Pharmabees project impact report

2019-2024

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1. Introduction to the Pharmabees project

Pharmabees is an award-winning outreach program run by Cardiff University which inspires primary school aged children to engage with science through the medium of innovative educational, digital and real-world resources (https://pharmabees.co.uk/). The project aims to create a bee friendly city, support the education of children of all ages and contribute to the fight against antibiotic resistant superbugs.

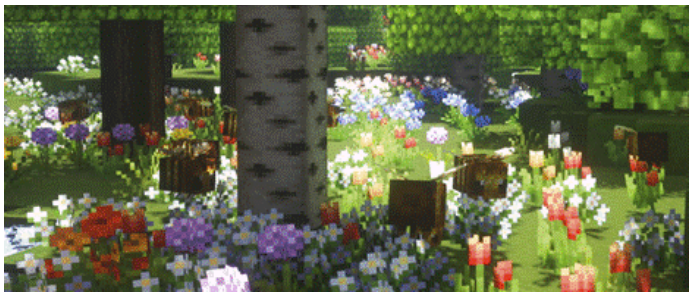
The project is designed for year 5 and 6 pupils in primary schools (aged 9 to 11 years). More than 1100 children from over 30 primary schools in Cardiff and the surrounding areas have taken part since 2017. Evaluations have previously been conducted for the 2017 and 2018 cohorts (Jenkins and Casella, 2018; 2019). This report summarises the evaluation data collected in 2019, 2022, 2023 and 2024. The project could not be delivered in schools in 2020 and 2021 due to the COVID-19 pandemic.

The Pharmabees website hosts educational resources in English and Welsh, including slides, worksheets, videos and notes for teachers. There are also bee themed activities which children and families can do at home, and links to citizen science projects.

Using bees as the central theme, a program of four connected sessions is delivered, exploring the impact of climate change on bees, biodiversity and the planet on which we all live.

Session 1. Why are bees important? The role that bees play in pollination how they support the production of most of the food we eat. It also covers the life of bee, the make-up of the hive and the production of honey. Finally, they can see inside a hive using VR goggles.

Session 2. Climate change. The causes of climate change and how it impacts on bees and biodiversity. The session also provides examples of steps which can be taken to mitigate the effects of climate change such as growing wildflowers which capture CO_2 and provide food for bees and other endangered pollinators.



Session 3. Creation of a Minecraft bee garden to model the impact of climate change on bees. Children develop their own Minecraft worlds in which they explore the impact of climate change on bee numbers and diversity. The world is designed so that activities which increase the production of CO_2 result in an increase in temperature and a reduction in bee numbers. Activities which reduce CO_2 levels, such as growing wildflowers lower the temperature and allow bee numbers to increase.

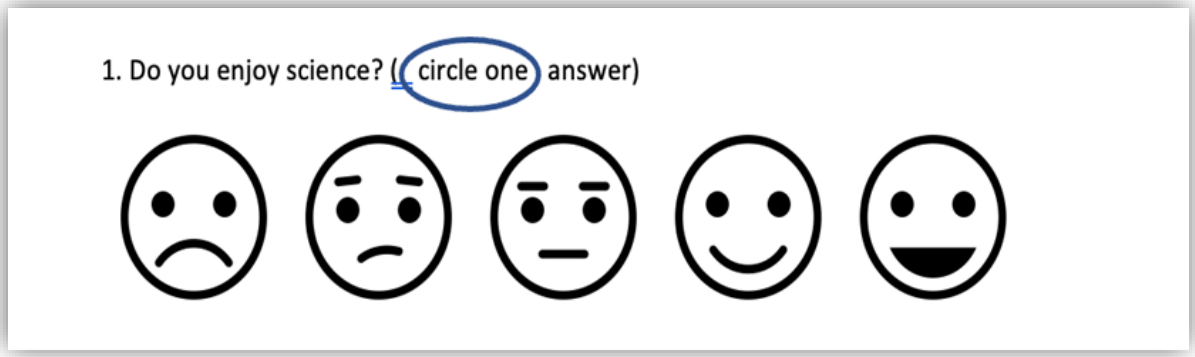
Session 4. Creating a wildflower meadow in the grounds of the school Using wildflowers seed provided by the university, students will create their own wild-flower meadows with help from the Pharmabees team. Once grown this meadow will attract a range of pollinators to the site for the children to explore. Such activities will allow the school, if they so wish to apply for recognition as a bee-friendly community http://www.biodiversitywales.org.uk/Bee-Friendly

