

# School Engagement Projects as Authentic, Community-Based Learning for STEM Undergraduates

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## Abstract

Capstone projects provide key learning opportunities for STEM undergraduates to consolidate knowledge gained over the life of their degree. These projects typically reflect lab- or fieldwork-based research, which can exclude students who do not wish to pursue these career avenues. Here we deployed school engagement projects (SEPs) as an alternative to provide an authentic, community-based learning experience to STEM undergraduates wishing to develop their skills in science education and/or communication. This report aims to highlight the extent to which SEPs can provide such an opportunity, with the opinions of various stakeholders, including STEM undergraduates and participating schoolteachers, gathered by focus groups and surveys. Analysis of transcripts demonstrates an overall positive impact and revealed the benefits of these projects in preparing students for teacher training courses through increased educational knowledge and experience. These projects make for effective alternatives to traditional capstones and present opportunities for local science outreach.

*Keywords: school engagement projects, capstone projects, authentic assessment, community-based learning, higher education outreach*



Final year capstone projects allow undergraduate students to apply their knowledge and skills obtained in previous academic years to perform research that has real-world applications and benefits (Schachter & Schwartz, 2018). University courses in the biosciences have traditionally offered students a lab- or fieldwork-based research project in their final year of study (Jones et al., 2020). However, fewer than 10% of students will enter a career in these fields, with approximately half of students entering a non-research-based career, including teaching (Lewis, 2020). This disparity between the capstone projects conducted at university and graduate career choices presents an opportunity for novel authentic, experiential, and community-based learning projects and assessment.

Several universities now offer capstone projects that provide direct engagement with schools in their local community. Often

referred to as community-based engagement initiatives (Dempsey, 2010), these capstone projects, herein termed *school engagement projects* (SEPs), enable students to directly experience the role of a teacher or science communicator, to actively prepare appropriate and intellectually stimulating material for use in the classroom, and to assess the impact of their initiatives on pupil learning and engagement. These projects also offer benefits to the participating schools and pupils, including collaboration with marginalized and underfunded communities (as these activities are often offered free of charge) and increased engagement with a diversity of real-world topics (Dempsey, 2010). With many schools under time and resource constraints while delivering nationally regulated curricula, it can be challenging for teachers to deliver additional content or particularly preparation-heavy lessons. SEPs offer an opportunity to expose pupils to a range of thematic areas,

including topical issues not yet included in the curriculum, and cutting-edge research accessible only within the higher education sector. By providing a predominantly pupil-centered learning activity, pupils can be given an opportunity to be inquisitive about new topics and enhance their critical thinking skills (Adom et al., 2016). This expansion of real-life application of knowledge outside the examined material should also increase their overall interest in science topics and increase their motivation to further their learning, perhaps by attending university when they did not originally plan to.

We argue that our SEPs can be categorized as examples of community-based learning (CBL). CBL is a pedagogical strategy that seeks to give students meaningful learning experiences that involve contributing to, and learning from, the community (Pedersen et al., 2014). As well as increasing motivation because of the importance of the project to the community (Adom et al., 2016), it also develops a range of interpersonal and academic skills within the student (Astin et al., 2000; Carlisle et al., 2017). Further, universities are public institutions and have a responsibility to disseminate information and to increase the awareness of the general public to their research (Lynton, 2016). Therefore, SEPs can provide an important mechanism by which universities may increase their outreach potential by engaging directly with school partners, benefiting the community by providing local pupils with a unique and authentic learning experience. Similarly, the benefits are reciprocated to the participating undergraduates who engage with their community partners and enhance a plethora of vital skills simultaneously throughout the projects, which provide a bridge between theory and practice, as well as connecting students to prospective employers and prominent organizations in relevant fields (Lynton, 2016).

SEPs also provide an experiential and authentic learning opportunity for those interested in a career in teaching, but before they commit to teacher training. Experiential learning can play an integral role in tertiary education to provide students with participatory learning opportunities, enabling them to become more actively engaged in the learning experience (Hawtrej, 2007). As a result, learning in this way can be more impactful and memorable for students by providing them with a more immersive educational experience. Moreover, authentic

learning practices can further compound the benefits from such experiences as students have an opportunity to connect with real-world issues, problems, and applications, by providing them with a learning environment similar to a real-world discipline (Quigley, 2014). In SEPs, students are placed within local schools and given the opportunity to lead self-designed educational activities on their chosen topic, placing them firmly at the center of their learning experience. Student engagement is crucial in education, and using a student-centered activity has been found to purposefully increase student engagement (McCubbins et al., 2018). Thus, the SEPs provide an important opportunity for both experiential and authentic learning to take place, and to better equip the participating students for a career path in education or science communication.

This article aims to present and evaluate the newly developed SEP initiative within the School of Biological Sciences at Queen's University Belfast (QUB) in conjunction with two local science outreach organizations, the STEM Hub and W5. We present insights gained from participating students and teachers to better inform the delivery of similar projects and analyze their effectiveness as substitutes for lab- or fieldwork-based capstone projects.

