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Experiences from a School–University Partnership Climate and Sustainability Education Project in England: The Value of Citizen Science and Practical STEM Approaches

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Abstract: Extracurricular citizen science and hands-on STEM (science, technology, engineering, and maths) projects can ensure that climate and sustainability education is not just superficial but truly transformative. Through working under the guidance of academic partners, young people can develop a deep appreciation for climate science and, most importantly, become aware of the real-world sustainable solutions being developed to address the consequences of our changing climate. We present the experiences of four stakeholders from one case study involving middle school students (9–13 years) and their teachers working on a climate change and sustainable drainage system (SuDS) project with academics from Newcastle University and the Schools Engagement programme of the Royal Society. We found that all stakeholders considered it to be a successful project with significant benefits, including engaging learning in the pupils, a challenge for the teachers, and meaningful data collection for the academic team. The funding organisation thought the positive interactions that they try to encourage between students and STEM partners were evidenced in this project perfectly. Young people are future decision makers; this type of project can enable them to develop essential skills and an understanding of a range of STEM careers. Subsequent developments may include refining the way similar projects are run.

Keywords: education; extracurricular; climate; sustainability; STEM; SuDS; drainage; engagement

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1. Introduction

The United Nations Decade of Education for Sustainable Development (2005–2014) sought to mobilise the educational resources of the world to help create a more sustainable future [1]. The executive summary stated, "there is now an increased recognition at the international policy level that education is essential to the advancement of sustainable development, with many countries committed to continuing to work to advance education for sustainable development at the national and local levels". Somewhat ironically for the United Kingdom, the release of the report was just after the Department of Education issued a new curriculum for England [2] that largely overlooks the climate crisis and fails to promote an understanding of what it means to live sustainably. Glackin and King [3] suggested that with no national or local directive, environmental education across secondary schools was patchy and restricted.

More recently, the UK Government Department of Education issued a strategy for sustainability and climate change that included no change to the curriculum [4]. Dunlop

and Rushton [5] provided a critical discourse analysis of this new strategy alongside the perspectives of young people, teachers, and teacher educators in relation to education for environmental sustainability. They found that the strategy fails to reorientate education towards climate change amelioration or the reversal of environmental degradation. In addition, they suggested that although STEM is key, more scientific knowledge is not the sole solution to young people's legitimate worries about the climate crisis, and there is an existing evidence base suggesting that educators and young people really need the inclusion of social justice and participation in social action in education on sustainability and climate change [6,7]. Significantly, through taking real climate action in their own settings, children can enjoy themselves and develop a stronger belief in their power to control their own goals and actions [8].

Kubisch et al. [9] acknowledged young people's roles as present and future decision-makers; they stated that their engagement is absolutely imperative in order to achieve Sustainable Development Goal 13, 'Climate Action'. A good STEM education seems critical to helping students understand the need for climate action and sustainable development. Using sustainability contexts for STEM activities can provoke critical discourse within schools and their wider communities, thereby creating new opportunities for education on sustainable development [10]. Furthermore, Greer et al. [11] suggested that optimal pathways for progress include orienting STEM skills, education, and research towards climate change mitigation. Hence, new methods of teaching and learning are necessary, and they must encourage transformative learning, which lays the foundations for transformative engagement. The global challenges young people face require a revolutionary shift in thinking and mindset on the part of teachers and students [12], and there is an urgent need to identify new roles in STEM education that will prepare students for this post-normal world as well as the problem-solving and creative mindset it requires.

There has already been real success in education on sustainability using citizen science. This is the practice of public participation and collaboration in scientific research to increase scientific knowledge. It can have a huge impact as it both enables students to become student-researchers and allows academics to gather meaningful data. Specific learning objectives are generally utilised by educators to integrate citizen science projects into curricula in formal learning environments, particularly when teaching children and adolescents at the primary and post-primary levels [13]. Citizen science has the potential to support children's learning and their understanding of science, while at the same time encouraging them to protect the environment [14,15]. Citizen science may also help us to achieve the UN Sustainable Development Goals [16], and there is a growing consensus that citizen science is a promising field for educational practices and research [17,18].

Although many educational researchers [13,19,20] recognise that developing and implementing public data-collection projects that yield both scientific and educational outcomes requires significant effort, they also suggest that citizen science in the classroom can instil community awareness, critical-thinking, problem-solving, and practical experience in students. Inquiry-based science education through citizen-science projects can be designed to nurture independence, persistence, creativity, and determination in the minds of young students to prepare them to solve community problems using a systematic approach. Rather than incorporating citizen science into content-heavy lessons, it is extracurricular settings that can provide the space to implement education for sustainable development that is relevant, interdisciplinary, and includes student decision making [21].

With several stakeholders in most citizen science projects, this case study provides a valuable opportunity to perform a 'deep dive' into one case study to understand the context, the value of extracurricular citizen science research, the benefits of a hands-on STEM investigation, and the perspectives of the four main participants: the students, teachers, academic partners, and funding organisation. The questions we consider are the following: how do different stakeholders view this citizen science and hands-on STEM project? Additionally, are there lessons that can be learned to ensure that future sustainability research projects are optimised?

2. Context

Corbridge Middle School (CMS), where the project was based, is a state-funded middle school (pupils aged 9–13 years) in Northumberland, situated in a relatively rural location a few miles away from the city of Newcastle, in North East England. As part of the education students receive, the school has a strong background in STEM enrichment. The project was initiated in 2019 as a cross-curricular collaboration between the science and geography departments. The science and geography teachers worked together to set up a Weather and Climate Club open to all students and applied for funding from the Royal Society Partnership Grant scheme.