2. Evaluation methods

Evaluation activities were completed by 550 children, from 22 primary schools in Eastern Cardiff, Aberfan, Llanelli and Blaenau Gwent. One was an independent fee-paying school, two were Welsh medium state primaries, and 19 were English medium state primary schools. Demographic information for each school is provided in appendix 1, and illustrates the diversity of this sample. The percentage of children eligible for free school meals varied between schools from 14 to 61%. Ethnic diversity also varied considerably, with the percentage of children from a black and minority ethnic (BAME) background ranging from 0 to 87%.

The impact of the program on pupils was assessed using surveys which were administered by class teachers before of the first session and following the final session. The survey consisted of six closed questions, with pupils answering on a five-point scale using faces to indicate agreement.

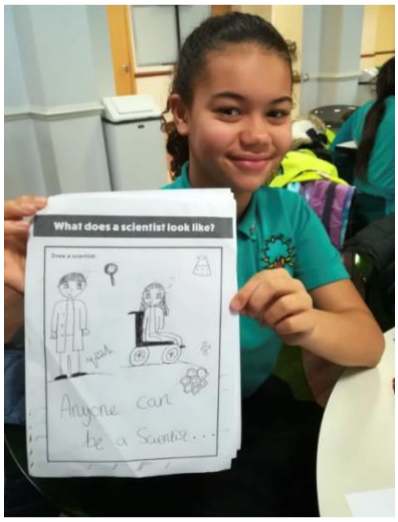
1) Do you think the environment is important?[1]
2) Do you enjoy science?
3) Do you think science is important to everyone?
4) Do you think people like you become scientists?
5) Do you talk to your friends about science?[2]
6) Would you like to be a scientist?



[1] This question was not asked in 2019
[2] Only used pre project in 2019, no post data

In 2019 only, the survey contained additional open-ended questions about career aspirations, perceptions of science and scientists, and antibiotic knowledge.

7) What would you like to be in the future?
8) What three words would you use to describe a scientist?
9) What is a scientist?
10) What are antibiotics?
11) Do you think you should take antibiotics every time you are sick?
12) Why are antibiotics important?



Teacher evaluation

An evaluation was conducted with participating teachers in 2019. Teachers completed surveys with a mix of closed and open-ended items both pre and post project. 9 pre and 6 post project responses were completed by teachers.

Statistical analysis

Sample size varied by item, as not all items were used consistently across pre and post surveys in all years. There was also a small amount of missing data where some children did not answer particular items. All statistical analyses were conducted in SPSS. Wordclouds were constructed in nVivo.

Where data are categorical, pre and post responses were compared using Pearson's chi square test. The five point Likert scale responses were treated as continuous data because of the large sample size. Pre and post project mean and SD were calculated. Individual children's pre and post project responses could not be linked, therefore pre and post project scores were compared using independent samples t-tests.

To examine which demographic factors predicted children's engagement, the same data were also analysed using a series of regression analyses (one for each item) to explore how these different factors interact. Time was entered as a dummy coded variable (0=pre project, 1=post). Before and after COVID was entered as a dummy coded variable (0= up to 2019, 1= 2022 onwards). The percentage of pupils in the school eligible for free school meals was entered as a dummy variable (0= less than 25% of pupils eligible for FSM; 1=25-40%; 2=more than 40%). The percentage of pupils in the school from a BAME background was entered as a dummy coded variable (0= less than 10%, 1=10 to 30%; 2= more than 30%). The WIMD ranking for the school postcode was dummy coded as (0=least deprived 50%; 1=30 to 50%; 2=20 to 30%; 3=10 to 20%; 4=10% most deprived). This corresponds to how the Welsh government groups LSOAs in terms of deprivation.