### School Engagement Projects

QUB is a long-established (1845), research-intensive university in Belfast, Northern Ireland. The School of Biological Sciences sits within the Faculty of Medicine, Health and Life Sciences, and intakes approximately 300 students each year across seven programs ranging from Biochemistry to Environmental Management. All undergraduate students in the school must complete a part-time, 8-month project in their final year alongside their studies, otherwise known as a capstone project. The majority of students complete a disciplinary-based project encompassing lab, field, or computation work; however, each year a small proportion (about 8%) wish to complete a more educational-focused research experience. The SEPs were envisaged in the 2020–2021 academic term as alternatives to lab- or field-based projects for students expressing interest in science communication or education-related development, to improve experience and training in these areas, as well as to benefit local schools and communities.

These projects are currently available across five of the school's programs, and involve undergraduate students designing and developing educational activities or sessions directed at a specific age group, relating to an area of research of their academic supervisor, which they deliver in multiple schools within the local area. These projects occur in collaboration with local science outreach organizations, including the W5 Science Discovery center (<https://w5online.co.uk/>) and the regional STEM Hub (<https://thestemhub.org.uk/>). These organizations provide an avenue for the educational activities to be advertised to local schools, and through registration with them as STEM Ambassadors, students acquire training and obtain Disclosure and Barring Service (DBS) checks to allow them to work with children in regulated environments, all free to the student. Students, under the guidance of their academic supervisors, produce activity briefs that summarize their activities and explain how they supplement the national curriculum for their target audience (see Appendix for an example). These activity briefs are sent out to prospective teachers via the partner outreach organizations. Once interested schools are identified by

the partner organizations, they inform the students, who liaise with the appropriate teacher to deliver the activity.

Outreach activities are evaluated, and thus require both risk assessments and ethical approval from the host university. Participating students within SEPs must complete the necessary paperwork for this process, whereby completed consent forms are managed by the partner outreach organizations. Students develop an evaluation plan for their activity, either from the participating students, teachers, or both, and this evaluation provides the basis for the assessment of the SEPs. In this way, students gain insight and experience in managing various aspects of research development (ethical approval, study design, data collection, etc.) as well as educational delivery.

Due to the COVID-19 pandemic, the projects were delivered solely online in the 2020–2021 academic year, with flexible delivery in 2021–2022. To provide an example of the variation in delivery of the SEPs across these academic terms, Table 1 illustrates four different activities developed, including the activity detailed in the Appendix.

**Table 1. Comparison of Four School Engagement Project Activities Delivered by Students in Local Schools**

	Topic	Delivery	Length	Age	Schools	Main Activities
<b>Activity A*</b>	Microbes in food waste	In-person	60 min	11–14	3	Interactive PowerPoint; online quizzes; poster production
<b>Activity B</b>	Malaria transmission & prevention	In-person	50 min	16–18	1	Interactive PowerPoint; online resource (yourgenome.org); group debate
<b>Activity C</b>	Genetic modification of food	Online	45 min	14–16	1	Self-paced online course; online group debate
<b>Activity D</b>	Deep-sea mining & biodiversity	Online	60 min	16–18	4	Self-paced online course; mining summit simulation

Note. \*The activity brief for Activity A is provided in the Appendix.

## Evaluation

To better understand the outcomes for students and partner schools who participated in SEPs, as well as how to improve the projects in future iterations, a program of qualitative evaluation was undertaken.

### Evaluation Methods

The evaluation was approved by the Faculty of Medicine, Health and Life Sciences Research Ethics Committee. A focus group of student instructors was conducted at the conclusion of each set of projects over the course of the two academic years (2020–2021 and 2021–2022) that the SEP ran. Purposive volunteer sampling was employed to recruit final year students in the School of Biological Sciences who had recently completed and submitted a SEP. Four individuals, including one male and three females, took part in the 2020–2021 focus group; three individuals, all female, participated in the 2021–2022 focus group. Five of these participants had applied for entry into a graduate program to become qualified teachers.

Focus groups lasted for approximately one hour, and asked participants to reflect on their experiences in undertaking a SEP, including the benefits and challenges, the relevance of this project to their future careers, and what they believed could be improved in future iterations of SEPs. The

questions used in both focus groups can be seen in Table 2. A 1–1 interview was also completed with a teacher from a local school that engaged with the SEP in the 2021–2022 academic year. These focus groups and interview were recorded and transcribed with the participants' permission.

In addition, an anonymous, online questionnaire (delivered via Microsoft Forms) was distributed to participating teachers; questions included are detailed in Table 3. Eight teachers provided responses to both open and closed questions based on their perspectives of the projects delivered in their schools. All eight teachers provided responses for the closed questions; the open questions received fewer responses.

The focus group transcripts and questionnaire responses were analyzed using thematic analysis. An inductive approach was preferred, meaning that themes were built from the codes identified in the transcript and preexisting theories or concepts were not used (Thomas, 2006). The codes were then reviewed each time the transcripts were reread, and after three readings, the codes were appropriately organized into themes. Five themes were identified (perceived employability, authentic career experience, benefits to school pupils, challenges of SEPs, community support) and are subsequently discussed.