The Partnership Grant scheme funds schools and colleges in the United Kingdom up to GBP 3000 to run investigative STEM projects in partnership with STEM professionals from academia or industry. The aim is for students to gain experience and understanding of the scientific process through participation in practical, investigative science projects. Teachers can facilitate students in developing the skills and confidence needed to solve complex challenges by providing them with opportunities to collaborate with academics and complete meaningful citizen science. The scheme is one of the best school programs available for doing just this by enabling young people to become "Tomorrow's climate scientists" and to develop the STEM skills they will need in the future [22].

CMS received a partnership grant to work collaboratively with Newcastle University. This funding was used to purchase a Davis Vantage Pro weather station shortly before schools transferred to mainly online learning during the pandemic. The teachers managed to sustain the project and around forty students from Year 5 to Year 8 have been involved to date, with eight students developing and leading an additional STEM research project for around 90 min each week. For comparison, the amount of time students spend on science in the CMS curriculum is approximately three hours per week and one hour a week for geography.

The academic partners are based in Newcastle University's School of Engineering and the Tyndall Centre for Climate Change Research. They are experts on climate and weather extremes, computational hydrology, and SuDS who investigate how the characteristics of heavy rainfall events change with the climate. The researchers are interested in the use of school-based weather stations for collecting data, an approach that has been trialled previously with mixed results and participation rates [23,24]. The researchers aim to determine effective and sustainable ways to increase the number of weather stations around the country, particularly in ungauged or data-sparse locations. By doing so, they hope to obtain useful and meaningful rainfall data, for example, on sudden concentrated downpours due to convective rainfall, which can result in localised flooding [25].

3. Method

This research reports on findings from a case study of one school's extra-curricular Weather and Climate Club from Year 5 to Year 8, which drew on a citizen science approach, with students working with academics from Newcastle University and conducting a hands-on STEM research project in the school's science laboratory. Case studies are an important qualitative strategy and a tradition in educational research. This is considered a robust research method, particularly in providing holistic, reflective, and in-depth explanations for social questions, issues, and concerns [26]. As part of a case study on research, Creswell (2013, p. 296) highlighted the value of a clear theoretical lens in that it "...becomes an advocacy perspective that shapes the types of questions asked, informs how data are collected and analysed, and provides a call for action or change." This case study is situated in a framework of inquiry-based learning (IBL), which includes citizen science projects. In the context of this case study, on the Weather and Climate Club, IBL is a research approach to learning in which students engage in posing research questions, collecting and analysing data, and identifying, evaluating, and disseminating their findings [27]. IBL is a student-centred approach to learning that draws on authentic or real-world contexts to ensure that learning is meaningful and relevant for students and teachers—features which have

been shown to be effective in the context of sustainability and climate change educational strategies [28].

Our approach to data collection was rooted in practitioner-based enquiry, where through critical reflection and engagement within and across education systems, new understandings and insights are developed [29]. Through the dual role that author one held as a practitioner (teacher) and researcher leading this practice-based enquiry, and through working collaboratively with both students and adults in varied roles and fields of expertise across the project, this research aimed to better understand the practice of citizen science projects in schools in the context of climate change and sustainability education. Data collection with young people was pragmatic and usually took place as part of regular meetings of the Weather and Climate Club, and data reported were predominantly developed during the course of conversations and discussions with the adults and children who participated in the projects. As such, there are no fixed interview schedules, recordings, or transcripts. Nevertheless, we contend that the reflections reported here are valid and useful sources of information regarding the experience and value of this approach in school-based sustainability and climate change education. Other data reported are the reflections of teachers and other adult partners. These were generated over the course of the project through conversations and individual reflections. In a final phase of critical reflections, the perspectives and ideas of the adult partners were developed through the co-authorship of this article, which involved multiple phases of drafting that provided further opportunities to clarify and crystallize research insights.

3.1. Citizen Science Research

During Phase 1 of the project, students asked, "can a school-based weather station provide accurate and useful data?" The Newcastle University team visited our Weather and Climate Club to run workshops on using virtual reality to demonstrate the effects of heavy rainfall and how urban design can be used to soak up rainwater. Paul Mooney, the Weather Team Leader for BBC in the North East, also came to school to answer our questions on meteorology and climate change. Two weather stations were installed at the school under the supervision of the Newcastle University researchers (one Davis Vantage Pro with the grant funding and one Netatmo weather station funded by the PTA). The weather stations have now been collecting data for over three years. Comparisons with data available from the nearest official rain gauge were made to determine the quality of data obtained via the weather stations. The data collected from our weather station is set to automatically upload to www.weatherlink.com (accessed on 6 June 2023).

3.2. Hands-On STEM Research

Following success in Phase 1, the school received further funding from the Royal Society to extend the project to Phase 2 to focus on adaptations to heavy rainfall events as these have caused localised flooding in the Tyne Valley. This phase of the project involved a hands-on STEM investigation of sustainable drainage systems (SuDS); the Year 7 students asked the question "Can we model how SuDS work in the lab?". They helped design and create a model of semi-detached houses with one side having no SuDS features and the other side having a pond, waterbutt, green roof, permeable paving, and swales to investigate how to slow down surface runoff and, therefore, mitigate flooding. The students worked scientifically to make predictions, identify variables, write reproducible methods, collect data, draw conclusions, and evaluate their investigation. Although the data collected in this phase might not be used by the university partners, a hands-on approach to understanding how effective SuDS features can be was not only very effective in aiding understanding but also highly enjoyable.