3. Evaluation results

Impact of the project on children's science engagement

Responses from the 2019, 2022, 2023 and 2024 cohorts were pooled. Raw data and descriptive statistics are reported in appendix 2. Figure 1 shows children's mean pre and post project responses. For all items, higher scores indicate greater agreement.

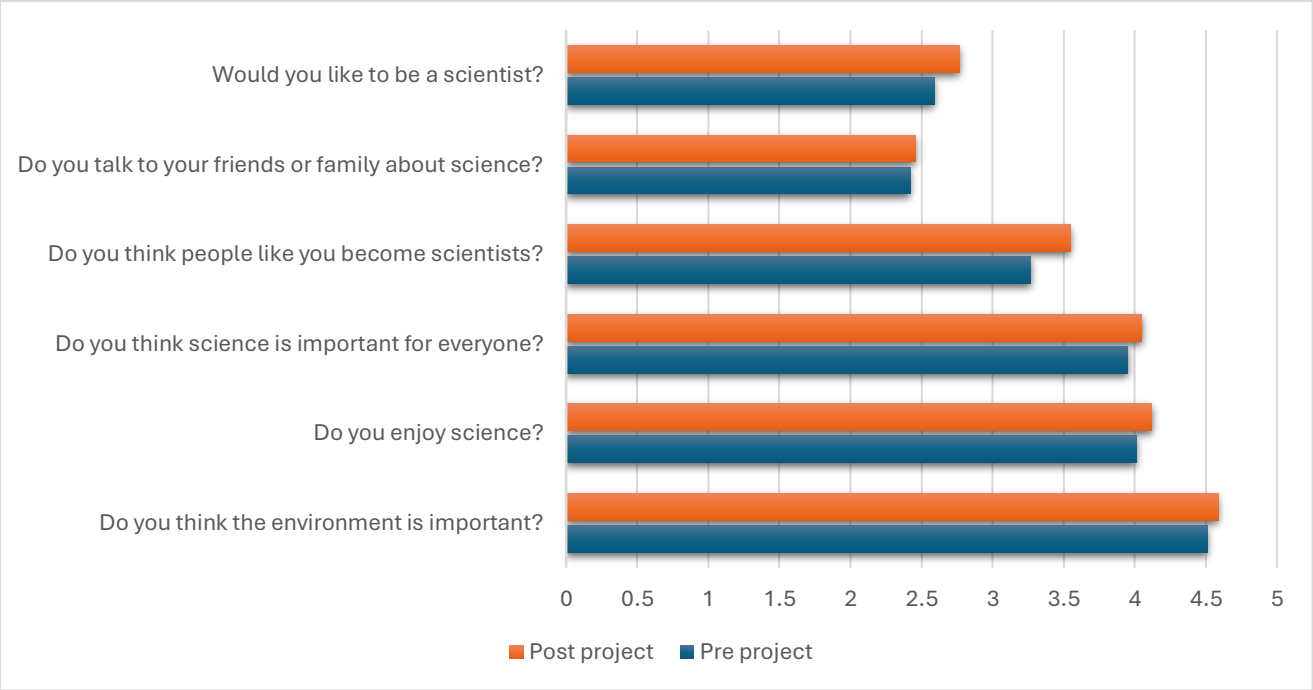


Figure 1. Children's mean pre and post project responses to science engagement items

Whilst mean scores were higher for all six items post project, not all of these differences were statistically significant, and effect sizes for all items were small.

Do you think the environment is important?

This item had the highest mean score, and almost 90% of children agreed or strongly agreed. There was no significant difference between pre and post project responses to this item. This may have been due to a ceiling effect as so many children had already given this item a maximum response.

Do you enjoy science?

Around three quarters of children agreed that they enjoyed science, and after taking part in the project, children reported enjoying science significantly more ($p=.047$).

Do you think science is important to everyone?