**Table 2. Questions Posed to the Student Participants of the 2020–2021 and 2021–2022 Focus Groups**

What are the top three advantages you think were specifically delivered by the School-Engagement Projects?
What were the top three challenges which you had to specifically overcome with the SEP, that you feel other students did not?
Do you think there are many opportunities in your degree to gain teaching experience?
Do you think the SEP provided a beneficial opportunity to experience teaching-related activities?
What, if any, do you think were the biggest impacts of completing and delivering the SEP remotely this year?
Would you recommend other students to undertake the programme, and if so why / not, why?

**Table 3. Questions Included in the Teacher Evaluation**

Did you find the activity too long, an appropriate length or too short?
Would you be interested in taking part in similar events delivered by Queen's University Belfast?
How would you rate the SEP you chose as an educational activity for your students overall?
If you have any comments on how to develop the activity further, what would you add / keep / remove?
Do you have a gauge (either formally or informally) on how your pupils felt about the SEP activity?
What do you think the biggest impact (if any) the SEP activity had on your pupils?
How do you feel about the delivery of the SEP activity, and was it effective for your class?
How do you think your pupils found actually completing the activity online and using the online resources?
Do you think there are elements of the curriculum these activities could best support?
From the activities you experienced, what elements do you think worked well, could be removed, or could be added to make them more effective?

### ***Evaluation Findings***

The five themes are presented here, accompanied by discussion.

**Theme 1: Perceived Employability.** Participating undergraduates found that the nature of the SEPs aided their personal and professional development, with a plethora of skills highlighted as being enhanced throughout the process, including public speaking, communication, adaptability, IT skills, and self-evaluation. Student Instructor 1 mentioned that “for those who don’t have as much experience with IT, you’re picking up new skills and you’re learning how to adapt in the workplace. . . .” These findings are consistent with previously cited benefits of similar science-communication-based capstone projects whereby students enhanced their communication skills working cooperatively with others in a group, as well as their ability to communicate via different means, both

written and oral (Kerrigan, 2015). Students are also provided with greater freedom to develop their own project and, as a result, can develop a plethora of skills such as problem-solving, critical thinking, and investigative skills, with Student Instructor 6 mentioning how “[situations continuously] went wrong and I had to adapt to them very quickly . . . it taught me a lot about how things very rarely go to plan . . . you need to be really adaptable.” Arguably, students who have completed their projects are therefore better equipped to progress into further study or prepare for their future career, including postgraduate research or teacher training, given that these skills are particularly important for these fields (Kerrigan, 2015). Student Instructor 6 further expressed how “learning how to communicate different concepts to appropriate audiences properly” provided a beneficial learning experience that prepared them for their future teacher training.

Graduate employability is heavily reliant on the possession of a variety of skills, including communication, problem-solving, and teamwork, but employers have experienced difficulties in recent years in acquiring appropriately qualified graduates who are expected to have further developed these skills with guidance from their university (Matsouka & Mihail, 2016). Thus, it is vital that universities provide the relevant opportunities to enhance key skills relevant to the future career aspirations of undergraduates. Key skills can be integrated into a capstone project designed to provide the relevant experience and skill development necessary for that future career; SEPs, for example, are specifically designed to provide such experience for the teaching profession. Further, these projects connect students to local schools and educational bodies that may provide employment or training opportunities later in their careers.

### **Theme 2: Authentic Career Experience.**

Students also highlighted the opportunities that the projects provided to gain relevant teaching experience, which Student Instructor 6 highlighted by saying, “I want to do teaching but throughout [my university] course, nothing arose like this. . . .” The lack of such experiences throughout tertiary education more generally was also noted. SEPs enabled students to gain direct experience while working in a school, allowing for contact between teachers and pupils, while also providing creative freedom to produce learning materials, such as PowerPoint presentations and quizzes, relevant to the content being covered. Similarly, in previous findings students undertaking a science-communication capstone project were shown to benefit from having freedom to enhance their creativity skills while accepting appropriate guidance from supervisors to ensure optimal delivery of the projects (Mokhtar, 2010). This creative freedom was appreciated by the participating undergraduates, with Student Instructor 5 highlighting its importance by stating that “it gave you a great opportunity to teach how you’d like to. . . .” Furthermore, taking on the role of teaching, even if only for a select number of sessions, provided a valuable insight into both lesson planning and effectively relating the content being covered to the pupils’ current curriculum, with Student Instructor 1 mentioning how “it gives you a really valuable insight . . . it gives you experience creating content and then delivering it to the classrooms ourselves.” Thus, the

school-engagement capstone project offered the students a career-building experience through authentic interaction with children and teachers, while also delivering an activity (Elwell et al., 2021).

The authentic nature of such projects has been proposed to give undergraduates a realistic job preview that many other capstone projects, as well as STEM courses, often cannot provide. Students can gain a greater sense of scope and confidence when choosing a future career, with Student Instructor 6 stating that “[it] gives you the full-on experience of being a teacher and taking over a classroom” (Beier et al., 2018). Student Instructor 5 also mentioned how “it was really interesting to have meetings with the classroom teacher . . . she was very open about all the things she was having to consider,” as opportunities to hear from teachers directly about their lived experience in the classroom prior to teacher training applications are difficult to obtain. This practical and valuable insight into such careers can enable prospective graduates to make more informed decisions as to how and in what capacity to enter the STEM workforce.