Over the course of the project, the teachers expanded the network to include representatives of the local Tyne River Trust and other members of the wider community. As part of a desire to take meaningful climate action during the project, the pupils planted trees and helped develop a rain garden on the school grounds.

To see larger-scale SuDS in action, the Weather and Climate Club visited the UKCRIC National Green Infrastructure Facility (NGIF) at Newcastle University, an outdoor 'living lab' with fully functional and experimental SuDS features. The students also took a trip to a new housing estate and took a tour of the SuDS water reservoir, which collects runoff underground. The report completed by club members on their STEM research gained them a Bronze CREST Award as a tangible recognition of their success. In one of the final stages, we recorded a film of the project in December 2023 that was funded by an additional filming grant from the Royal Society.

The timeline of the project is given in Figure 1. Table 1 presents the stakeholders involved in the project.

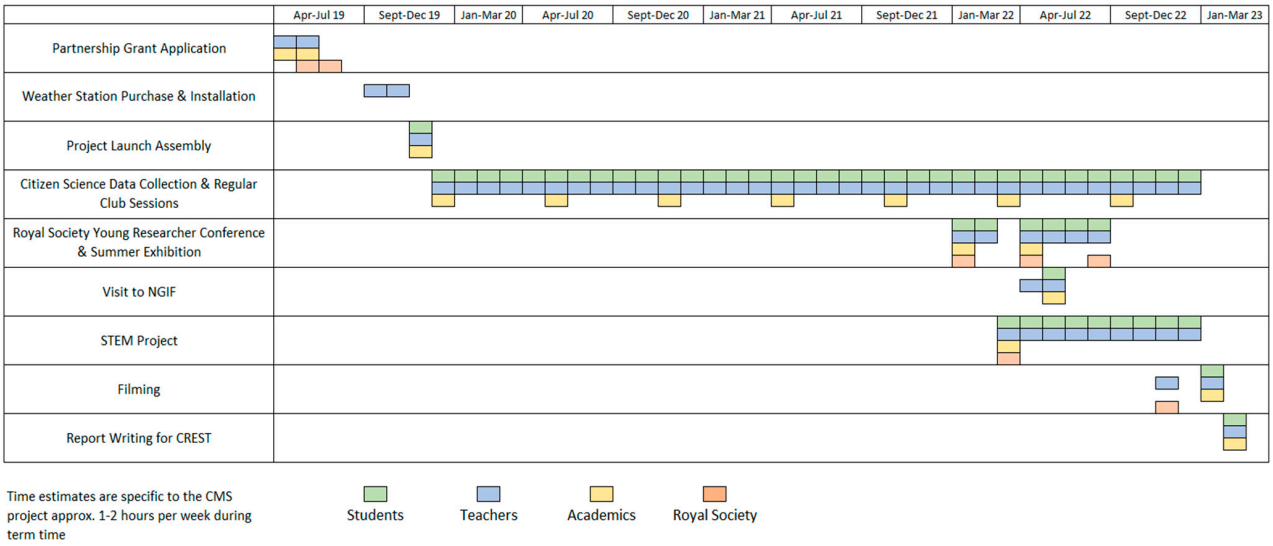

Figure 1. Timeline for the CMS project (timings are approximate).

Table 1. Stakeholder groups, the number of people involved, and a description.

Stakeholder	Number of People	Description
Students at CMS	8	Year 7 and Year 8 students, who committed the most time on the project and worked on the STEM research with the SuDS model, dedicated 1–2 h to the project each week.
	40	Year 5 to 8 students, who have been involved in the project between 2019 and 2023, dedicated 0.5 h to the citizen science project each week, but not all of them stayed for the duration of the project.
School Staff at CMS	2	Lead teachers (the subject leader for science and the subject leader for geography) dedicated 1–2 h to the project each week.
	2	The office administrator for funding/grant management and the caretaker for the installation of equipment dedicated 1–2 h to the project on an ad hoc basis but never more than an hour or so per month.
Academic Staff at Newcastle University	4	Two PhD researchers, one lecturer/deputy director of research and innovation, and one professor of climate change impacts dedicated 1–2 h to the project on an ad hoc basis but never more than an hour or so per month.
Royal Society Schools Engagement Team	3	Schools Engagement manager and officers dedicated 1–2 h to the project on an ad hoc basis but never more than an hour or so per month.

3.3. Ethical Considerations

For this article, the lead author invited contributions from the adult partners in this citizen science project, including teachers and academics from the University of Newcastle and the Royal Society Partnership Grants scheme. Through the co-authorship of this article, all authors read and commented on the contributions from across the team. It is important to note that the authors' contributions to this article are entirely voluntary and the work reflects the professional ethics and norms within the teaching profession, rather than a university-based ethical review board. However, this work is consistent with and informed by the principles outlined in BERA's (British Educational Research Association) guidelines [30]. At the outset of the project, permission was obtained from CMS leadership to establish and implement the project. Prior to their participation in the project, written parental consent was obtained for all young people to engage in project activities, including visits, lunchtime project meetings and permission to take and publish photographs of children engaged in the project, including for this paper. Throughout the project, children were reminded that their participation was voluntary and unconnected to assessment or any other value judgements. By the time of publication of this article, all the students involved in this study will have left the school.