There was no significant difference in children's pre and post project responses to this item.

Do you think people like you become scientists?

Post project, children gave significantly more positive responses to this item ($p<.001$).

Do you talk to your family and friends about science?

This item had the lowest mean rating. There was no significant difference in children's pre and post project responses to this item.

Would you like to be a scientist?

Post project, children gave significantly more positive responses to this item ($p=.028$).

Demographic predictors of children's science engagement[3]

We wanted to explore whether economic disadvantage or ethnicity predicted children's levels of science engagement. As we did not have data for individual children, we used school level data to uncover broad trends.

Children attending schools with a greater proportion of black and minority ethnicity (BAME) children were more likely to agree that they enjoyed science; more likely to agree that people like them could become scientists; and more likely to agree that they would like to be a scientist.

Children attending schools in more deprived neighbourhoods[4] were less likely to agree that they would like to be a scientist; less likely to agree that science is important for everyone; less likely to agree that people like them could become scientists; and less likely to agree that that they talked to family or friends about science.

[3] Full regression output is reported in appendix 3.

[4] Determined by Welsh Index of Multiple Deprivation

Children's career aspiration

In 2019, children were asked an open question about their career aspirations *What would you like to be in the future?* Whilst some children left this blank, or said they did not know, others named 1, 2 or more possible careers. These careers were coded according to: whether scientist was specifically named; whether careers named involved STEM (Science, Technology, Engineering and Medicine; and also whether careers named required a university education. Children's coded responses are summarised in table 1 below.

Table 1. Summary of children's responses to the question "What would you like to be in the future?"

	Pre % (n= 265)	Post % (n=197)
A scientist	16.9	25.3
STEM career	39.1	41.6
Graduate career	45.6	45.2

Chi square tests were conducted to see whether there were significant differences between children's aspirations pre and post project. There was a significant increase in the proportion of children who specifically said they would like to be a scientist, from 17 to 25% (df=1, chi sq= 4.262, p=.039). However, there was no significant change in children aspiring towards either wider STEM careers (df=1, chi sq=.285, p=.593), or graduate careers (df=1, chi sq=.133, p=.715).

In their own words: Children's beliefs about science and scientists

This wordcloud was generated from children's responses to *What three words would you use to describe a scientist?*

These are some of the answers children gave to the question *What is a scientist?*

"A scientist discovers new things and explores."

"They make the world better."

"Someone who asks a question and finds the answers."

"A person who is up for a challenge."

"Someone who finds out something that other people don't know."

"Someone that can find out things that could save the world."

Impact of the project on children's knowledge about antibiotics

Children's open text responses to the questions *What are antibiotics?* and *Do you think you should take antibiotics every time you are sick?* are shown in appendix 4. Both before and after the project, most children answered that antibiotics were a type of medicine. Many also answered that antibiotics could make you better. Some children did not answer at all, or said they did not know. We also examined whether children's answers contained specific scientific concepts, such as the correct information that antibiotics kill bacteria, or the incorrect idea that antibiotics are painkillers. Figure 3 shows how these responses differed pre and post project.