The nature of capstone projects provides a unique opportunity to research an area of interest. Participating undergraduates expressed gratitude for their increased educational knowledge, as the SEPs had provided an opportunity to engage with pedagogical and educational research for the first time, with Student Instructor 5 expressing that “the research plan [an assignment within the SEP schedule prior to the delivery of the designed activity] was all very much pedagogical and educational research . . . it was really, really interesting and I think that gave us a real good advantage . . .” Student Instructor 1 agreed, mentioning that “instead of focusing solely on science, you’re also focusing on the theory of education and the aspects of education which is really interesting as it broadens your knowledge on both.” Student Instructor 2 also expressed the need for familiarization with the curriculum to provide the best learning experience for pupils, saying how “I’ve familiarized myself with their curriculum and had based my project around something that they would use in their curriculum.” Furthermore, the students noted that reading educational journals had provided a greater understanding of how children learn, with Student Instructor 6 saying that “there would be so many papers on communicat-

ing with [children] . . . after reading it all, it was amazing to see the different types of ways that kids actually learn. . . .” Previous research has also demonstrated how such acts of community engagement can directly enrich undergraduate learning in relation to both pedagogical and scientific content, noting how undergraduates had been able to identify how the scientific knowledge they had accumulated would translate into a classroom setting (Theriot, 2006).

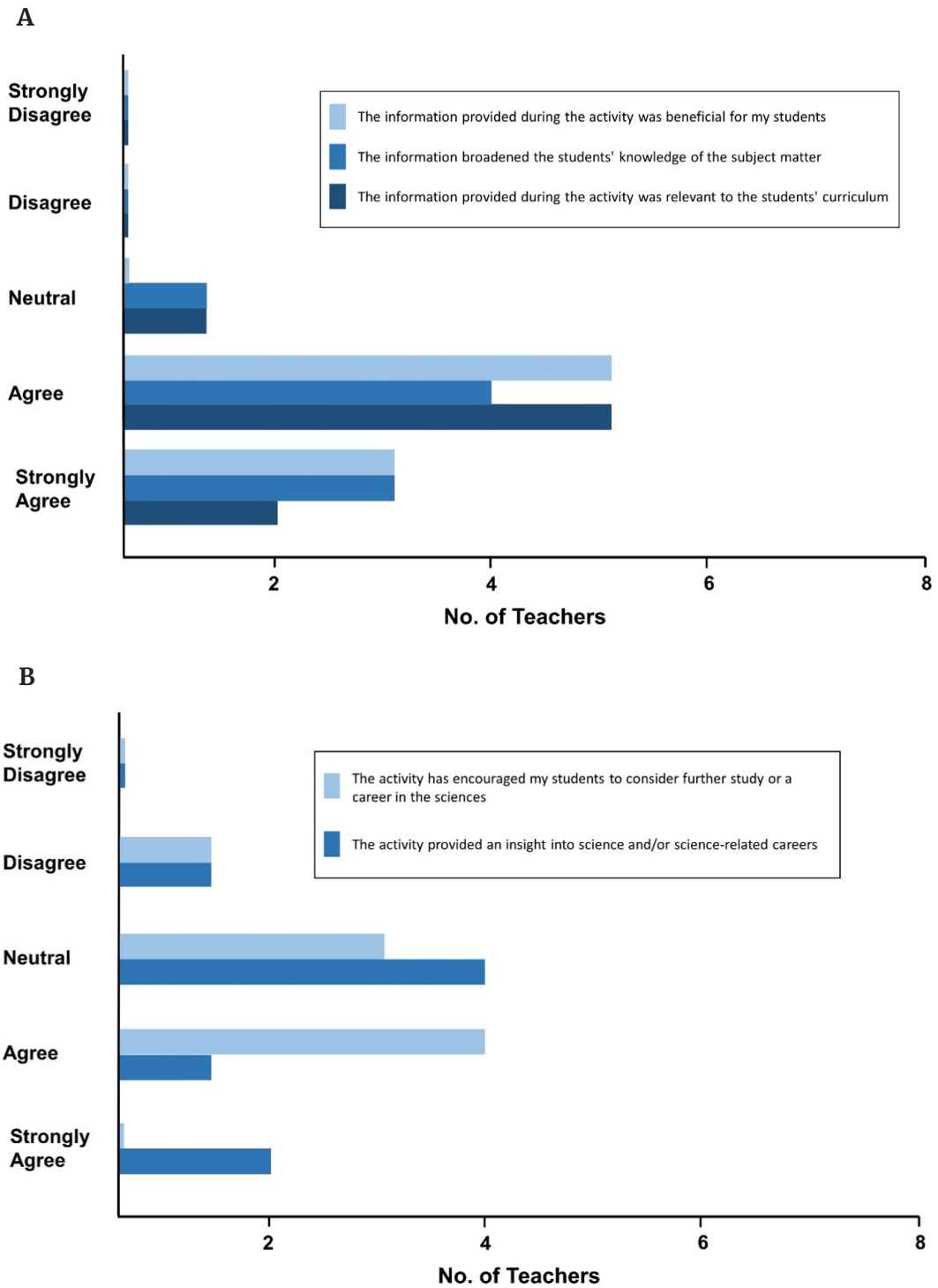
The majority of students who participated had expressed the importance of completing this project as it benefited their application for a PGCE (postgraduate certificate in education) program following completion of their degree-level studies. Student Instructor 5 mentioned how “[the project] was really helpful for me. I could use [it] in an interview,” and Student Instructor 2 mentioned how “I applied to do a PGCE, and I got in . . . I could talk about my research project [and] how it was part of the STEM Hub at W5, [which] was really beneficial and it probably pushed me ahead of other candidates that maybe didn’t have that.” Each PGCE course is highly competitive, and being able to demonstrate classroom experience has proved integral in the success of these students’ applications. Figures released by the Universities and Colleges Admissions Service (UCAS) for the 2021 cycle show that of 48,300 UK applicants to a teacher-training course, only 30,115 of those were accepted (UCAS, 2022). Five out of seven undergraduate students who participated in the focus groups had already been successful in their application and noted how beneficial the SEP experience had been, providing a myriad of relevant talking points in their interview. Student Instructor 3 expressed how beneficial the SEP had been during their interview with how “talking about a dissertation, in that we were able to interact with students, you could tell that the interviewer was really interested in it. . . .”