The authors are aware of the study limitations. This is a single case study of a school that has relatively significant parent engagement and a supportive school leadership team, so it is perhaps not representative of schools across England. Additionally, there was no intentional collection of young researcher perspectives via recorded dialogue or a questionnaire, but rather a series of discussions with members of the Weather and Climate Club during regular lunchtime sessions and other project activities, such as visits. As we have noted at the outset, this approach of practitioner-based enquiry has clear affordances in that it is rooted in long-standing and trusting partnerships between teachers, students, and the wider school community, which enables different insights to be drawn than those of a researcher who is new to the context and only present for a short period of time.

4. Findings and Discussion

4.1. The Teachers' Perspective

From the chalkface, the teachers involved in this case study feel that teaching to the current national curriculum does not adequately prepare children for life on our rapidly-changing planet. Incredible educational experiences are possible within lessons, but it is the time and freedom allowed in extracurricular activities that can really make learning meaningful and engaging. The teachers were motivated to participate in a citizen science project in response to a desire for students to contribute to research that could provide data to understand real-world challenges. Providing students with opportunities to work alongside academics and present their work through science communication has brought the teachers involved huge levels of satisfaction as educators in the wider context. Running the Weather and Climate club has also strengthened collaboration between the science and geography departments in the school. Both the science and geography curricula encourage opportunities to collect data, yet it is much more meaningful if the data collected is for citizen science and academic research.

The eight students who decided to complete the citizen science and then dedicate further time to the STEM activities were all girls. They seemed to really enjoy the competitive aspect of the project and any external reward motivation (i.e., trips to London or gaining award certificates). Using the digital interface of the weather station has helped the club members improve their scientific skills as they learned how to ask questions, manipulate data, draw conclusions, and collaborate with the academic partners. Both the weather station and SuDS model continue to be used within lessons and the school has new starters in the Year 6 Weather and Climate Club with 10 new student members, equally split between both female and males.

The teachers in this project found their experiences to be consistent with those of research-active science teachers identified by Rushton and Reiss [31]. Through participation

in research projects, teachers developed a multi-faceted sense of professional identity that includes the roles of teacher, scientist/researcher, mentor, and coach. Being a research-active teacher enables the development of a complex professional network that has a positive impact on the teacher: a sense of professional worth and self-belief. The teachers in this project similarly found that, although the project took up time that was often unremunerated, there was a real sense of doing something worthwhile compared to the day-to-day teaching of a curriculum that has very limited relevance to the climate crisis. The project provided the teachers themselves with stretch and challenge, which aided their professional development and allowed them to provide students with an experience that was relevant to the issues they will face. Both teachers included the project in their departmental action plans and personal appraisals.

Teachers aim to bring out the best in their students to allow them to reach their full potential. The young scientists in this project have gained confidence and a real-world understanding of the importance of scientific research to solve issues such as those posed by climate change. One of the teachers involved in this case study suggested that the experience of watching the students develop confidence and skills through the course of the project had been 'joyful.' An aspect that possibly allowed this project to be particularly successful was that it was conducted in a middle school, where there may be more flexibility in the KS2 and KS3 curricula and young people start to decide on their future careers. Extra-curricular STEM enrichment in KS4 may not be as effective, as students have already made their option choices for subjects to be taken in examinations and the paths available to them become more limited.

Transformative learning can be understood as involving deep learning that is coupled with changes in behaviour [32], and the teachers in this study identified barriers to providing such opportunities for pupils. To ensure success, teachers dedicated many unpaid hours to the project that were not part of their usual job description. Time was spent on completing the funding application, project management, maintaining clear communication between the different stakeholders, purchasing equipment, arranging for equipment to be installed, running the lunchtime sessions, supporting the students, arranging visits, completing risk assessments, and report writing. None of these were onerous, but they were needed for the project to run smoothly. In addition, the teachers organised a three-day trip to London so that members of the club could present their project at the Young Researcher Zone of the Royal Society Summer Exhibition, which formed one of the highlights of their experiences. The Schools Engagement team of the Royal Society provided training in science communication for the students and covered all financial costs for the entire project.

Howard-Jones et al. [7] found teachers are constrained by under-resourcing and, to a lesser extent, by a lack of support from their schools but are, otherwise, ready and willing to move forward with radical, action-oriented climate change educational programmes that can help drive change rather than just respond to it. A supportive senior leadership team is essential, yet really embedding climate and sustainability citizen science projects in all schools would require a huge coordination effort from the Department of Education.

4.2. The Students' Perspective

As part of their science and geography lessons in school, students learn about the causes and consequences of climate change. They also gain a basic understanding of what can be done to mitigate and adapt to these changes on a global level. However, through attending the extra-curricular club over the past couple of years, the club members now understand why sudden downpours are increasing in number and intensity and that data from their weather station has been helping scientists to unpick the data we need to make predictions for the future.

Through a project review discussion with their science teacher, the Weather and Climate club members stated they have developed an appreciation that "STEM can help solve real world problems" and "improved their ability to analyse information, evaluate

designs and propose creative solutions". In addition, they were "pushed and challenged but never beyond our comfort zone," such as when they engaged in science communication at the Royal Society Summer Exhibition, talking to hundreds of members of the public and several fellows of the society and using their model to promote dialogue on climate and sustainability. The students found going to see the academic staff at the university "really inspiring" and were delighted to have all their questions answered. They were delighted to hear back from one of the researchers, who said, "For such young scientists, their understanding of these relatively complex systems was impressive."

All the members of the club stated they would be "more likely to become a scientist or engineer" in the future and all of them declared they would be "100% behind doing the project again". One of the parts of the project they gained the most from was "planting trees and making a rain garden to take our own climate action". They loved the range of different sessions throughout the project. It was "never boring like some lessons". They also enjoyed aspects of autonomy, as they decided on the direction they wanted their research to take with guidance from their teachers and academic partners. They developed their "working scientifically" skills through the practical STEM activity and found it hilarious when they repeatedly caused minor flooding in the teacher's laboratory (Figure 2).

Figure 2. Using the SuDS model in the laboratory.

The students found the most challenging aspects were to "work together as a team, listening to each other and not arguing" and that "checking through the weather station data made my head hurt".

Since they completed the STEM investigation, members of the club have identified that they would also like to study the effect of rainfall on soils, which can lead to soil erosion, and they aim to compare our rainfall data to the height of local rivers in more detail to see what the lag times are from rain falling to river rising. They do not want the project to stop, even though they are coming to the end of their time at CMS. One student said it has been an "exciting and memorable adventure".

The project has also had wider impacts on other students, such as promoting an understanding of sustainable development, alongside a sense of global citizenship and social justice as the club shared their understanding of climate change with the whole

school by running a Mock COP26 event for all students. In the discussions, it became clear that the students appreciate the wide range of careers that will be available to them that could ameliorate the issues they face from the changing climate, from civil engineering and land management to ecology and hydrology.

Using a panel of young people, Rushton and Dunlop [33] identified that experiential approaches are ideal for climate and sustainability education. The youth voice identified that "Teachers should be role models for us to follow. If they're helping, it will encourage students to help too". In addition, "Teachers should also provide opportunities for people to take action and promote taking action."

4.3. The Academic Partners' Perspective

Working with CMS provided an opportunity for the academic partners to establish what works well with engagement projects relating to the hosting of weather stations. The research focus was on extreme rainfall and the use of automated observation collection, which facilitates the generation of high temporal resolution data (as opposed to manual rain gauges that record daily rainfall). The team approached over 40 schools offering to implement activities and support funding applications; however, CMS was the only active participant. It is likely that this was heavily influenced by the sudden impact of COVID-19 during the inception phase of the project in February/March 2020, but there was also a degree of commitment by staff at Corbridge not noted at other schools. The presence of staff already personally and professionally engaged in learning about climate change, including having status as a UN accredited climate change teacher, resulted in participation not seen elsewhere. We were unable to determine whether this is a result of priorities or a degree of confidence in the subject area.

The data generated by weather stations at the school were of good quality, in agreement with previous research [34]. Figure 3 shows the correlation between data generated by the school weather stations (Davis and Netatmo) with observations from an official monitoring station at Maften, approximately 1 km from the school.

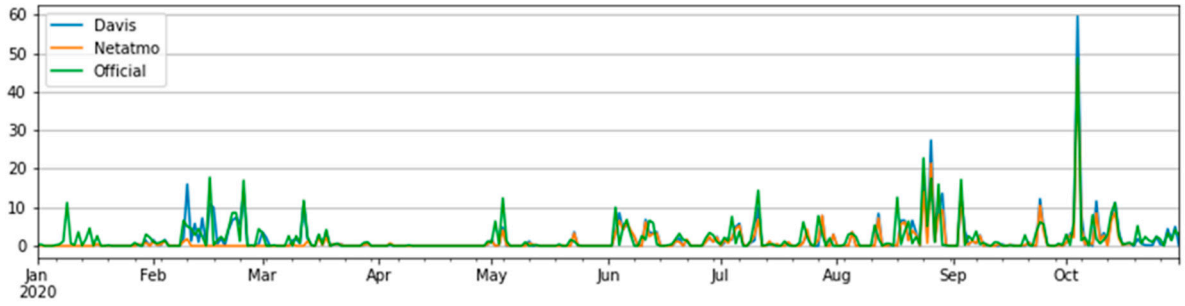

Figure 3. Daily rainfall from gauges at Corbridge Middle School and Maften (official monitoring station) for 2020.

Figure 3 shows that, during the earlier part of the year 2020, the observations from the Netatmo station were inconsistent with the Davis and Maften gauges, which was due to the weather station having been placed on a roof out of harm's way, but subsequently falling over. Once this was rectified in April 2020, the correlation between the observations improved.

A Pearson correlation of 0.84 was calculated over 2020 between both school-based weather stations and the official rain gauge, and a correlation of 0.98 was calculated between the Davis and Netatmo weather stations, demonstrating the close correlations between observations from the three stations. The difficulties in finding a suitable location for a weather station on school grounds are noted, and although the cost of the Netatmo station was significantly lower than that of the Davis station (circa £150 versus £500), the more robust design of the Davis station makes it better suited to the typical school environment.

The findings from working with CMS confirmed that it is possible to obtain reliable rainfall observations from weather stations located on school grounds, and they have enabled us to develop our engagement activities for the future. The work with the school has highlighted the temporary or cyclical nature of participation due to curriculum constraints, and we would not approach schools to be long-term weather observers; however, this could be an activity repeated year after year to introduce climate change and extreme weather concepts via experiential learning. Use of the weather station continues in the school and has been included as part of the curriculum in geography planning for the Year 6 students, who continue to look at "Extreme Weather" events and the impact of heavy rainfall on their school grounds and runoff into the River Tyne.

4.4. The Grant Providers' Perspective

The Tomorrow's Climate Scientists scheme, which sits within the Royal Society's Partnership Grants scheme, was borne out of our observations of children and young people marching past the society's windows on the Mall in London during a school strike for climate—there was a collective sense of wanting to support these youngsters to address the challenges of climate change themselves. You could sense the passion and urgency coming from these young people and their frustrations with the seeming lack of action. The scheme supports young people to put themselves in the midst of an identified problem to try and find a solution. Sometimes they find one and sometimes they do not; but along the way, they experience the realities of working as a scientist—it is not always fun, bells, and whistles, but they are certainly challenged. This is something that is referenced by Bianchi et al. [35], who identified 10 problems with how children learn science in primary school. The curriculum does not easily accommodate open-ended investigations, independent thinking, or the challenge of what to do when it all goes wrong. Whilst the students in this case study were not primary school aged, they were still fairly young and needed the opportunity to see how science is relevant to their own lives. You can see the benefits of them taking the research in their own direction and developing their ideas as they progress in this sustained project.

The main feature of the scheme, and this is evidenced perfectly here, is the interaction between the students and the STEM partner. As part of the application and review process, the Partnership Grants Allocating Panel insists on sustained partnerships between schools and academics (or schools and industry partners). This is not always easy to develop, and whilst we receive many queries from teachers worried that they cannot a find a partner, it is interesting to note that the partners here were rejected by 40 schools—certainly the pandemic did not help, but curriculum restraints and the pressures teachers face are preventing many from taking this crucial step to engage. When we start to consider new and emerging technologies, it is essential that schools use the expertise of their partners to support their students in developing key skills and knowledge. Anecdotally, we see that the benefits are not one-sided, with academics frequently stating that they have developed their own communication skills and gone on to other outreach activities after being involved in the scheme. In this case, the partners have used the evidence from the project to develop their own engagement activities.

The feature that really stands out in this project is the cross-curricular learning opportunity, enabling the youngsters to see transferable skills from geography and science and how their mathematical skills are required to handle the data they collected. The scheme is designed to enable young people to get involved in science at an entry point that is right for them—whether that is researching, experimenting, designing, building, number crunching, analysing, communicating, or filming. Multiple groups of young people have come together and worked on an issue that has meaning for them and their community, giving them confidence and skills for their future careers.

5. Final Reflections

From their lessons and what they glean from life in general, students in UK schools are becoming increasingly aware of climate change and biodiversity loss, but they are often not given the chance to be involved with meaningful citizen science or to take their own form of climate action or biodiversity protection. Participation in climate or biodiversity research projects can develop students' sense of agency in the context of global challenges, including students who are not already active in pro-environmental groups or activities [36]. A study by Heiss et al. [37] on citizen science in schools suggests that a future direction for implementing citizen science would be to implement curriculum-based citizen science projects, which, by definition, require the participation of the whole class. Ideally then, students in all schools would have the opportunity to conduct citizen science projects within their schools during lesson time.

However, this is not an ideal world and the curriculum for England feels outdated and in real need of a change in direction to ensure young people have the understanding and skills to live sustainably and thrive on our changing planet. In the teachers' experience, running this type of project through an extracurricular club ensures that, at the very least, the students involved are all enthusiastic about taking part. To ensure success, the lead teachers need to be willing to commit to the project, and in this case study, they found the experience to be time consuming yet highly rewarding. It is also essential that the senior leadership team is supportive by providing additional free time, cover, and administrative assistance to make running collaborative projects feasible.

Any citizen science project to promote sustainability must have encouraging and considerate academic partners; if possible, they should be from a local university so that face-to-face meetings or visits can be coordinated. Working with young people can be a challenge; they have a lot of questions, often a short attention span, and a lack of experience in working as scientists, so data manipulation, avoiding errors, or even just handling equipment may need responsible adults involved to demonstrate patience and maintain a sense of humour. The academic partners in this case worked incredibly well with the students.

Citizen science projects with an environmental and ecological focus allow large amounts of climate or biodiversity data to be collected across the country. This is potentially of huge benefit to the academic community, especially in climate and sustainability research that monitors environmental change. In addition to funding, the support provided by organisations, such as the Royal Society, can be critical for attracting academic or industrial partners to work collaboratively on projects with the students.

Finally, in state-funded UK schools, expendable financial resources for STEM enrichment to promote sustainability are often not available. However, there are many organisations in the United Kingdom that promote and fund citizen science or STEM projects; teachers just need to become aware of the opportunities and be given the time to apply (for example, via www.stem.org.uk/ as accessed on 6 June 2023).

6. Conclusions

We have considered the views of four stakeholder groups in a case study on a school–university partnership climate and sustainability education project involving citizen science and practical STEM activities. All of those involved—the teachers, students, academics, and funding providers—have very positive views on the project, and there have been huge benefits, both tangible and abstract, to all involved. The project enabled pupils to develop a real understanding of the value of climate data collection and analysis but also of how the data can be used to encourage sustainable development; with global warming resulting in heavier rainfall, we need to redesign our built environment.

The teachers enjoyed the challenge and experiences that the project provided. In terms of continuing professional development (CPD), it has stretched and challenged them but promoted a sense of job satisfaction that day-to-day teaching of the curriculum

cannot provide. The project has also had a positive effect on the school's profile, which has delighted the head teacher.

From studying the weather and climate and the solutions that SuDS provides, the students have become more enthusiastic about pursuing a STEM career and have developed skills that make them more attractive to future employers. They have also found learning to be an "exciting and memorable adventure". They undoubtedly gained self-confidence through the course of the project but also found taking their own climate action, such as planting trees or through science communication, hugely rewarding. One limitation was that there was no intentional collection of young researcher perspectives via recorded dialogue or a questionnaire to produce high-quality quantitative data that could be used to evaluate the efficacy and effectiveness of the program; this could be an area of future development.

Within this study, the university researchers have found that the scientific data collected are of real value to the academic community and will help lead to a better understanding of localised storm events. In addition, the funding body, the Royal Society, has achieved its aim for the Partnership Grant scheme to promote collaboration between schools and academia alongside increasing the confidence and skills of young people in their future careers.

Education for sustainable development may not yet be covered in detail in the curriculum in England, but there are opportunities through extracurricular hands-on STEM projects and citizen science research that can make learning relevant for young people in a rapidly changing world. Clear communication between the stakeholders, and their wider networks, is probably the most important factor in ensuring the project's success. There is no doubt that running citizen science projects in schools has its challenges, but it can also ensure that climate and sustainability education is truly transformative and leads to real world action. In this case study, all stakeholders agreed that the benefits of the project far outweighed any issues and demonstrated that teacher-researchers and student-researchers can make significant contributions to the scientific and wider communities.

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References

1. UNESCO. *Shaping the Future We Want: UN Decade of Education for Sustainable Development*; Final Report; UNESCO: Paris, France, 2014; p. 201; ISBN 978-92-3-100053-9.
2. Department for Education National Curriculum for England. 2013. Available online: https://www.gov.uk/government/collections/national-curriculum (accessed on 6 June 2023).
3. Glackin, M.A.; King, H. *Understanding Environmental Education in Secondary Schools in England: Report 1: Perspectives from Policy*; King's College London: London, UK, 2018.
4. Department for Education. The Department for Education's Strategy for Sustainability and Climate Change for the Education and Children's Services Systems. 2022. Available online: https://www.gov.uk/government/publications/sustainability-and-climate-change-strategy (accessed on 6 June 2023).
5. Dunlop, L.; Rushton, E.A.C. Putting climate change at the heart of education: Is England's strategy a placebo for policy? *Br. Educ. Res. J.* **2022**, *48*, 1083–1101. [CrossRef]
6. British Educational Research Association [BERA]. A Manifesto for Education for Environmental Sustainability. 2021. Available online: https://www.bera.ac.uk/publication/bera-research-commission-2019-2020-manifesto-for-education-for-environmental-sustainability-efes (accessed on 6 June 2023).
7. Howard-Jones, P.; Sands, D.; Dillon, J.; Fenton-Jones, F. The views of teachers in England on an action-oriented climate change curriculum. *Environ. Educ. Res.* **2021**, *27*, 1660–1680. [CrossRef]
8. Trott, C.D. Reshaping our world: Collaborating with children for community-based climate change action. *Action Res.* **2019**, *17*, 42–62. [CrossRef]
9. Kubisch, S.; Krimm, H.; Liebhaber, N.; Oberauer, K.; Deisenrieder, V.; Parth, S.; Frick, M.; Stötter, J.; Keller, L. Rethinking Quality Science Education for Climate Action: Transdisciplinary Education for Transformative Learning and Engagement. *Front. Educ. Sec. STEM Educ.* **2022**, *7*, 1–14. [CrossRef]
10. Pitt, J. Blurring the Boundaries—STEM Education and Education for Sustainable Development. *Des. Technol. Educ.* **2009**, *14*, 37–48.
11. Greer, K.; King, H.; Glackin, M. The 'web of conditions' governing England's climate change education policy landscape. *J. Educ. Policy* **2023**, *38*, 69–92. [CrossRef]
12. Khadri, H.O. Becoming future-proof STEM teachers for enhancing sustainable development: A proposed general frame-work for capacity-building programs in future studies. *Prospects* **2022**, *52*, 421–435. [CrossRef]
13. Bonney, R.; Cooper, C.B.; Dickinson, J.; Kelling, S.; Phillips, T.; Rosenberg, K.V.; Shirk, J. Citizen Science: A Developing Tool for Expanding Science Knowledge and Scientific Literacy. *BioScience* **2009**, *59*, 977–984. [CrossRef]
14. Makuch, K.E.; Aczel, M. *Children and Citizen Science, Citizen Science—Innovation in Open Science, Society and Policy*; Hecker, S., Haklay, M., Bowser, A., Makuch, Z., Vogel, J., Bonn, A., Eds.; UCL Press: London, UK, 2018; pp. 391–409; ISBN 9781787352339.
15. Varaden, D.; Leidland, E.; Lim, S.; Barratt, B. 'I Am an Air Quality Scientist'—Using Citizen Science to Characterise School Children's Exposure to Air Pollution. *Environ. Res.* **2021**, *201*, 111536. [CrossRef]
16. Fritz, S.; See, L.; Carlson, T.; Haklay, M.M.; Oliver, J.L.; Fraisl, D.; Mondardini, R.; Brocklehurst, M.; Shanley, L.A.; Schade, S.; et al. Citizen science and the United Nations sustainable development goals. *Nat. Sustain.* **2019**, *2*, 922–930. [CrossRef]
17. Saunders, M.E.; Roger, E.; Geary, W.; Meredith, F.; Welbourne, D.J.; Bako, A.; Canavan, E.; Herro, F.; Herron, C.; Hung, O.; et al. Citizen science in schools: Engaging students in research on urban habitat for pollinators. *Austral Ecol.* **2018**, *43*, 635–642. [CrossRef]
18. Kloetzer, L.; Lorke, J.; Roche, J.; Golumbic, Y.; Winter, S.; Jõgeva, A. Learning in Citizen Science. In *The Science of Citizen Science*; Springer: Cham, Switzerland, 2021; pp. 283–308. [CrossRef]
19. Shah, H.R.; Martinez, L.R. Current Approaches in Implementing Citizen Science in the Classroom. *J. Microbiol. Biol. Educ.* **2016**, *17*, 17–22. [CrossRef] [PubMed]
20. Roche, J.; Bell, L.; Galvão, C.; Golumbic, Y.N.; Kloetzer, L.; Knoben, N.; Laakso, M.; Lorke, J.; Mannion, G.; Massetti, L.; et al. Citizen Science, Education, and Learning: Challenges and Opportunities, Citizen Science and Social Innovation: Mutual Relations, Barriers, Needs, and Development Factors. *Front. Sociol. Sec. Sociol. Theory* **2020**, *5*, 613814. [CrossRef] [PubMed]
21. Rushton, E.A.C.; Batchelder, M. Education for Sustainable Development Through Extra-curricular or Non-curricular Contexts. In *Quality Education. Encyclopedia of the UN Sustainable Development Goals*; Leal Filho, W., Azul, A.M., Brandli, L., Özuyar, P.G., Wall, T., Eds.; Springer: Cham, Switzerland, 2020. [CrossRef]
22. Royal Society n.d. Partnership Grants. Available online: https://royalsociety.org/grants-schemes-awards/grants/partnership-grants/ (accessed on 6 June 2023).
23. Reges, H.W.; Doesken, N.; Turner, J.; Newman, N.; Bergantino, A.; Schwalbe, Z. CoCoRaHS: The Evolution and Accomplishments of a Volunteer Rain Gauge Network. *Bull. Am. Meteorol. Soc.* **2016**, *97*, 1831–1846. [CrossRef]
24. Illingworth, S.M.; Muller, C.L.; Graves, R.; Chapman, L. UK Citizen Rainfall Network: A pilot study. *Weather* **2014**, *69*, 203–207. [CrossRef]
25. Fowler, H.J.; Ali, H.; Allan, R.P.; Ban, N.; Barbero, R.; Berg, P.; Blenkinsop, S.; Cabi, N.S.; Chan, S.; Dale, M.; et al. Towards advancing scientific knowledge of climate change impacts on short-duration rainfall extremes. *Philos. Trans. R. Soc. A Math. Phys. Eng. Sci.* **2021**, *379*, 2019054. [CrossRef] [PubMed]
26. Creswell, J.W. *Qualitative Inquiry & Research Design: Choosing among Five Approaches*, 3rd ed.; SAGE: Thousand Oaks, CA, USA, 2013.