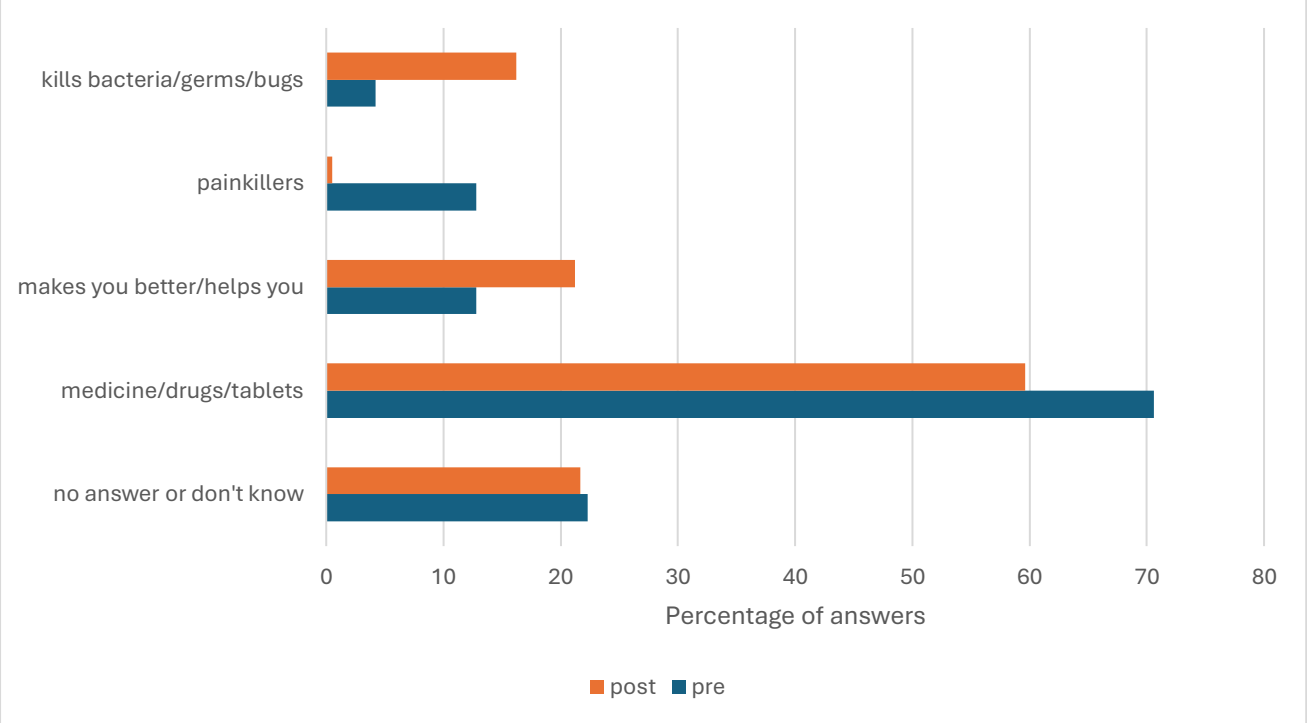


Figure 3. Children's pre and post project answers to "what are antibiotics?"

Chi square tests were conducted to determine whether there were significant differences between children's pre and post project answers. Before the project, a substantial minority of children wrongly believed that antibiotics were painkillers, but post project only a single child gave this answer. This difference was statistically significant (df=1, chi sq=24.51, p<.001). Before the project, only 4% of children correctly answered that antibiotics kill (or fight) bacteria (or germs/bugs); post project, four times as many children gave this information in their answer. This difference was statistically significant (df=1, chi sq=19.58, p<.001). For the question *Do you think you should take antibiotics every time you are sick?* there was no significant difference between the proportion of children answering correctly pre and post project (df=1, chi-square = 3.6469. p= .056).

Teacher evaluation

Only 9 pre and 6 post project responses were completed by teachers, meaning little analysis could be conducted on this data.

Two thirds of the primary teachers involved in the project told us did not have a background in science.

100% of teachers said the training session had improved their confidence level in teaching these lessons.

As part of the evaluation, teachers were also asked whether they would feel confident in teaching the sessions themselves, using stand-alone resources. Teachers' comments showed that they really valued the expert input from scientists, and felt that this added extra value in terms of providing diverse role models for children.

> *"I feel it would be very beneficial for kids in the area to meet and see a real scientist delivering the sessions in order to have a higher impact and hopefully inspire them for the future - high aspirations for life!"*

> *"I feel science coming from a scientist coming from a scientist is so valuable, I would not do the content justice."*

> *"I don't think you would replicate the high level of engagement without the contact at the university."*

> *"I feel it would be difficult to implement this project without support from the specialist. As teachers we receive lots of packs to download but often lack the confidence and time to implement them."*

Conclusions

Most of the 9- to 11-year-old children who took part told us that they enjoyed science, and there was an increase in children's positive attitudes to science and science careers following engagement with the Pharmabees program. Almost all children indicated that the environment was important to them, so this aspect of the project could be further enhanced for future cohorts.

We found an increase in the percentage of students who thought that people like them could become scientists, and also an increase in the percentage of students who named scientist as a future career option. However, this was a very specific effect, as the percentage of children naming wider STEM careers, or graduate careers did not change. Research has shown that career decisions are often shaped by family role models and by exposure of students to science rich experiences at school and home (Archer et al, 2020). The negative responses to the question *Do you talk to your friends or family about science?* suggests that many children lack science capital at home, and taking part in Pharmabees did not significantly change this. In future, finding ways to increase family involvement could be a positive step to address this issue and widen children's career aspirations.

Attending a school in a neighbourhood with low WIMD ranking was a predictor of lower science engagement, justifying targeting future school projects at schools in areas with low WIMD rankings. Interestingly, children attending schools with majority BAME students had greater science engagement and were more likely to aspire to science careers.

Taking part in the project also increased children's scientific knowledge about some specific aspects of antibiotics, although certain key messages may need to be more strongly reinforced.

Due to low numbers of completed teacher evaluations, it was not possible to perform any statistical analysis with the data, but teachers' comments in response to open text questions helped to shape the delivery of the project to future cohorts. Teachers valued the expert input of university staff, and felt that they would not be able to deliver the content so effectively without that support.

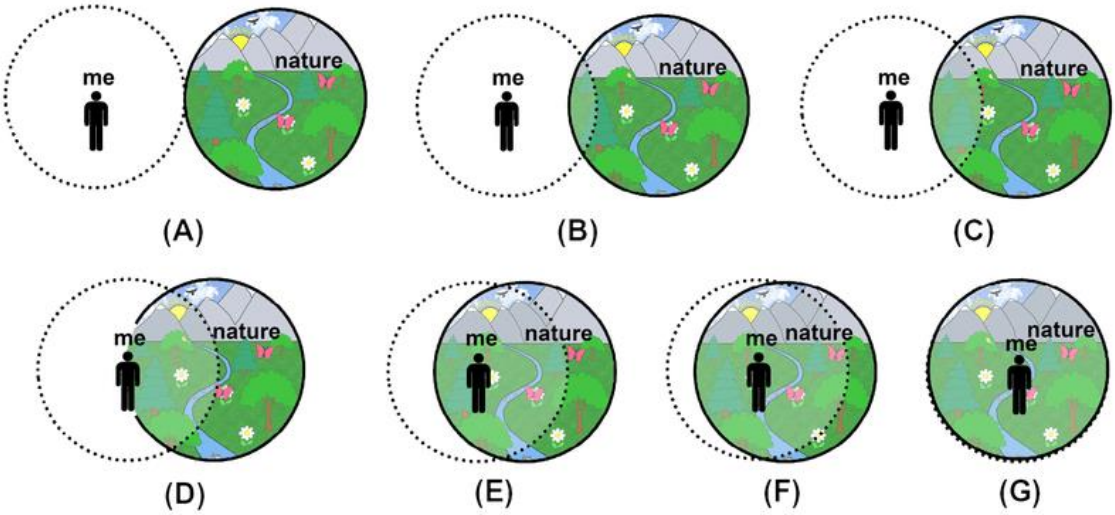
Suggestions for future evaluations

A limitation of this evaluation was that the individual pre and post responses could not be linked, as data collection was anonymous for ethical reasons. This limited how the data could be analysed, and the questions we could address. It would be particularly valuable to compare outcomes for those children with initially low science engagement, as that is where there is the most potential for impact. A possible method for collecting linked pre and post data whilst maintaining child anonymity in this situation is to staple pre and post surveys together, with an extra slip of paper in front for the child's name. Teachers can ask children to write their name when completing pre project surveys, then store until post project survey is completed. At this stage, the name slips can be removed before handing surveys over to researcher, leaving each individual's pre and post surveys stapled together (and therefore linkable for analysis) but ensuring children's anonymity.

It would be useful to ask children's gender on the survey, as that would allow an analysis of whether science engagement and project impact is the same for girls and boys. The ASPIRES study identified that science engagement and/or aspiration may vary for boys and girls (Archer et al, 2020). Individual ethnicity data would also be really valuable, but ethnicity is regarded as sensitive data so the ethics may be too complex. Asking children about parents' jobs would also be interesting and give scope for further analyses exploring the issue of science capital and aspiration.

A key evaluation question was whether the project increased children's engagement with nature or the environment? Looking at the responses to *Do you think the environment is important?* there is no evidence of any significant change. However, pre project responses to this item were so high that there is a ceiling effect making it unlikely that we would be able to detect any change.

A different possible item would be to measure nature connection using the single 'Illustrated Inclusion of Nature in Self' item (IINS, Kleespies et al, 2021). This consists of the statement 'choose the picture which best shows how close you feel to nature' plus either 5 or 7 pictures showing circles with various degrees of overlap. This measures the psychological construct of nature connection, and there are large datasets available for comparison.



Another possibility might be to ask specific questions about bees? See Portus et al (2025) for some ideas.

e.g. I do things that help bees.

I know how I can help bees.

Finally, it would be worthwhile to interview teachers to understand more about their feelings of efficacy for science teaching, and what they perceive to be the barriers to engaging children with science. Appendix 5 contains suggestions for interview/focus group questions to ask participating teachers in future.

References

Archer, L., Moote, J., MacLeod, E., Francis, B., & DeWitt, J. (2020). ASPIRES 2: Young people's science and career aspirations, age 10-19. London: UCL Institute of Education).

Kleespies, M. W., Braun, T., Dierkes, P. W., & Wenzel, V. (2021). Measuring Connection to Nature—A Illustrated Extension of the Inclusion of Nature in Self Scale. *Sustainability*, *13*(4), 1761. https://doi.org/10.3390/su13041761

Portus, R., Williams, S. J., Peklanska, E., Portus, R., & Walmsley, T. (2025). Buzzing about bees: exploring action-based storytelling as a tool for children's environmental engagement and agency. *Environmental Education Research*, 1–21. https://doi.org/10.1080/13504622.2025.2478430

Appendix 1. School level demographic information for participating schools 2019 to 2024

school	year	pre	post	% FSM	% BAME[5] ethnicity	WIMD[6] overall
Greenway	2019	25	24	61.1	43.9	455
St Mellons	2019	28	21	18.9	26.6	618
Pen Y Bryn	2019	29	26	47.5	30.9	618
Llandough	2019	28	16	16.1	41.4	1543
Bryn Hafod	2019	40	0	50.7	27.8	435
Cardiff Muslim	2019	34	33	n/a[7]		
St Monicas	2019	52	43	35	87.3	958
Trowbridge	2019	22	26	65.5	47.2	97
Ysgol Rhyd y Grug	2022	52[8]	52	13.8	0	34
Ynysowen	2022			26.9	7.2	967
Afon Taf	2022			20.6	1.0	596
Morfa	2023	22	22	47.1	11.1	553
Stebonheath	2023	15	15	40.3	15.2	810
Old Road	2023	7	7	35.5	26.3	499
Bryn Teg	2023	41	41	43.4	10.2	728
Pen Rhos	2023	24	24	46.9	19.8	396
Glanhowy	2024	19	19	31.7	3.6	1089
Bro Helyg	2024	19	19	19.7	0	138
Georgetown	2024	22	22	15.8	3.6	1183
St Illtyds	2024	21	21	29.7	8.2	250
St Josephs	2024	21	21	35.8	25.3	217
Sofrydd	2024	22	22	32.8	8.5	215
Wales average				**29.3**	**11.3**	

[5] The percentage of children eligible for free school meals indicates levels of disadvantage specifically in the families with children attending the school.

[6] The Welsh Index of Multiple Deprivation (WIMD) gives a ranking of every neighbourhood area in Wales, from 1 to 1909, with lower numbers meaning greater disadvantage in the neighbourhood where the school is located.