**Theme 3: Benefits to School Pupils.** The SEPs were found to have real-world and immediate impacts in the local community, as they involved direct contact with school pupils and provided them with a novel and unique learning opportunity. The student-developed sessions provided an opportunity to create an authentic learning environment whereby the participating pupils adopted an instructional approach (Adom et al., 2016). This approach encouraged the pupils to ac-

tively explore a variety of resources covering novel and real-world contextual material, including topics related to, but not covered within, the curriculum, such as deep-sea mining and gene editing, allowing them to be inquisitive and construct their own knowledge from the materials provided. Thus, a constructivist approach was used, to increase both the pupils’ knowledge and interest in the subject. By making the subject applicable to real life, the educational experience is likely to enhance pupils’ motivation to learn and thus can benefit their performance in future studies (Sawyer, 2014). Student Instructor 4 highlighted the ability of such projects to deliver valuable scientific knowledge to those not involved in research, mentioning how “this project made an immediate difference to pupils . . . it was nice just to go straight to the public with something.” Student Instructor 6 also thought the participating pupils were engaged throughout, and benefited from the activities, stating that “they actually did learn the [content] through the way I was teaching them.” The teachers involved also identified these benefits. All ( $n = 8$ ) indicated that the information provided during the activity was beneficial for their students (Figure 1A); seven agreed that the information broadened the pupils’ knowledge of the subject matter. Importantly, the majority (seven) of teachers also agreed that the information provided during the activity was relevant to the students’ curriculum. One teacher, however, was neutral about this statement, and an undergraduate student had also indicated that their project was surplus to the requirements of the curriculum, which was thought to have a negative impact on student engagement, as participation was completely voluntary and not necessary. Student Instructor 3 also expressed concern, mentioning how “teachers can’t force the pupils to engage with the project as it’s not part of the curriculum.” As a result, future considerations should be made to accommodate only those projects that are relevant to the curricula at that time. Research by Sedlak et al. (2010) has also suggested that every faculty member should consider the relevance of community engagement projects, ensuring the project meets both the needs of the community partner and undergraduate course objectives.

These benefits were also highlighted during the teacher interview, where teachers described how the projects increased their

**Figure 1. Teachers' Perspectives on the Impact of the Educational Activities**



Note. Number of teachers responding on a Likert-type scale (from *strongly disagree* to *strongly agree*) regarding the impact of the educational activities on (A) the information disseminated during the teaching sessions and (B) the encouragement of students to consider further engagement in science.



pupils' knowledge base through building upon what was being learned in class, but also encouraging further interest and conversation about the subject matter. The teacher highlighted the beneficial nature of the activities by saying that "it did spark some further conversations . . . it was very much linked and ideally placed—it was a step up from what they had been learning about in class. . . ." The teacher also described how the overall experience of the projects was beneficial to their pupils, as it provided excitement and they were enthusiastic to take part in something novel, saying that "our pupils were enthusiastic to take part . . . they were keen, they were interested. . . ."

School-outreach initiatives can provide a positive and meaningful experience for undergraduates and pupils alike, with numerous benefits having been cited, including teamwork, interpersonal, organizational, and communication skills, all of which have been found to be transferable into numerous scientific disciplines (Illingworth & Roop, 2015). Similar to the SEPs, these projects were found to be successful in engaging school pupils through the inclusion of real-world material and allowed for the development of early career scientists through increased motivation to learn and engage with new resources.