27. Hmelo-Silver, C.E.; Duncan, R.G.; Chinn, C.A. Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and. *Educ. Psychol.* **2007**, *42*, 99–107. [CrossRef]
28. Monroe, M.C.; Plate, R.R.; Oxarart, A.; Bowers, A.; Chaves, W.A. Identifying effective climate change education strategies: A systematic review of the research. *Environ. Educ. Res.* **2019**, *25*, 791–812. [CrossRef]
29. Murray, L.; Lawrence, B. *Practitioner-Based Enquiry: Principles for Postgraduate Research*; Psychology Press: London, UK; Routledge: London, UK, 2000; Volume 20.
30. British Educational Research Association [BERA]. *Ethical Guidelines for Educational Research*, 4th ed.; BERA: London, UK, 2018. Available online: https://www.bera.ac.uk/researchers-resources/publications/ethical-guidelines-for-educational-research-2018 (accessed on 6 June 2023).
31. Rushton, E.A.C.; Reiss, M.J. From science teacher to 'teacher scientist': Exploring the experiences of research-active science teachers in the UK. *Int. J. Sci. Educ.* **2019**, *41*, 1541–1561. [CrossRef]
32. Mezirow, J. *Transformative Dimensions of Adult Learning*; Jossey-Bass: San Francisco, CA, USA, 1991; ISBN 978-1-555-42339-1.
33. Rushton, E.A.C.; Dunlop, L. Youth perspectives on contributions to the SSR special issue: Science education in the context of the climate emergency. *Sch. Sci. Rev.* **2021**, *103*, 48–50.
34. Paul, J.D.; Cieslik, K.; Sah, N.; Shakya, P.; Parajuli, B.P.; Paudel, S.; Dewulf, A.; Buytaert, W. ApplyingCitizen Science for Sustainable Development: Rainfall Monitoring in Western Nepal. *Front. Water Sec. Water Hum. Syst.* **2020**, *2*, 62. [CrossRef]
35. Bianchi, L.; Whittaker, C.; Poole, A. The 10 Key Issues with Children's Learning in Primary Science in England, Report for The University of Manchester and The Ogden Trust. 2021. Available online: https://www.scienceacrossthecity.co.uk/wp-content/uploads/2021/03/3634_Childrens_Learning_in_Primary_Science_Report_2020_v8.pdf (accessed on 6 June 2023).
36. Rushton, E.A.C. Increasing Environmental Action Through Climate Change Education Programmes that Enable School Students, Teachers and Technicians to Contribute to Genuine Scientific Research. In *Climate Change and the Role of Education*; Leal Filho, W., Hemstock, S., Eds.; Climate Change Management; Springer: Cham, Switzerland, 2019; pp. 507–523. [CrossRef]
37. Heiss, R.; Schmuck, D.; Matthes, J.; Eicher, C. Citizen Science in Schools: Predictors and Outcomes of Participating in Voluntary Political Research. *SAGE Open* **2021**, *11*, 21582440211016428. [CrossRef]

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