[7] No data available as it is an independent school, and pupils are assumed to be drawn from a wider geographical area.

[8] Data pooled for 3 schools.

Appendix 2. Children's responses and summary statistics for the six closed evaluation questions pre and post project

Q1 Do you think the environment is important?

	1 (not at all)	2	3	4	5 (definitely)
Pre (n=285)	2.5	2.5	5.6	20.7	68.8
Post (n=287)	0.7	2.4	4.9	21.6	70.4

Q2 Do you enjoy science?

	1 not at all	2	3	4	5 definitely
pre (n=541)	3.7	5.7	16.8	34.0	39.7
post (n=470)	3.8	4.3	13.8	32.8	45.7

Q3 Do you think science is important for everyone?

	1 (not at all)	2	3	4	5 (definitely)
Pre (n=542)	2.9	5.2	25.3	27.5	39.1
Post (n=472)	0.8	4.0	24.6	30.3	40.3

Q4 Do you think people like you become scientists?

	1 not at all	2	3	4	5 definitely
Pre (n=535)	11.2	14.6	28.8	26.5	18.9
Post (n=465)	7.1	12.0	26.5	26.9	27.5

Q5 Do you talk to family and friends about science?

	1 not at all	2	3	4	5 definitely
Pre (n=540)	36.1	16.9	17.6	16.1	13.3
Post (n=284)	36.6	20.8	17.3	10.9	14.4

Q6 Would you like to be a scientist?

	1 not at all	2	3	4	5 definitely
Pre (n=540)	36.3	17.0	17.2	10.7	18.7
Post (n=472)	31.4	15.0	19.1	14.8	19.7

Summary statistics for pre and post project responses

	Pre n	Pre mean (SD)	Post n	Post mean (SD)	P value	Effect size
Do you think the environment is important?	285	4.51 (.90)	285	4.59 (.76)	.123	-.097
Do you enjoy science?	540	4.01 (1.06)	470	4.12 (1.05)	.047	-.106
Do you think science is important for everyone?	542	3.95 (1.06)	471	4.05 (.94)	.051	-.102
Do you think people like you become scientists?	535	3.27 (1.24)	465	3.55 (1.22)	<.001	-.224
Do you talk to your friends or family about science?	285	2.42 (1.44)	285	2.46 (1.44)	.363	-.029
Would you like to be a scientist?	540	2.59 (1.52)	468	2.77 (1.51)	.028	-.121

Appendix 3. Regression output

I can’t find where I saved this, but I will locate it for the final version!

Appendix 4 Children's responses to antibiotics questions

Q10 What are antibiotics?

	Pre (n=265)	Post (n=197)
No response/don't know	59	43
Medicines/tablets/pills/drugs	187	117
Makes you better/helps you	34	42
Painkillers	34	1
Kills/fights bacteria/germs/bugs[9]	11	32

Q11 Do you think you should take antibiotics every time you are sick?

	Pre	Post	Total
Correct answer	173	145	318
No answer or incorrect answer	92	52	144
Total	265	197	462

NB. With the open text responses to this item, if a child said no, or no plus an explanation, they were considered to have given the correct answer. If they gave no answer, said they did not know the answer, or gave an incorrect answer, they were coded as not answering correctly.

[9] Excluded if they specifically said antibiotics kill viruses

Appendix 5 Suggested interview/focus group questions for teachers

What is your job role? (how long, what age children, school size and location)

Does your job involve teaching science?

What is your own background in science?

Do you enjoy teaching science?

Do you feel confident teaching science?

Do you think that there any difficulties to teaching science in primary schools?

What would help to overcome these issues?

Has the new curriculum made a difference to how you teach science?

Do the children in your class enjoy science?

What sort of career aspirations do children in your class have? Are they thinking about university?

Did COVID have an impact on engagement with science and career aspirations?

What worked well about the Pharmabees project? What didn't work so well? How could we improve?

Did taking part in Pharmabees make a difference to you as a teacher? Or to the children in your class?

Anything else you want to tell us?