In addition, the projects also provide a valuable opportunity to promote the sciences and encourage schoolchildren to consider further study or a career in the sciences. Four of the teachers ( $n = 8$ ) involved agreed with this statement (Figure 1B). Student Instructor 4 mentioned that "[I] could really see how clearly beneficial [the project] was in schools, given the opportunity that it was giving, and I suppose it's really nice to see that science has such an impact everywhere . . . and it can make a real impact to adult life in the public as well." Moreover, three of the teachers agreed that the experience provided an insight into science or science-related careers. For this reason, the undergraduate students had noted how these projects, through direct school engagement, could have wider and longer term impacts, encouraging more people to consider being a STEM teacher while also inspiring schoolchildren to consider their future career and how they can make an impact in the world. With a career in education having become less attractive to graduates in recent years, primarily due to workload and pay (Dupriez

et al., 2016), the shortages of STEM teachers across the UK and other parts of the world need addressing. Quality STEM education is vital for ensuring successful future careers of young people and greater scientific developments to address numerous real-world issues, including climate change and mitigating its impacts. Such issues are regularly addressed by the United Nations, which has highlighted the importance of education in the effort to address climate change through providing knowledge-based lessons that encourage people to change their attitudes and behavior for the benefit of wider society (UN, n.d.). Thus, recruiting more teachers from a STEM background, and ensuring they have sufficient experience and expertise, will prove integral in mitigating the effects of climate change and associated environmental issues. Student Instructor 6 also expressed concern over the shortage of STEM teachers, stating that "they're literally crying out for STEM teachers, so it is a really good opportunity to get people pushed into going into teaching."

Online delivery proved divisive among participating undergraduates, but several conclusive benefits were noted by those who chose online delivery in 2021–2022. One such benefit was the ability to use videos as a learning aid, of which Student Instructor 7 said, "[Online delivery] more lended itself to some really cool footage from movies. . . ." Other benefits included the provision of more interactive and engaging content for the pupils, the ability to access more pupils, greater anonymity during the sessions (which may have allowed pupils to feel more confident in asking questions), and the use of third-party applications to aid learning, enabling a better content layout. Student Instructor 7 also mentioned that through online delivery, "I could access a lot more people" and

I had questions from people sending a little message to me through Canvas [the virtual learning environment utilized] more so than I think might have happened if it wasn't online . . . I got quite a lot of people who would just send me a little message and say, "Oh, I'm not sure about this." There was a lot of that, so I think it helped. . . .

Student Instructor 7 also mentioned that "I don't think [my project] would have been laid out nearly as well if it hadn't been

[online] because I used lots of different plug-ins, so I had Ed Puzzle and ThingLink . . . it just gave it a really nice platform which was pretty easy to work through.” In addition, Student Instructor 5 also found that “the [online] delivery made it very easy for [the pupils] to work through it. . . .”

Although online learning has been used as a mitigation against the direct impact of COVID-19 on education in recent years, its benefits have been widely debated in the literature (Paudel, 2021; Teymori & Fardin, 2020). As it allows greater access to a plethora of bespoke learning tools, the use of computers can lead to an increased rate of teaching and promotes the separation of the teacher from the students, placing students toward the center of the learning experience, giving them greater autonomy (Paudel, 2021). This autonomy can have positive impacts within a constructivist pedagogical framework, but the lack of personal interaction and guidance can lower the pupils’ intrinsic motivation and disengage them from their educational activities (Syahputri et al., 2020). This perspective was highlighted during the teacher interview, with teachers stating they would like to see online learning removed as a way of making a future improvement to the project, as pupils were found to have lost interest in the activity and began using computers for other activities. As COVID-19 restrictions ease, in-person learning is more likely and will allow a greater level of communication and understanding between pupils and their student instructor during the SEP.

**Theme 4: Challenges of SEPs.** Although the SEPs delivered a variety of benefits to both students and pupils alike, several limitations and challenges in the delivery and logistics of the projects need to be recognized. Undergraduates highlighted a number of difficulties that they had experienced in relation to the paperwork associated with the project, as well as the SEPs’ schedule, which students undertaking a more traditional lab-based project did not have to encounter. Student Instructor 7 stated that “most of my friends [completing a traditional lab-based project] at least got their data given to them in an Excel spreadsheet . . . we were very much needing to collect the data from scratch and work through how we were going to collect it.” Primarily, the students expressed concerns with having to collect the data and having to identify how to collect, manage, and analyze it effectively.

This issue, however, is likely to be specific to the context at the time, as many traditional capstone projects within the School of Biological Sciences offered precollected data during COVID, whereas in more normal conditions, the majority of projects, regardless of type, require students to collect, manage, and analyze their own data.

Undergraduate students also felt that the workload during the SEP was overwhelming, with Student Instructor 5 saying, “We probably had a lot of individual stuff outside of the actual research, so, like, making sure you had your AccessNI [criminal records check and finding the school . . . that was quite stressful. . . .” Student Instructor 7 mentioned how

you need to be very much able to take on a lot of stuff completely independently and on your own, because I know certainly my supervisor wasn’t an expert in education and teaching . . . they weren’t the one with the answers when it came to doing AccessNI forms. . . .

Student Instructor 6 also expressed concern over how “the dissertation deadline was way too close to exams.” This perception of limited time, however, is a common perspective of students at this stage, irrespective of the type of capstone project.

