target audience and was used in this research to develop an adapted version of this questionnaire to fit the research population, being Dutch school children aged 9-13. Our first task was then to test the viability of this adapted questionnaire, which gave the sub question: Can the adapted MATS questionnaire be used on Dutch school children? When the viability of the questionnaire was achieved, we would be able to measure the effect of the intervention and answer the main research question. Next to answering the main research question the obtained data was used to answer another question: Are there any differences in attitude towards science between boys and girls? This was made possible through the abundance of opinions on attitude towards science we obtained through the questionnaire.

The research was conducted within the citizen science project called ‘Nederland Zoemt’ (‘the Netherlands buzzes’). The main goal of the project is to make the Netherlands more suitable for wild bees, because of their importance for agriculture and the ecosystem in general. One way to achieve this goal was to involve the general public in research on wild bees. This was done with a national bee count, to get more information on the abundance and dispersion of different species of wild bees. Surrounding this bee count, a lesson program was developed by staff of Naturalis (one of the partners in the project). This lesson program was used in this research to expose students to citizen science and monitor the effects of an aspect of citizen science on the students’ attitude towards science through a quasi-experimental design.

Methods

Participants

The participants were students from schools who were interested in the Nederland Zoemt project. The schools or classes were randomly assigned to the control- or intervention group. Four schools wanted to participate with two classes each. We used stratified randomization to get two schools in the control group and two schools in the intervention group.

The pretest in the intervention was filled in by 90 students. The posttest in the intervention group was filled in by 83 students. This was because of the absence of some of the students during the lessons or at the time of the posttest. Two of the students were excluded because they did not take the questionnaire seriously, as they had answered all questions neutral. We also gave the parents of the children the option to let their child opt-out of the research. This meant that we did not use the data of these children. They were already excluded from the pretest data. Five children opted-out of the research with no reasons specified. One of the four classes of the intervention group was eventually excluded from the research for not completing one of the necessary components of the research. Only students were used who filled in both the pretest and the posttest. This gave us 53 students from two different schools and from three different classes.

Strategy

This study is used to assess the effect of participation in a citizen science project on attitudes towards science. The study was performed in the citizen science project called "Nederland Zoemt" ('the Netherlands Buzzes'). The project Nederland Zoemt is designed in cooperation between scientists and educators. The project as a whole has the goal to get more information on the occurrence and dispersion of the bees in the Netherlands and to make (parts of) the Netherlands more suitable for bees. Because of the nature of the project we decided to add a test on connection to nature to see whether the project had an effect on this subject.

The study followed a quasi-experimental design. A pre- and posttest on attitudes towards science was administered to children in a control group (lessons on bees) and an intervention group (lessons on bees + citizen science project). Participants were 5th and 6th grade students in primary school. To get more in-depth information, interviews were held with eight students from both groups. The research is therefore based on a mixed-methods approach: Quantitative data from the surveys and qualitative data from the interviews. The lessons on bees have been developed and performed by staff of Naturalis. Naturalis was one of the main partners of the Nederland Zoemt project and one of their responsibilities was to develop lesson materials on bees to support the widespread citizen project and make the project suitable for primary education. Next to the development of the lesson material, the staff members were also the ones who gave the lessons. This was done to control as many conditions as possible.

Setting

The intervention group and the control group followed the same program. The difference is that the intervention was based on data collection that will be used for scientific research. To make sure that the intervention group knew that they are participating in a citizen science project the following four aspects were added to the lessons.

1. The students were made aware that they are collecting data for actual scientific research in a standardized manner.
2. The students saw a video with a scientist asking for their help.
3. They were required to submit their data online.
4. They got feedback on their own data and about the national results of the research.

Procedure

Before the lessons took place, each participating pupil filled in the pretest. A week after the pretest the students participated in a lesson on bees and biodiversity which was developed by the educational team of Naturalis. The intervention group got the same lesson but the aforementioned aspects were added to the lesson. Approximately two weeks after the lesson the students filled in the posttest, which was identical to the pretest. Afterwards, two students of each class were interviewed on more complex aspects of attitudes towards science and to test whether they felt they participated in a citizen science project. The students were chosen by the original teacher of each class. Some teachers opted for an allotted approach and others had a preference for certain students.

Instruments

Quantitative data:

To gather the quantitative data the MATS questionnaire was used. This instrument measures four dimensions of attitude (Attitude towards school science, Desire to become a scientist, Value of science to society and Perception of scientist) and is developed for the age of 8-18 and contains 40 questions (Hillman et al., 2016).

Dimension	Alpha reliability			
	Elementary level	Middle school	High school	Total
Attitude toward school science	0.878 $n = 81$ 11 missing cases	0.841 $n = 299$ 28 missing cases	0.909 $n = 127$ 3 missing cases	0.866 $n = 507$ 42 missing cases
Desire to become a scientist	0.732 $n = 92$	0.658 $n = 318$ 9 missing cases	0.757 $n = 128$ 2 missing cases	0.700 $n = 538$ 11 missing cases
Value of science to society	0.780 $n = 86$ 6 missing cases	0.780 $n = 288$ 39 missing cases	0.833 $n = 124$ 6 missing cases	0.794 $n = 498$ 51 missing cases
Perception of scientists	0.432 $n = 84$ 8 missing cases	0.495 $n = 305$ 22 missing cases	0.526 $n = 125$ 5 missing cases	0.539 $n = 514$ 35 missing cases

Figure 1. Original reliability analysis of MATS questionnaire (Hillman et al., 2016).

To make the questionnaire suitable for the Dutch school children it had to be adapted. First of all the category of attitude towards school science was removed, because we do not have an active school science curriculum in the Netherlands. Secondly, we added a connection to nature scale to the questionnaire because of the topic of the citizen science project at hand, namely wild bees and their importance for nature and agriculture. For this purpose we used the short version of the Nature Relatedness Scale from Nisbet et al. (2008) also used by Bragg et al. (2013) from the University of Essex. Thirdly, the questions were translated to Dutch to fit the Dutch school population. Fourthly, to check for loss of meaning through translation we re-translated the Dutch questionnaire to English and compared this to the original. Finally, the questionnaire was piloted with nineteen children to check whether the students could answer and understand all questions and the questionnaire was adapted accordingly.

We ended up with a questionnaire of 30 questions divided in four constructs (appendix 1):

1. Value of science to society (12 questions, of which 6 were worded positively and 6 were worded negatively).
2. Perception of scientists (12 questions)
3. Desire to become a scientist (2 questions, 1 positive and 1 negative)
4. Connection to nature (6 questions)

The questionnaire being used consisted of four constructs which were analyzed separately. For the analysis of each construct only students were used who completely filled in the pre- and posttest on the construct at hand. This is why the N has a different value per construct, because of missing data. For the control group we ended up with four classes from different schools and the following number of students. These numbers were achieved in the same way as described above, without the exclusion of one of the classes from the research.

Table 1

Number of Students in Intervention and Control Group per Construct.

Construct	**N Intervention group**	**N Control group**	**Number of questions**
Value of science to society	46	85	12
Perception of scientists	47	85	12
Connection to nature	52	87	6
Desire to become a scientist	53	90	2

Qualitative data

For the qualitative aspect of the research a semi-structured interview was developed. This interview was used to get deeper insight into the attitudes towards science of the students. The interviews were conducted with two students per participating class and took a maximum of ten minutes. In the interviews, some of the questions from the questionnaire were repeated to see where the opinions of the students originated from. Another important goal of the interview was to check whether the students felt they were part of a citizen science project or not. This was done to check whether the intervention was strong enough.

Data analysis

The quantitative data collected is on a 5-point Likert scale, this means that the data collected is categorized as ordinal. The questionnaire consisted of four different constructs (value of science to society, perception of scientists, connection to nature and desire to become a scientist). Each of the four constructs was analyzed separately because of the different nature of the questions. For example the value of science to society construct consisted of six positively and six negatively worded questions, which means that the answers on the negatively worded questions should be mirrored. The ordinal character of the Likert scales might be a reason to not use parametric tests but Norman (2010) shows that Likert-scale data can be analyzed as interval data and it is viable to use parametric tests.

The first analysis we did on the results was to test the reliability of the questionnaire, to see whether the questionnaire is viable to be used with this research population. To test for the reliability of the questionnaires, a reliability analysis was performed per construct with a *Cronbach's Alpha* with SPSS 25. The data per construct were tested for normality, if it matched the criteria for normality the *paired samples t-test* was used to test whether there was a significant difference between the means of two groups. If the data did not match the criteria for normality the *Wilcoxon signed rank test* was used to test for significant differences. First, the difference between the pre-and posttest data was analyzed with a *paired samples t-test* or the *Wilcoxon signed rank test.* Afterwards the difference in the control group was compared to the difference in the intervention group with an *ANOVA* per construct. Because of the multidimensionality of the construct scientific attitude sub-analyses were conducted to see whether which aspect of attitude has changed and on the connection to nature scale.

The semi-structured interviews are transcribed and are used to explain some outcomes of the questionnaires as anecdotal evidence. They were used to answer some additional questions that could not be answered with the questionnaire. For example where their opinions on scientists originate from and whether they felt they were part of a citizen science project. We interviewed two students per participating class.

Results

Baseline characteristics

Table 2

Baseline Characteristics from Pretest

	Control	Intervention
Mean age	11,3	10,5
Number of participants	90	53
Number of males	48	28
Number of females	46	25

In table 2 the baseline characteristics from the pretest are shown. This is with excluding students who were later excluded from the research for different reasons specified in the methods section.

Reliability Analysis

A reliability analysis is performed on each construct separately because each construct measures another aspect of attitude towards science or connection to nature. The reliability analysis is done with a *Cronbach's Alpha* on SPSS 25. The results can be found in table 3.

Table 3

Reliability Analysis of the Different Constructs Measured with the Questionnaire

Construct	Pretest both groups (*Cronbach Alpha*)	Posttest both groups (*Cronbach Alpha*)	Intervention only Pretest (*Cronbach Alpha*)	Intervention only Posttest (*Cronbach Alpha*)	Control only Pretest (*Cronbach Alpha*)	Control only Posttest (*Cronbach Alpha*)
Value of science to society	0,57[1]	0,64[1]	0,76[1]	0,80[1]	0,73[1]	0,80[1]
N	131	131	46	46	85	85
Perception of scientists	0,60[2]	0,67[3]	0,68	0,60[4]	0,60[5]	0,77[5]
N	132	132	47	47	85	85
Desire to become a scientist	0,50	0,37	0,86	0,75	0,87	0,87
N	143	143	53	53	90	90
Connection to nature	0,85	0,88	0,80	0,86	0,85	0,87
N	139	139	52	52	87	87

[1] Questions 5 and 6 excluded from analysis.
[2] Question 9 excluded from analysis.
[3] Questions 1 and 6 excluded from analysis.
[4] Question 10 excluded from analysis.
[5] Questions 1 and 10 excluded from analysis.

The *Cronbach's Alpha* of the three constructs adapted from the MATS questionnaire do not show a high internal validity if you look at the combined pre- and posttest data, which is visible in columns two and three. The connection to nature scale does show an excellent internal consistency in the combined dataset. When we look at the intervention and control group separately we can see an overall higher internal consistency in all three of the constructs adapted from the MATS questionnaire. In the Value of science to society construct the internal consistency was improved by excluding questions 5 and 6 from the analysis. In the perception of scientists construct different exclusions yielded an improved internal consistency. The values of *Cronbach's Alpha* when we separate the intervention group from the control group shows that the different constructs of the questionnaire are suitable to use for the target audience of the research.

Reliability of questionnaire

A reliability analysis was also performed with R giving some visual output on the different correlations between the questions of the questionnaire.

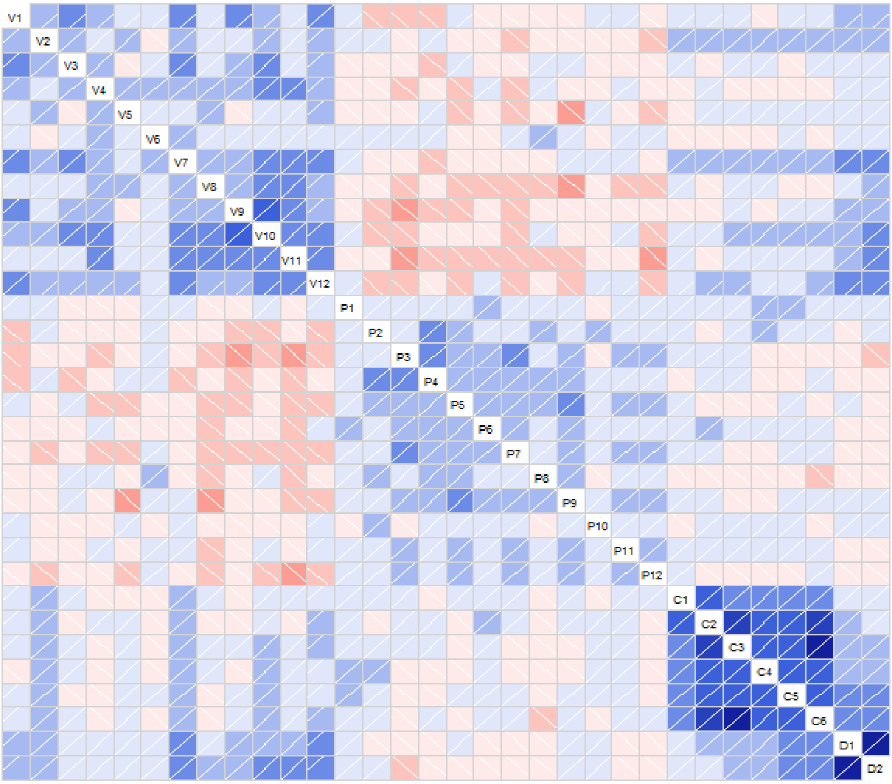

Figure 2. Visualization of Reliability with R. Blue shows a positive correlation between the questions where red shows a negative correlation. The darker each color is, the more correlation is between the questions.

You can clearly see a positive correlation in the four constructs of the questionnaires. The Desire to become a scientist (D1 and D2) and Connection to nature (C1 to C6) show a clear internal consistency. The Value of science to society (V1 to V12) and Perception of scientists (P1 to P10) constructs also show a sufficient internal consistency but they would be stronger with the exclusion of V5 and V6 in the Value of science to society construct and an exclusion of P10 from the Perception of scientists construct. These findings are in accordance with the sub-analyses mentioned above.

Effect of project

To see whether the intervention had an effect on the research population different analyses were performed. First of all the pretest of each group (control and intervention) were compared to the posttest of each group on each of the four constructs measured with the questionnaire.

Table 4

Effect of Project by Comparing Means of Pre- and Posttest Data.

Control group					**Intervention group**				
Construct	**N**	**Pre (mean)**	**Post (mean**	***p*-value**	**N**	**Pre (mean)**	**Post (mean**	***p*-value**	**Statistical test**
Total	78	116,89	116,97	,924	40	117,91	117,2	,597	*Paired t-test*
Value of science to society	85	45,87	45,60	,560	46	45,45	44,37	,144	*Paired t-test*
Perception of scientists	85	26,91	26,08	,088	47	28,93	27,55	,043	*Paired t-test*
Desire to become a scientist	90	20,34	20,07	,802	53	6,17	5,77	,114	*Wilcoxon signed rank test*
Connection to nature	87	5,66	5,65	,310	52	23,25	23,10	,506	*Wilcoxon signed rank test*

Control group

The pre- and posttest for the control group were filled in entirely by 78 students. The pre- and posttest show no significant difference in total score. A paired samples *t*-test was used because the data were normally distributed. We did a sub-analysis on each of the four constructs measured with the questionnaire.

Value of science to society

On the value of science to society (V) construct 85 students completed the twelve questions in the pre- and posttest. The data was normally distributed which meant we could do a paired samples *t*-test. From the analysis we did not find a significant difference in the pre- and posttest scores on this construct.

Perception of scientists

On the perception on scientists construct of the questionnaire 85 students completed the twelve related questions. The data was normally distributed which meant we did a paired samples *t*-test to analyze the data. From the analysis we did not find a significant difference (p=0,088) in the pre- and posttest scores on this construct. It does seem like a definite trend is visible towards a positive effect on this construct. The posttest score is lower than the pretest score because this construct is about preconceptions on scientists. The lower the score, the more normal scientist are seen by the students.

Connection to nature

The connection to nature construct was completed by 87 students. The data was not normally distributed which meant the *Wilcoxon signed rank* test was used to check for a difference between pre- and posttest data. The analysis did not yield a significant effect.

Desire to become a scientist

The desire to become a scientist construct existed of two questions which 90 students answered in the pre- and posttest. The data were not normally distributed and the *Wilcoxon signed ranks* test did not show a significant effect.

Intervention group

The pre- and posttest for the control group were filled in entirely by 40 students. The pre- and posttest show no significant difference in total score. A paired samples *t*-test was used because the data were normally distributed.

We did a sub-analysis on each of the four constructs measured with the questionnaire.

Value of science to society

On the value of science to society (V) construct 50 students completed the twelve questions in the pre- and posttest. The data was normally distributed which meant we could do a paired samples *t*-test. From the analysis we did not find a significant difference (p=0,144) in the pre- and posttest scores on this construct.

Perception of scientists

On the perception on scientists construct, 47 students completed the twelve related questions. The data was normally distributed which meant we did a paired samples *t*-test to analyze the data. From the analysis we did find a significant difference (p=0,043) with an effect size of **-1,37234** in the pre- and posttest scores on this construct. The posttest score is lower than the pretest score because this construct is about preconceptions on scientists. The lower the score, the more normal scientist are seen by the students.

Connection to nature

The connection to nature construct was completed by 52 students. The data was not normally distributed which meant the *Wilcoxon signed rank* test was used to check for a difference between pre- and posttest data. The analysis did not yield a significant effect (p=0,506).

Desire to become a scientist

The desire to become a scientist construct existed of two questions which 53 students answered in the pre- and posttest. The data were not normally distributed and the *Wilcoxon signed ranks* test did not show a significant effect.

Intervention versus control

To test the effect of the intervention we compared the gain scores of both groups. This was done by computing the gain score in SPSS and comparing the gain score of the control group with the gain score of the intervention group with an one-way *ANOVA*. We did this for the total questionnaire and for the four different constructs.

Table 5

Comparison of Gain Scores between Control and Intervention

Construct	*p*-value
Total	,607
Value of science to society	,330
Perception of scientists	,498
Connection to nature	,802
Desire to become a scientist	,164

None of these scores show a significant difference in gain scores between the two groups.

Perception of scientists

The perception of scientists was the only construct that showed a significant result. This is why we did an extra analysis based on combined data of the control and intervention group of the effect of the lessons on bees on the research population. We conducted a *paired-samples t-test* to compare the pretest scores on this construct with the posttest scores. From this analysis we found a significant difference with p = 0,009 with an effect size of **1,01894.**

Analysis of pretest

Male versus female

Another analysis we have done is to see whether there might be a difference between male and female participants. Therefore the mean scores for each construct on the pretest are compared between male and female participants.

Table 6

Difference in Pretest Scores between Females and Males

Construct	Mean score Female	N	Mean score Male	N	Difference	*p*-value
Value of science to society	45,75	63	45,69	68	0,06	,940
Perception of scientists	28,46	67	26,77	65	1,69	,048
Desire to become a scientist	5,54	70	6,15	73	-0,62	,105
Connection to nature	21,41	68	21,45	71	-0,04	0,961

By conducting an independent samples *t*-test no significant difference was found in the value of science to society, desire to become a scientist and the connection to nature constructs. The Perception of scientists construct did show a significant difference between males and females with a *p*-value of 0,048. This means that males scored significantly lower on this construct.

Interviews

The interviews were used to get a deeper insight in the opinions and attitudes of the students towards science. One of the questions was about characteristics of scientists where the students would answer that scientist in general are ‘normal people’, everyone could be one. But some students did mention crazy as a characteristic of scientists; this is mainly because of the portrayal of scientists in movies, shows and comic books. Other characteristics that were mentioned were intelligent, interested, curious (discovering things) and nature lovers.

The following part of an interview shows the way these students think about scientists.

F2: ‘’They love to discover things, learn about new things. They just really love to learn about new things, to broaden their knowledge.’’

F1: ‘’Curiosity.’’

F2: ‘’Yes.’’

I: ‘’And what more?’’

F1: ‘’’Sometimes a bit crazy, a little cuckoo.

(F stands for female and I stands for interviewer)

Another question focused on the appearance of scientists, where multiple students would answer that scientists could wear normal clothes but when they would visualize a scientist they would see a lab coat. This is clear from the following quote from an interview with two boys:

M: ‘’A scientist, it does not matter what you look like, it could be anything. But still when I think about a scientist, I still picture a man, working in a laboratory, doing all kind of experiments. This might not be true, but I still picture this when you say scientist.’’

(M stands for male)

Next to talking about scientists, the interviews were used to check whether the students knew why they had counted wild bees and whether their collected data would be used for something. The students from the intervention group talked about the accumulation of data, these data were then used to see how many bees were living in the Netherlands. How the research worked was not completely clear to them. The students from the control group were more doubtful about the reason for collecting data. They just had to give their data to the teacher, but they did have an idea about the data being used for research.

Here are two quotes from interviews to support these claims:

Control group:

I: ''Was the data that you collected used for something?''

F: ''We just wrote everything down.''

M: ''Yes on a sheet, which we had to hand in.''

F: ''I do not know why.''

M: ''We did not do anything with the data, just hand them in.''

Intervention group:

I: ''Why did you conduct the bee count?''

F: ''To be outside in the nature and for the bees.''

M: ''There was this organization which wanted to know how many bees there are in the Netherlands approximately. So he made some sheets where you could count bees for fifteen minutes, and he will add them all up to calculate the average.''

I: ''So your data is being used for this?''

M: ''I think it will.''

Another result from the interviews was that the students might see me as a scientist. This was mentioned in one of the interviews:

F: ''It is just a normal person that just likes to be a scientist. But when he tries to invent something he would were a lab coat for hygiene and stuff.''

M: ''Yes, you would wear a labcoat in the laboratorium. But you are not wearing a labcoat right now.

I: ‘’You mean that I am a scientist?”

M: ”You just explained your job, that sounds like a scientist to me.”

Conclusions

The question we wanted to answer with this research was: What is the effect of contributing data (through a citizen science project) on primary school students (age 9-13) attitude towards science and connection to nature?

By analyzing the results we cannot say that the intervention had any effect on the research population. The intervention group does not show a more positive improvement on either of the four constructs ('Value of science to society', 'Perception of scientists', 'Desire to become a scientist' and 'Connection to nature') than the control group. The 'Perception of scientists' construct did show a significant improvement in the intervention group on its own.

The students from the intervention felt they were part of actual research more than the control group but this has not given them a more positive attitude towards science. This research does show that the MATS questionnaire can be used to measure the attitude towards science in Dutch primary school children.

Reliability of questionnaire

The adapted MATS questionnaire seems usable for the Dutch school population when you use homogeneous groups considering age. When you use the questionnaire on an age group like 9-13, the questionnaire does not show high scores on internal consistency on each of the three constructs. When we analyze the two groups separately the internal consistency gets higher scores and the questionnaires should therefore be viable. It depends on the construct and target audience whether you should exclude certain questions from the analysis. It would be beneficial to test the questionnaire on a bigger sample of students. The connection to nature scale shows a very high internal consistency on each analyzed group and can anyway be used on Dutch school children aged 9-13.

Perception of scientists

By analyzing merely the pretest data we can see that boys score significantly lower on perception of scientists compared to girls. This means that boys have less preconceptions on scientists and see scientists more like ‘normal’ people.

When we look at the total effect on perception of scientists of the control group and the intervention we found that the posttest scores were significantly lower than the pretest. This effect can be explained by the people who were involved in the lessons on bees, where we showed a video of a scientist who worked with bees. The students might also have labelled me as a scientist conducting his research in their classroom. This means that by simply showing scientist in a movie, or by visiting the classroom as a scientist the children might already have less preconceptions on scientists. It is also possible that the children see scientists as more normal people because they felt like they were able to be scientists themselves with the bee count, or they saw another way of being a scientist like working with bees (from the movie and bee count), or working with children in the classroom (research on themselves).

The data on student’s attitudes towards science gives more information about the way students think about science. This makes the pretest data of this research very valuable for people working in science education. They can decide which aspects they want to improve and try to come up with a strategy to make this happen.

The research is also valuable because the MATS questionnaire (or at least three constructs of the questionnaire) have been adapted and validated for the Dutch school children. Which means this questionnaire can now be used more often to monitor the attitudes towards science of the children. It is important to have a homogeneous research population, because as we have discovered in this research there is a difference in attitudes between grade 5 students and grade 6 students. Our intervention group was significantly younger than our control group. The mixed dataset of both control group and intervention group did not show high values of internal consistency. While the separated group did show high values of internal consistency. This is probably because of the age of the students in each group and the changes children go through in this period of their lives.

Discussion

This study has not given any evidence on a positive effect of contributing data through a citizen science project on students aged 9-13. This might be because of several reasons. First of all the size of the intervention group was cut short because one of the participating classes did not perform the bee count necessary for the research. This meant that we had uneven groups for the analysis of 40 to 53 students in the intervention group and 78 to 90 students in the control group. Basically, this means that we did have high enough power for the analysis of the control group (no effect) but we might not have the sufficient power to see differences in the intervention group. Even though we had a low amount of students in the intervention group we did find a significant effect on the perception of scientists construct.

Secondly, it was difficult to control all the conditions surrounding the research. We could not control the way the teachers introduced the project. Some teachers from the control group mentioned to their class that they would be part of research, while the students should not know this. This might be because of the media attention surrounding the project, especially surrounding Leiden where Naturalis and most of the participating schools were situated. The teachers would hear or read about the project and introduce it in their own way to the class. Other conditions which we could not influence were the weather conditions during the bee count. Bees are less active when it is cloudy outside. This was the case on most days of our research, which means there were less bees active, this would give the students a less positive experience, especially because the theme of bees is completely new for these students. The lesson was not a normal lesson for the students because it was given by an employee of Naturalis, this might be of influence on the students. Another factor that might influence the answers of the students is the fact that they knew that they were part of our research and might therefore answer the questions more positively. We stressed to them that the questionnaire was about opinions and that they were free to answer as they pleased. We would not grade their answers or comment on them.

Thirdly, the students already scored high on the different constructs during the pretest. This way it is harder to get an improvement in their attitude towards science. In general, a lot of questions were already answered with ‘agree’ or a score of four out of five. It is harder to get an improvement from ‘agree’ to ‘totally agree’ than to get from neutral to agree or from disagree to neutral for example. The high scores on the pretest might be caused by the nature of leading questions in the questionnaires, which will make the students answer the questions positively. The posttest that was used was a copy of the pretest, this means that satiation might have occurred in answering the questions. This might give the posttest less value for the research, but this was something that could not be prevented. We tried to make the period between the two tests as long as possible to limit this effect.

Fourthly, the difference in baseline characteristics of the two groups might have made it difficult to compare the gain scores between both groups. This difference in baseline characteristics is visible by looking at the average age of the participants. The difference was caused because of the availability of classes who wanted to participate in this research. Four schools were willing to participate in the research with two classes each. We decided to conduct the stratified randomization process on school level instead of per class. The disadvantage of this choice was that three grade 6 classes and one grade 5 class were placed in the control group versus three grade 5 classes and one grade 6 class in the intervention group. The benefit of this placement would be to limit the possibility of cross contamination when we have a control class and intervention class in the same school. Where the teachers might interact and notice the different treatment of the two classes.

Finally there might be some problems with the intervention. From the interviews it seemed that even the intervention group was not completely sure that their collected data was being used for actual research, which was an essential part of the research. The control group was less certain about their contribution to actual research but the distinction between the two groups should be clearer, which means that the students should be informed more thoroughly on the goals of the lessons. Because of the fact that the citizen science part (contributing data to actual research) was not clear to most of the students gives the intervention less power to have an effect on the participants. It seemed that the effect that was found on the perception of scientists was mainly caused by the exposure of the students to actual scientists, in a short clip and by visiting the classroom. These findings show the limitations for using citizen science in the classroom. A possible explanation for this is that the students experience the lessons as being part of the regular school practice, which limits the citizen science experience. The intervention to let the students be part of citizen science was not invasive enough to make significant changes in their attitudes towards science. The effect that we found on the whole pool of participants, control and intervention groups and on the perception of scientists can therefore not be attributed to the citizen science aspect of the lessons. By analyzing all the pre- and posttest differences, there was a significant effect on perception of scientists, because both groups were visited by a scientist and were shown a short clip of a scientist. The effect should therefore be attributed to the exposure of the students to actual scientists.

Recommendations

For further research on using citizen science in a classroom setting we would need a longer project. The aspect of contributing data to actual scientific research could not get enough attention in the current project. The participating classes only got one lesson and did 30 minutes of counting bees. Apparently this was not enough to create a shift in the students attitude towards science. It would also be beneficial for the project if the students would spend more time outside of the classroom. This will give a future project more of a citizen science feel. By using a longer project it will get even harder to control all the conditions surrounding the project. This should always be kept in mind. With this research we did find a clear effect of the interaction with actual scientists on the students. Both the control and intervention group showed an improvement on perception of scientists. This seems like an easy way to improve children perception of scientists by showing that scientists are ‘normal’ people, to get rid of some preconceptions about scientists.

Next to the minor effects we found with this research we did gather a lot of useful information on students attitudes towards science. From the pretest we got 185 opinions from children aged 9-13 on the value of science to society, perception of scientists, desire to become a scientist and connection to nature. This data gives valuable information and can be used in future research or for designing new projects or school exercises about science. For example the fact that boys score significantly higher on perception of scientists compared to girls should be something to focus on, by giving more attention to female scientists.

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Appendix 1 Questionnaire

Stelling	Helemaal oneens	Oneens	Neutraal	Eens	Helemaal eens
1. Onze wereld is fijner om in te leven door wetenschap.	1	2	3	4	5
2. Om een wetenschapper te zijn moet je een beetje gek zijn.	1	2	3	4	5
3. Ik denk na of wat ik doe gevolgen heeft voor de aarde.	1	2	3	4	5
4. Wetenschappers dragen een labjas.	1	2	3	4	5
5. Technologie is een voorbeeld van een belangrijk product van wetenschap.	1	2	3	4	5
6. Ik voel mij sterk verbonden met de aarde en alles wat leeft.	1	2	3	4	5
7. Wetenschap helpt om de dagelijkse problemen op te lossen.	1	2	3	4	5
8. Wetenschappelijke ontdekkingen helpen mensen niet aan een beter leven.	1	2	3	4	5
9. Als wetenschappers een ontdekking hebben gedaan over de wereld, dan proberen ze deze niet meer te verbeteren.	1	2	3	4	5
10. Wetenschappers werken in een laboratorium.	1	2	3	4	5
11. Wetenschappers hebben geen tijd om plezier te hebben.	1	2	3	4	5
12. Als een wetenschapper zegt dat een idee de waarheid is, dan geloven alle andere wetenschappers dat.	1	2	3	4	5
13. Een belangrijk doel van de wetenschap is om nieuwe medicijnen te ontwikkelen en daarmee levens te redden.	1	2	3	4	5
14. Een land kan zelfs zonder wetenschappers sterk zijn.	1	2	3	4	5

Stelling	Helemaal oneens	Oneens	Neutraal	Eens	Helemaal eens
15. Gevoel voor de aarde en de natuur hoort bij mijn karakter.	1	2	3	4	5
16. Mensen zouden wetenschap moeten begrijpen omdat het een belangrijk deel uitmaakt van hun leven.	1	2	3	4	5
17. Ik merk dieren en planten op, waar ik ook ben.	1	2	3	4	5
18. Ik zou graag wetenschapper willen worden.	1	2	3	4	5
19. Wetenschap is alleen nuttig voor wetenschappers en voor niemand anders.	1	2	3	4	5
20. Wetenschappers verbeteren geen fouten in het werk van andere wetenschappers..	1	2	3	4	5
21. Mijn favoriete plekken bevinden zich buiten in de natuur.	1	2	3	4	5
22. Ik zou geen wetenschapper willen worden, want ik heb daar geen interesse in.	1	2	3	4	5
23. Ontdekkingen van wetenschappers hebben geen effect op de mensen om mij heen.	1	2	3	4	5
24. Wetenschappers zijn mannen.	1	2	3	4	5
25. Mijn band met de natuur is een belangrijk deel van wie ik ben.	1	2	3	4	5
26. Wetenschappelijke ontdekkingen hebben geen effect op mijn leven.	1	2	3	4	5
27. Wetenschappers werken alleen.	1	2	3	4	5
28. Alles wat wetenschappers zien en vinden tijdens hun werk schrijven ze nauwkeurig op.	1	2	3	4	5

Stelling	Helemaal oneens	Oneens	Neutraal	Eens	Helemaal eens
29. Je moet oud zijn om een wetenschapper te zijn.	1	2	3	4	5
30. Het is niet nodig voor mensen om wetenschap te begrijpen, want het heeft geen invloed op hun leven.	1	2	3	4	5
31. Voor wetenschappers telt alleen denken, niet hoe ze zich over dingen voelen.	1	2	3	4	5
32. Wetenschap helpt ons om de wereld beter te begrijpen.	1	2	3	4	5

33. Heb je thuis een tuin?	**Ja / Nee**
34. Ben je vaak buiten?	**Ja / Nee**
35a. Ga je weleens naar een museum?	**Ja / Nee**
35b. Zo ja, welke?	
36a. Ga je wel eens op vakantie?	**Ja / Nee**
36b. Zo ja, Wat voor type vakantie meestal?	Appartement / Kamperen / Hotel / Vakantiepark anders namelijk:
37. Heb je een wetenschapper in je familie?	**Ja / Nee**
38a. Doe je iets buiten school om met wetenschap?	**Ja / Nee**
38b. Zo ja, kan je een voorbeeld geven?	

Bedankt voor het invullen!