In addition, the nature of these projects meant that students were reliant on participation by, and communication with, schools. Participating students encountered difficulties in obtaining schools to sign up to their activity, with Student Instructor 1 mentioning how “I struggled to actually get schools from W5.” A lack of communication between the undergraduates and their community partners had also been noted in previous research, suggesting that difficulty communicating is a common obstacle that can impede the fluency and impact of such projects in schools (Blouin & Perry, 2009). Student Instructor 4 highlighted the difficulties they experienced in communication with their community partners, saying, “Once [W5] put you in contact with a school, it was the teacher then not getting back to you and you had to chase people. . . .” Efforts should be made to ensure communication between all stakeholders involved is consistently clear to ensure optimum delivery of the projects. Students also found they had to manage a lack of continuity between

the requirements of different schools. They believed this inconsistency made the process of connecting and communicating with a partner school more convoluted, with Student Instructor 7 mentioning that “I got let down twice by different schools and groups, so I very quickly had to adapt my project. . . .”

Undergraduate SEP students were also reliant on pupils’ engagement, and some felt that pupil engagement diminished as the planned educational session progressed, with Student Instructor 2 expressing concern, stating that “a lot of kids . . . filled out the first questionnaire and then as the activity went on, they started dropping out, so my numbers dwindled so much. I think obviously if we were face-to-face, we wouldn’t have that problem” and also that

if you were face-to-face, you would have more evaluations and you wouldn’t necessarily have that issue as much as you would have online [when] trying to keep the attention of a 15-year-old or 14-year-old, which is a very difficult thing to do.

Thus, they felt engagement with pupils was a challenge, especially with online delivery, as interaction with the pupils was difficult. Student Instructor 4 expressed how online delivery meant that

you don’t know how much [the pupils] have missed and how much they’ve understood. And when they do the questionnaire at the end and they don’t get it right, you’re like, “What have I done wrong?” and you don’t know because you don’t have that interaction.

Although delivery of these projects will likely return to a face-to-face format as COVID-19 restrictions ease, students did face challenges with online delivery, despite the aforementioned benefits, with Student Instructor 3 citing the difficulty in creating content:

“I made prerecorded videos, and I made them so many times and it took so long that I was putting them up anyway because I couldn’t actually do it any longer when I felt like they were rubbish . . . [it] would just be so much better if I could just talk to the students.

They found it challenging to make sure the content was fully accessible, and it was also a challenge to make every aspect of the project engaging for the pupils. Student Instructor 5 noted how “[it was challenging] making sure that [all of the content] was accessible . . . and making sure everyone was going to be able to get in [the learning session].” It was noted that in-person delivery allows the educator to be more interactive with the students and can make sure the students are engaged. Student Instructor 7 expressed how online delivery meant that

[it was challenging] trying to find ways of making it more than just an online activity and more about them by actually engaging with the content, which is hard to do when it’s online because there’s not an actual live person to chat to.

Furthermore, it was noted during the teacher interview that online delivery had meant that “I was the middle person saying, ‘This isn’t working,’ ‘This is working,’ ‘What are we doing?’ and ‘Should we click here?’ It’s an extra layer of communication you have to go through which just slows things down.” As a result, the teacher explained how communication could be improved through a transition back to in-person projects.

**Theme 5: Community Support.** All participating students noted a lack of communication with others completing a SEP. They believed they would have benefited from being allowed to ask each other questions and discuss logistics of their project with understanding individuals. Student Instructor 1 noted that

it would have been nice to even meet others who are doing the same dissertation in person or through [Microsoft] Teams so we can all get to know each other. I think it would make it a lot easier since we’re all in the same boat to ask questions.

It was suggested that online meetings would provide the space to communicate; however, most students would prefer in-person meetings, which are less formal and allow for the discussion of problems more easily. Developing a sense of community is an important step in preventing feelings of isolation, and can develop knowledge through peer-to-peer learning among un-

dergraduates. Because few students within their cohort are likely to be completing a similarly structured project, students engaged in SEPs have a limited pool to ask for guidance (Trespacios & Uribe-Florez, 2020). Supporting this contention, Student Instructor 4 mentioned that “having more people who understood what was happening maybe would have been helpful.” Students were provided with an online Microsoft Team with relevant resources whereby they could communicate with each other; however, meeting with other students virtually is likely to be less beneficial in developing such relationships compared to meeting in an in-person setting (Rogerson & Anderson, 2020), and as a result the online platform was seldom used. Student Instructor 7 suggested that “[in-person] is a less formal environment . . . if you have a problem, then you’re not worrying that [it’s] going to be written on Teams or someone’s going to see this and it’s going to be brought up.” Thus, Student Instructor 7 suggested that “a biweekly in-person meet . . . and discuss if you’ve got any problems, and actually chatting to each other would probably be the best.” Therefore, as had been suggested, having an in-person meeting regularly from the beginning of the project would serve as a space to ask questions and talk through problems.

Students undertaking the SEPs also acknowledged that they would benefit from additional support, including instruction as to how they should engage with schools and being able to see work that has previously been done for a SEP. Student Instructor 5 had suggested that it would be beneficial to “show examples of someone’s previous project just to see how it all comes together.” Student Instructor 7 also mentioned how supervisors should “explain the exact way that we were going to be getting schools,” which they thought would be beneficial from the beginning of the projects. They also noted that getting support from someone who is not a supervisor, but who knows how to help, would be effective, with Student Instructor 6 suggesting that “[it would be beneficial to] bring past people that have done the project to talk about it” and Student Instructor 7 mentioning that it would be an improvement to get “support [from] someone who isn’t your supervisor but who knows roughly what to say and how to give you a hand with something if your supervisor’s not getting back to you.”

## Conclusions and Future Direction

Although this report details the efficacy of community-centered capstone projects within an education setting, it is important to note that such projects can be used in a variety of different settings to provide similar authentic and community-based learning opportunities for undergraduates and outreach opportunities for pupils. Science-communication-based capstone projects have been used in a variety of degree courses including, but not limited to, medicine, engineering, marketing, and law (Chamberlain et al., 2020; Metcalf, 2010; Ward, 2012). It is also important to highlight how a well-developed network is vital for the efficient organization and running of such projects. In Northern Ireland, the STEM Hub and W5 have played an integral role in communicating with, and gaining participation from, schools in the local area. With the time constraints experienced in the busy final year of an undergraduate degree, it is vital that projects are well-organized to ensure undergraduates are not at a disadvantage relative to those completing a more traditional honors project. The nature of these projects also meant that schools were chosen within a relatively local proximity to the university and, as a result, all participants, including STEM undergraduates, pupils, and teachers, were local. This limited scope of participation meant that the perspectives of the various stakeholders, and thus the benefits, challenges, and insights derived from the stakeholders’ experiences, could be specific to a Northern Ireland context. It is important to note that such projects are subject- and university-specific and thus are likely to be conducted differently to yield different benefits and challenges.

SEPs have been found to provide a unique community-based learning opportunity, with undergraduate students having the chance to develop professional skills through learning about real-world issues and directly working with schools in the community to deliver this information in engaging approaches. Moreover, the community partners can subsequently benefit by receiving intellectually stimulating and relevant learning resources to broaden their knowledge on the subject matter and encourage future career ideas. Initiatives like the SEPs therefore are an effective means of outreach for the university, aiding the achievement of one of their purposeful and

valued cornerstones within the community.

Although the circumstances in previous years have meant that the predominant method of delivery has been online, the varied responses from undergraduates and teachers alike have meant that future delivery options will likely be mixed, and the choice will be given to undergraduates who can determine the most suitable method for their project. The next academic years will bring new cohorts of undergraduates wishing to undertake SEPs, and thus it is imperative to develop new resources using the feedback gained from various stakeholders to both streamline and improve their experience, and that of the pupils. Looking forward, to optimize the outcomes of these projects for both undergraduates and pupils alike, it will be imperative to provide several adjustments, including (but not limited to)

- The facilitation of a regular in-person student-organized meeting for SEP students to discuss issues or concerns regarding the development or progress of their projects
- An overview from local outreach partners to the recruitment procedure for schools to the SEPs at the

beginning of the project schedule, as well as a communication agreement between students and these partners

- The completion of a handbook specific to the SEPs outlining brief timelines and resources for tools and training resources
- Engagement with local community-based, informal educational organizations (museums, discovery centers, etc.) to open opportunities to deliver bespoke activities to their audiences

Together these projects will provide a unique and beneficial opportunity for STEM undergraduates to develop key skills as an alternative to more traditional lab-based projects, priming their entry into an education- or science-communication-related career in the future. With the implementation of the preceding suggestions, which aim to address the concerns raised by various stakeholders, the success of these projects can continue and grow in the coming years, offering effective opportunities for authentic and local community-based learning.



### About the Authors

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## Appendix. Activity Brief Example

**Name:** [Student Name]

**Supervisor:** [Supervisor Name]

**Project Title:** The Role of Microorganisms in Food Loss and Waste



**Delivery:** This activity aims to be delivered in person but can be delivered online if necessary

**School Selection:** Key Stage 3 pupils aged 11–14, Schools in Derry/Londonderry or Belfast if in-person. No restrictions if remote

### Description:

The “*Role of Microorganisms in Food Loss and Waste*” activity has been designed to educate pupils about the real-world problem of food loss/waste and of the dual role that microorganisms play in this. Globally around one third of all food produced is lost or wasted. Approximately one-quarter this is due to microbial growth on food which can cause it to spoil and to become unsafe to eat. However, microorganisms and their actions may also offer a solution to this world wide issue by transforming food waste into useful materials such as biofuels, bioplastics and biofertilizers. Through a series of interactive activities students will explore the real world problem of food loss/waste, understand how controlling microbial growth on food can reduce food loss/waste and develop awareness of how the normal everyday activities of microorganisms makes them key players in addressing food loss/waste and contributing to the development of a circular economy.

This activity will complement the Science and Technology component of the NI CEA Key Stage 3 Curriculum: in particular, in the areas of learning “*Organisms and Health*” and “*Earth and Universe*”. In-person delivery of this activity is preferred however it can be delivered online if necessary. IT facilities will be required for both modes of delivery.

The topic of this project is linked with the following Sustainable Development Goals:

