Can. J. Sci. Math. Techn. Educ. (2026) 26:20
https://doi.org/10.1007/s42330-026-00455-8

The Impact of a Place-Based Citizen Science Project on Students' Attitudes Toward STEM

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Received: 2 April 2025 / Accepted: 13 January 2026 / Published online: 11 February 2026

Abstract This research describes a place-based citizen science project (PBCSP) between primary school students and a science-based agency, *Wet Tropics Management Authority* (WTMA), working on eradication of an invasive ant species in Queensland, Australia. The school is in a low socio-economic area with many students speaking a language other than English (LOTE) and many who identify as First Nations Peoples. The aim was to assess the impact of the PBCSP on student participation in science through involvement in a "real-life" science project. A mixed-methods case study design provided a comprehensive analysis of the research problem. Quantitative and qualitative data were collected with the school as a single case. In the quantitative phase, a Likert survey and science test provided data on students' attitudes and knowledge of science. Qualitative data included interviews with teachers, WTMA personnel, and students. These indicated students' attitudes towards science had become more positive. Quantitative data revealed a statistically significant improvement in attitude towards science

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s42330-026-00455-8.

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following participation. The project was mutually advantageous, raising the interest of primary school students in science while furthering the aims of WTMA through community participation. These findings are encouraging due to the often-reported correlation between students from low socio-economic backgrounds and poor learning outcomes.

Résumé Cette étude décrit un projet scientifique citoyen axé sur le territoire (PSCAT) mené par des élèves du primaire et une agence scientifique, la « Wet Tropics Management Authority» (WTMA), qui vise l'éradication d'une espèce de fourmis envahissantes dans le Queensland, en Australie. L'école est située dans une zone socio-économique défavorisée où de nombreux élèves parlent une langue autre que l'anglais (LAQE) et beaucoup s'identifient comme appartenant aux peuples autochtones. L'objectif était d'évaluer l'impact du PSCAT sur la participation des élèves aux sciences en les impliquant dans un projet scientifique « réel». Un modèle d'étude de cas par méthodes mixtes a permis une analyse complète de la problématique de recherche. Nous avons recueilli des données quantitatives et qualitatives à l'école dans le cadre d'un cas unique. Au cours de la phase quantitative, un questionnaire à échelle de Likert et un test scientifique ont permis de fournir des données concernant les attitudes et les connaissances des élèves en matière de sciences. Les données qualitatives comprenaient des entrevues avec des enseignants, le personnel de la « WTMA» et des élèves. Ces entretiens ont révélé que les attitudes des élèves envers les sciences étaient devenues plus positives. Les données quantitatives montrent une amélioration statistiquement significative de l'attitude envers les sciences après la participation au projet. Celui-ci s'est avéré mutuellement profitable, suscitant l'intérêt des élèves du primaire pour les sciences tout en contribuant aux objectifs de la « WTMA» grâce à la participation communautaire. Ces résultats sont encourageants compte tenu de la corrélation souvent relevée entre les élèves issus de milieux socio-économiques défavorisés et les mauvais résultats scolaires.

Keywords STEM · Science attitudes · Place-based citizen science · Primary school

Introduction

Science, technology, engineering, and mathematics (STEM) is vital because it "touches every aspect of today's world, and the innovations that emerge from these fields underpin the global economy" (Department of Education and Training, 2016, p. 1). Several studies (DeBacker & Nelson, 2000; Marginson et al., 2013) emphasize that the primary years of schooling play an important role in forming students' future career intentions and developing the foundations of STEM competence. This paper reports on a study that aimed to assess the impact of place-based citizen science projects (PBCSP) on student participation in STEM through involvement in a "real-life" science project. The study results are especially significant since the participant student cohort is drawn from a school that is located in a low socio-economic area and may hold negative perceptions of STEM subjects (Australian Government Department of Education, 2024).

The paper begins with a discussion of the status of STEM enrolments in Australia followed by factors that influence student interest in STEM education. It will then go on to discuss the role of place-based citizen science projects in STEM education, including the part it plays in STEM education for ethnic and racial minority students and students from low socio-economic backgrounds. The review will end with the research questions that were addressed in this study.

Literature Review

Declining enrolments and negative perceptions of STEM subjects have for some time been an international concern (Kennedy et al., 2016), as shown by studies from England and Wales (Smith, 2011), France (Charbonnier & Vayssettes, 2009), Israel (Trumper, 2006), the USA (Sadler et al., 2012), and China (Cheng & Wan, 2016). Globally, student interest and participation in STEM subjects continues to remain low, despite the vast contribution of STEM programs to peoples' daily lives (Sithole et al., 2017). This trend is more extreme for Indigenous students (Bollinger & McSkimming, 2024; Alkholy et al., 2017), students from ethnic minority backgrounds (Coleman, 2020), and students from low socio-economic backgrounds (Rozek et al., 2019).

Status of STEM in Australia

In Australia, Lyons and Quinn (2010) interviewed 3759 year 10 students who had recently chosen their subjects for year 11. The authors found that approximately 76% had chosen to enrol in one or more year 11 science subjects while 24% had selected no science subjects. Most students who did not choose any science did so because they did not find science engaging and did not aspire to a career in science. More recently, a study commissioned by the Department of Industry, Science and Resources (DISR) (2023) surveyed 2948 young people aged 12 to 25 years in Australia to build an understanding of the perceptions and attitudes of young people towards STEM. The DISR study reported that, in general, there was strong participation in STEM subjects overall amongst year 11 and 12 students. However, the findings also indicated that students from lower socio-economic backgrounds and those identifying as First Nations Peoples were less likely to select subjects such as advanced Mathematics, Chemistry, and Earth and Environmental science. Thompson et al. (2019a, b) also found that in Australia, negative attitudes were more common amongst disadvantaged students, who liked mathematics and science less, were less confident in their mathematics and science abilities, and valued mathematics and science to a lesser extent than their more socially advantaged peers. Additionally, students from lower socio-economic backgrounds and First Nations students showed a long-term decline in reading, mathematical, and scientific literacy (Thompson et al., 2019a, b).

In 2024, the Australian Government Department of Education highlighted that uptake of STEM subjects had not improved since Thompson et al.'s finding, noting that:

- The average 15-year-old Australian from a low socio-economic background is 3 years behind in terms of their mathematics and science performance compared to their peers from a high socio-economic background.
- Students are more likely to have negative perceptions of STEM disciplines.
- Students are less likely to aspire to STEM careers.
- Adults from low socio-economic backgrounds are underrepresented in the STEM workforce.

Factors That Influence Interest in STEM Education

A range of factors can impact students' decision to continue with or leave a STEM field of study. Research indicates that students' self-efficacy and interest in STEM subjects can play an important role in whether they choose to study these subjects (Franz-Odendaal et al., 2016). Low self-efficacy in STEM subjects has been linked to a declining interest in STEM careers (Blotnicky et al., 2018; Halim et al., 2018). Nugent et al. (2015), in their study with youth aged 10 to 14, found that educators, peers, and family influenced youth STEM interest, which in turn predicted their STEM self-efficacy and career outcome expectancy. The importance of parental influence is shown in other research which reports that young people whose parents have an education in STEM or work in a STEM-related field are more likely to take part in STEM-related study than those whose parents do not (Department of Industry, Science and Resources (DISR) (2023)). Timely exposure to STEM subjects also plays an important role as indicated by Mangu et al. (2015) who found that grades 7 to 9 (12–15-year-olds) was the key time period for influencing STEM career interest. Student engagement in STEM subjects also plays a critical role in whether they choose to take part in STEM-related study because of its impact on their attitude towards STEM subjects. According to Mercier et al. (2025), student disengagement and low participation rates in STEM subjects can be due to student perceptions that STEM subjects are abstract and disconnected from their daily lives.

Research shows that STEM programs that capture student interest and engagement have a positive impact on student attitudes towards STEM subjects (Knipprath et al., 2018; Struyf et al., 2019; Krajcik & Delen, 2017). Kennedy and Odell (2014) point out that high-quality STEM programs must be underpinned by a rigorous curriculum with appropriate instructional strategies that promote scientific inquiry and emphasize the design process. Instructional approaches that are student-centred, use problem-based learning, and allow students to work on authentic real-world problems that are place-based are viewed as a critical focus in STEM education (Nugent et al., 2015; Kennedy & Odell, 2014; Struyf et al., 2019; Lamb, 2016). Furthermore, place-based programs are well placed to improve participation of First Nations students in STEM education, particularly if they are aligned with traditional knowledge and students' everyday experiences (Ricci & Riggs, 2019; Karagatzides et al., 2011).

Role of Place-Based Citizen Science Projects in STEM Education

Place-based citizen science projects involve research projects that encourage young people to take part in meaningful, real-world data collection and information sharing (Lamb, 2016). According to Lamb (2016), place-based citizen science projects enhance the relevance of STEM for students, thereby increasing student participation. Such projects not only promote personal and community resilience and offer unique opportunities to connect students with their communities but also foster scientific literacy (Mercier et al., 2025; Bascopé & Reiss, 2021; Ballard et al., 2017; Smith & Sobel, 2010; Solé et al., 2023). Many authors have reported on the positive impacts of place-based citizen science projects on students of different ages. Paige et al. (2015) reported that classroom-based citizen science projects increased the development of scientific literacy in Australian students. Similarly, Houseal et al. (2014) found positive impacts on science knowledge development amongst US elementary students, while Hiller and Kitsantis (2014) reported a similar impact amongst middle school students, and Williams et al. (2021) and Bradley et al. (1999) amongst high school students. Such projects also contribute to scientific skill development and improvement in students' argumentation and critical thinking skills which are important in STEM education (Araújo et al. 2022; Kennedy & Odell, 2014). Additionally, the transdisciplinary and cross-cultural nature of place-based citizen science projects fosters the scientific communications practices that are essential for addressing existing and emerging problems and also involves stakeholders from diverse backgrounds (Coleman et al., 2019). Students involved in place-based citizen science projects have meaningful interactions with elders, scientists, and community partners as they focus on studying locally relevant phenomena and identify authentic design problems. Such involvement can be highly engaging for students and also "foster local agency, responsibility, accountability, and relationships through the development of a shared sense of place" (Coleman et al., 2019, p. 1).

Place-based citizen science projects can also play a critical role in engaging racial and ethnic minority students as well as students from low socio-economic backgrounds in STEM education. Gallay et al. (2021), reporting on racial/ethnic minoritized students in the US participating in a place-based STEM project, observed the participants using science to "foster community resiliency in the face of environmental crises" (p. 8). Connecting STEM education to students' lived experiences fosters meaningful learning and offers the potential for educators to address issues of inequality and social justice by enabling students to apply their STEM learning to mitigate local environmental issues (Gallay et al., 2020, 2021). Karagatzides et al. (2011) describe an outreach program with Grade 8 First Nations students in Ontario, Canada, which addressed environmental concerns that were of direct relevance to their culture, such as environmental contamination. The authors found that the program, which was contextualized to the Ontario region and consisted of group activities and hands-on experiential teaching, was effective in engaging the students. Murphy (2020) described a study from four low SES schools located in Victoria, Australia. He found that the place-based learning experiences which involved students in authentic activity in the local community and environment contributed to their success in STEM subjects.

The aim of this study was to examine the impact of the PBCSP on student participation in science through involvement in a "real-life" science project. Specifically, we aim to answer the following research questions (RQ):

RQ1: How does a place-based citizen science project impact students' scientific knowledge and skills?
RQ2: How does a place-based citizen science project impact students' attitudes towards science?

Study Context

The research reports on a project initiated by an inner-city primary school in Far North Queensland in Australia in conjunction with *Wet Tropics Management Authority* (WTMA), a science-based agency. In this project, the students involved in the school's STEM Academy were partnered with professional scientists from the WTMA and First Nations People at the local level to manage cultural and natural heritage within the World Heritage designated area. Since its establishment, the WTMA has partnered with First Nations Peoples as required by the Wet Tropics World Heritage Protection and Management Act 1993 (State of Queensland, 2023).

The outcomes of this research should be contextualized in light of the school's proximity to a World Heritage area and its broader social context, which is close to the central business district of a large regional city in Far North Queensland. At the time of the research, the school had a low socio-educational ranking (ICSEA) according to the *Australian Curriculum and Reporting Authority* (ACARA, 2022), which is consistent with the school's location in relation to the *Australian Bureau of Statistics* (ABS) *Index of Relative Socioeconomic Disadvantage* (IRSD) postcode ranking for the same period. This national comparative ranking is determined by four factors: family income, family educational levels, First Nations Australian enrolments, and geographical location (ACARA, 2015).

Apart from low engagement with STEM, as discussed above, the education research literature highlights a strong correlation between degrees of social disadvantage, such as in our research, and lower degrees of engagement with schooling as well as learning achievement (see, e.g., Department of Education, Skills and Employment, 2022; Lingard, 2011; Sriprakash & Proctor, 2013; Tait, 2013). In terms of the research school, this is evident in the National Assessment Program – Literacy and Numeracy (NAPLAN) outcomes in the year of the research that placed students in the school at either "below" or "well below" the national average in numeracy as well as all areas of literacy tested (ACARA, 2022).

As an offset to the described social disadvantage, it must be noted that the school possesses high degrees of social capital in a supportive parent/carer base who "agree" (92 to 100%) that the school is seeking to do well for their children across several attitudinal indicators. These indicators included statements about whether their child's learning needs were being met at the school and whether the teachers at the school motivated their child to learn. The above statistics represent an increase from the previous year (Queensland Government, 2022). School attendance rates (86%) are above the regional average (81.3%) for Far North Queensland (Department of Education Queensland, 2024).

Stem Academy

The project was part of the STEM Academy at the primary school. The academy had been running at the school under the guidance of the second author for 2 years. The main objectives of the academy were to engage students in STEM with the view to more students potentially selecting STEM subjects in high school; to encourage underrepresented groups including young women and First Nations students to participate in STEM; and to create avenues and networks for students to gain entry into specialist academies at two local high schools. Student participants in the STEM academy generally reflect the school's ranking: school enrolment includes students who speak at home a language other than English (LOTE) (at least 51%), students who identify as First Nations Australian (51%) and students in the lowest socio-educational quartile (55%) (ACARA, 2022).

Initially, academy activities were run out of school hours; however, the year this PBCSP occurred, the activities were timetabled into normal school hours. Students who joined the STEM Academy during the PBCSP were informed about the project at the start as part of the ethics process. The project was described in detail in parent and student information sheets and was advertised on the school's social media channels. Ethical approval was provided by the James Cook University Human Research Ethics Committee, approval number H8719. Approval was also granted by the Queensland Department of Education.

Yellow Crazy Ants

The International Union for Conservation ranks the yellow crazy ant (*Anoplolepis gracilipes*) amongst the world's 100 worst invasive alien species by Nature due to their negative impact on native species and ecosystems (Global Invasive Species Database, 2024). Originating from Southeast Asia, this species thrives in areas of anthropogenic disturbances, disrupting local ecosystems by preying on invertebrates, including insects, spiders and arthropods, and small vertebrates, including ground-nesting birds (Global Invasive Species Database, 2024; Green & O'Dowd, 2009; Lach, 2003; O'Dowd et al., 2003).

This opportunistic pest was first discovered in Far North Queensland over 20 years ago, having been unwittingly transported via cargo shipping (Wet Tropics Management Authority, 2023). Its ability to create super colonies due to a lack of aggression between nests is thought to be the main reason for its success (Wet Tropics Management Authority, 2023). The ant represents a significant threat to the fragile World Heritage listed Wet Tropics Area of Far North Queensland, having caused the displacement of native ants and disruption of existing ecological networks. Efforts to control yellow crazy ants involve a combination of chemical, physical, and biological methods (Department of Climate Change, Energy, the Environment and Water [DCCEEW], n. d.). However, successful eradication remains challenging due to the ants' adaptive behaviour and widespread distribution.

Methodology

This research aimed to assess the impact of involvement in the STEM Academy PBCSP project on participating students. The *Queensland STEM Strategy* (Department of Education and Training Government, 2016), which emphasizes "working together through partnerships with industry, universities and the community" (p. 2), supported the study.

Project Description

The overall project was designed by the university researchers in collaboration with the STEM Academy teacher. The university researchers were originally approached by the teacher who wanted to encourage more students to participate in the STEM Academy, particularly young women and First Nations students. The researchers organized a meeting between the teacher and scientists from WTMA, which led to the initiation of this project.

The project commenced with 21 participants from years 4 to 6 (9 to 11 years old) who had elected to join the STEM Academy at the school—a quarter of the students identified as First Nations People.

Phase 1 of the project was a field day aimed to raise awareness of the yellow crazy ant problem and attract more students to apply to the STEM Academy (Fig. 1) by showing primary school students in years 3 to 6 displays organized by the WTMA, which included ant-trapping methods, using sniffer dogs to detect ants, using GIS mapping, and examining yellow crazy ant anatomy using microscopes. In addition, First Nations rangers from the WTMA presented artefacts located during fieldwork, explained their traditional uses, and explained how traditional knowledge is used to manage the land and care for Country.

As a result of the field day, six additional students joined the STEM Academy.

Phase two involved delivery of an integrated unit that included aspects of technology to engage students and showcase their learning journey in a format different from the commonly used assessment formats. During this term-long unit, students began by learning how to create a simple app using https://code.org to document and present project data and learnings. As the unit progressed, the students incorporated aspects of their learning into the app such as researching the significance and value of the World Heritage site to the region in terms of biodiversity, impacts of invasive species on the World Heritage site, planning and conducting surveys for yellow crazy ants, analyzing survey results, and practicing their coding skills by remixing a "find the object" app, where users had to locate a regional animal amongst other animals. In addition, the school and WTMA facilitated another visit from a local First Nations ranger who shared local lore, Traditional Ecological Knowledge and practices, and the importance of connection to Country for First Nations Peoples.

In the third and final phase, students participated in field surveys of yellow crazy ants in collaboration with WTMA field staff. They set traps along a designated transect and then collected and identified the ant species they trapped. Under the supervision of the classroom teacher and WTMA field staff, students collated and analyzed the results.

As a culminating outcome for the whole project, students created a page for the class app that focused on one aspect, such as identifying yellow crazy ants, field survey procedure, and analysis of findings (Figs. 2 and 3). Students then presented their portfolio of work as well as an overview of their experiences to the WTMA board members.

Data Collection

This research employed quantitative and qualitative data collection methods, enhancing the validity of the results (Creswell, 2014). Quantitative data collection involved a survey with 15 Likert-scale items and a science test. Student focus groups were used for qualitative data collection and interviews with teachers and personnel from WTMA.

The items in the Likert-scale instrument were selected from the much larger Test of Science-Related Attitudes (TOSRA) (Fraser, 1981) to assess students' enjoyment of science learning experiences. The instrument was trialled on several STEM Academy students to check for content validity, resulting in minor adjustments to the wording of items to improve clarity (S1).

The science test comprised 15 multiple choice questions based on the year 4 to 6 *Australian Curriculum: Science* document. The first author developed the test, and its purpose was to assess the impact of the PBCSP on students' science knowledge and skills. The STEM Academy teacher, who is the second author, checked the test and amended it to ensure questions aligned with the curriculum for the year levels (S2).

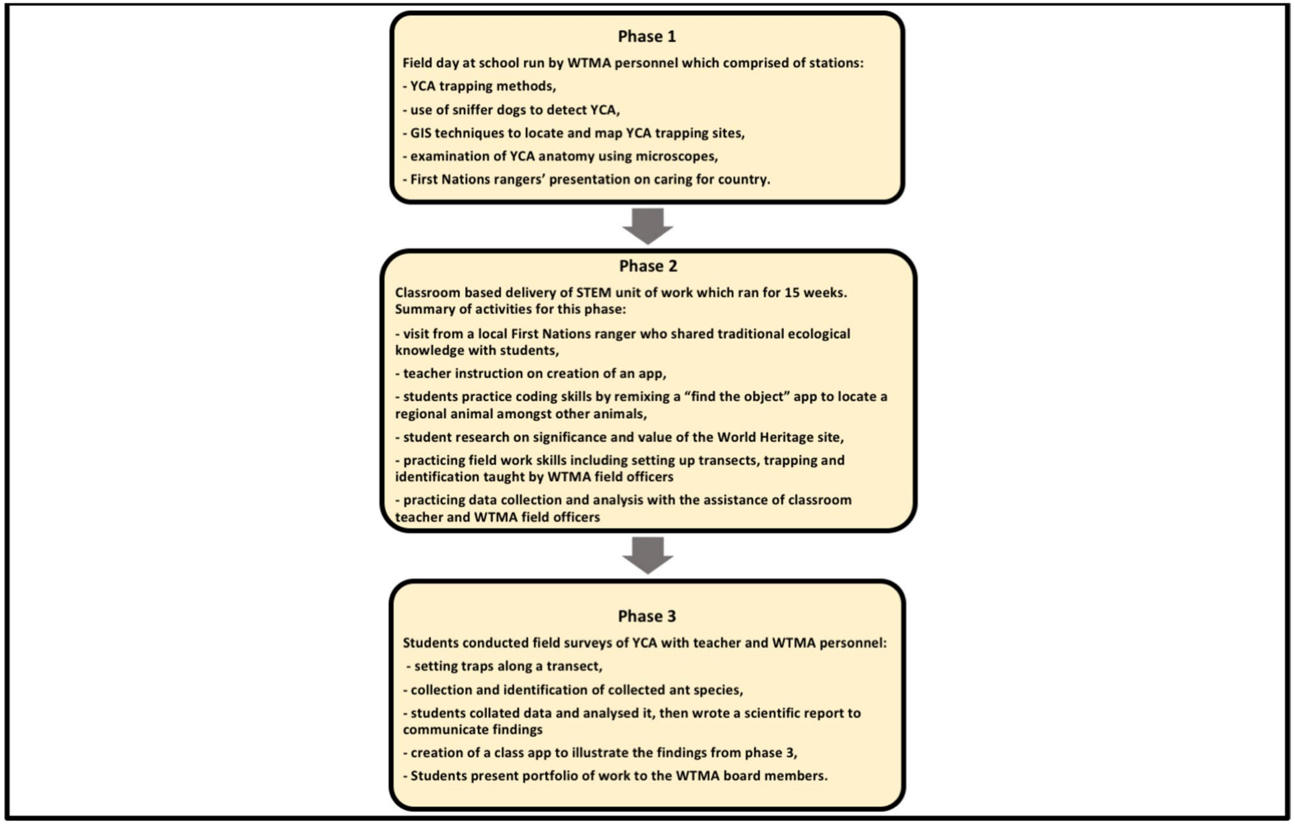

Fig. 1 Activities undertaken during the different phases of the project

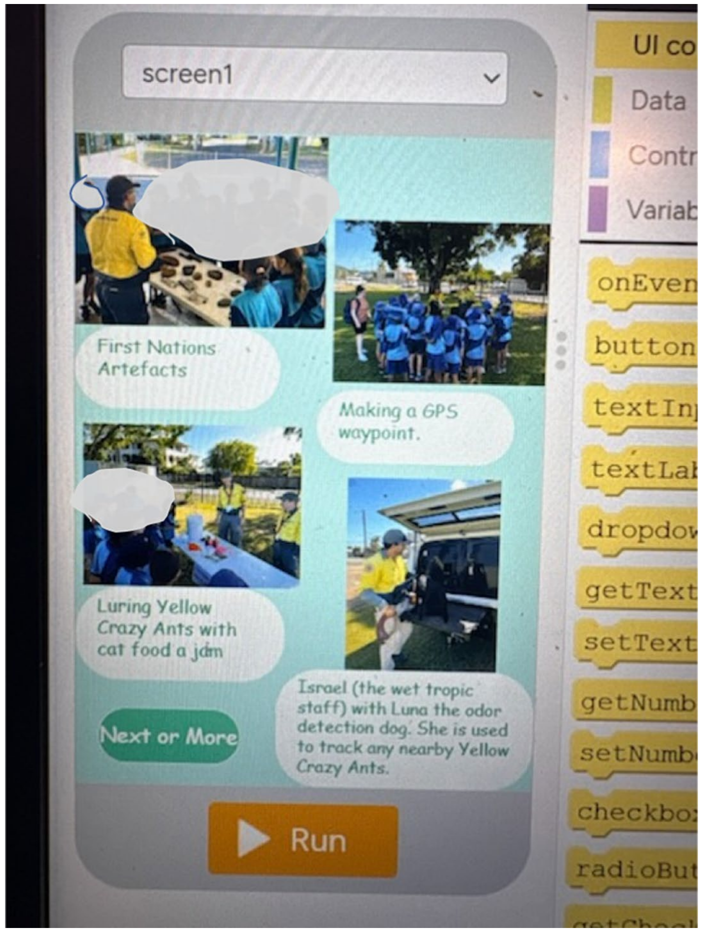

Fig. 2 Page from class app showing activities undertaken during the field day

Study participants completed both instruments before their involvement in the PBCSP (pre-test) and again at the end (post-test).

The qualitative data were collected at the end of the project using focus group interviews with students in groups of 3 to 4. Only 16 students were available for the focus group interviews. Interviews were also conducted with the two class teachers of the participants and two science personnel from the WTMA (S3).

The focus group interviews were audio-taped and transcribed using software called *Descript*. The class teachers and WTMA personnel were interviewed using *Microsoft Teams*, and the transcription facility in *Microsoft Teams* was used to transcribe these interviews. All interviews were conducted, transcribed, and checked by the first author.

Data Analysis

Twelve out of the 27 participants completed all instruments for the pre-test and post-test data collection. Incomplete data were not included in the analysis. The responses from the 5-point Likert-scale questions were converted to numerical data by assigning a value of one for a “strongly disagree” response and a value of five for a “strongly agree” response to an item. Items 8, 11, 13, and 15 were negatively worded and thus reverse-coded before analysis (Pallant, 2016) (Supplementary Information S1). The scores from each student

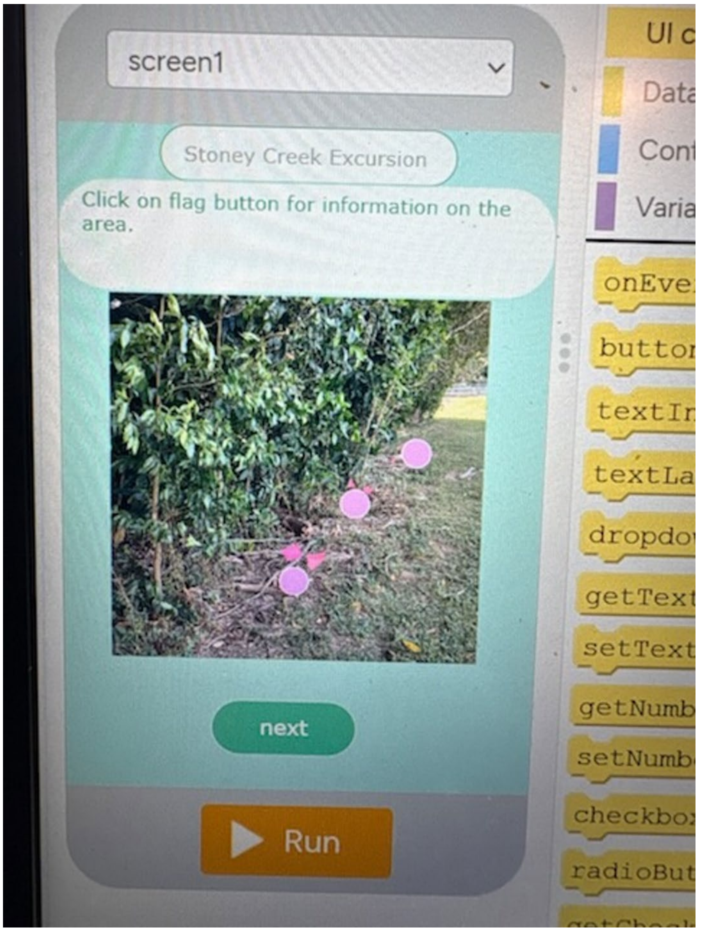

Fig. 3 Page from class app showing field survey data points

were added to provide a total score for assessing students' enjoyment of science learning experiences before and after involvement in the PBCSP.

The science tests completed by the 12 students were marked, and a score out of 15 was given to each student based on correct answers to assess the impact of the PBCSP on their science knowledge and skills.

Numerical data was analyzed using the *IBM SPSS Statistics for Windows Version 27* software package. The non-parametric Wilcoxon signed-rank test was used to analyze the pre- and post-test data from the attitude survey and the science test because of challenges verifying the data's assumption of normality about the data given the small sample sizes (Ramachandran & Tsokos, 2014).

Qualitative data from the participants' oral responses in the interviews and focus groups were transcribed into written text, then analyzed. The analysis looked for trends and patterns in keywords and utterances used by each participant, using the study's two research questions as a guide. The relatively small sample size enabled this analysis to be done manually without using a qualitative data analysis tool.

Results

Tables 1 and 2 show the pre- and post-test results from the Likert-scale items used to assess the impact of the students' enjoyment of science learning experiences before and after involvement in the PBCSP project.

Table 1 Participants' pre- and post-test scores from the Likert-scale items with difference between scores

Student participant	Pre-test score from Likert-scale items	Post-test score from Likert-scale items	Difference between pre- and post-test scores
1	33	61	+28
7	49	66	+17
2	54	66	+12
10	48	60	+12
11	48	57	+9
9	47	55	+8
12	64	67	+3
3	59	61	+2
8	64	65	+1
6	56	55	−1
5	60	57	−3
4	59	55	−4

Table 2 Wilcoxon signed-ranks test

Total *N*	12
Test statistic	66.000
Standard error	12.733
Standardized test statistic	2.121
Sig*	.034

*The significance level is 0.050

Tables 3 and 4 show the pre- and post-test results from the science test used to assess the impact of the PBCSP on their science knowledge and skills.

Qualitative data was analyzed according to phenomenological principles that give primacy of place to the lived experiences of those integral to the research inquiry (Eddles-Hirsch, 2015); in this case, the STEM academy students involved in the citizen science initiative, their everyday classroom teachers, and the WTMA leaders who partnered with the students. Phenomenology considers research participants' "perceptions, perspectives, understandings, and feelings" (Hilton & Hilton, 2020, p. 81) as crucial to understanding the targeted phenomena; in this case, students' knowledge development and attitudinal changes concerning science. Accordingly, the following sections discuss the trends and themes identified in the data which go towards addressing the two research questions: students' initial motivations to join the STEM academy and participate in its activities; growth in students' scientific knowledge as a result of participation (RQ1); and changes in attitudes towards science as a result of participation (RQ2).

Individual participant responses are tagged using pseudonyms. By way of illustration, the student's first initial and focus group number, for example, W1—William in Focus Group One. Likewise, individual teacher and WTMA responses are tagged with initial and group, for example, ST—Sue Teacher and BWTMA—Brian WTMA.

Again, it is important to emphasize that the students involved in the STEM academy approximately represent the total school enrolment and the social and cultural characteristics of the inner-city area that the school serves. Therefore, the results described are to be understood in terms of the relatively low socio-economic and socio-educational levels and relatively high degrees of First Nations Indigeneity and language backgrounds other than English (LOTE).

Table 3 Participants' pre- and post-test scores from the science test with difference between scores

Student participant	Pre-test score from science test	Post-test score from science test	Difference between pre- and post-test scores
9	4	9	+5
12	5	8	+3
4	8	10	+2
11	10	11	+1
3	11	11	0
8	13	13	0
2	15	14	−1
7	15	14	−1
10	8	6	−2
6	8	5	−3
1	13	9	−4
5	13	9	−4

Table 4 Wilcoxon signed-ranks test

Total *N*	12
Test statistic	23.000
Standard error	9.766
Standardized test statistic	−0.461
Sig	0.645

Motivation for Joining STEM Academy

Students in the focus group interviews were asked why they joined the STEM Academy to elicit insights into their initial attitudes towards science. The 16 interview participants provided a range of motivations for joining the STEM Academy, with prior interest in science and technology being a common reason (9 students). For example, H4 said:

> [T]o join mostly because I wanted to learn a bit more about science and technology. And because I enjoyed learning about new things and how that it was like four subjects in one [STEM].

Six students found the science learning available to them via the academy as something inherently fun and enjoyable to do after talking to friends or siblings who had been doing science, either through a previous iteration of the STEM academy or through science experiences in secondary school. For example, J1 said:

> [W]hen the STEM club first came out, I was interested because my brother was doing a STEM academy in high school. So I wanted to figure out what it was like.

The fun experienced by some students while doing science was expressed in the language choices used to describe the various activities (A1, R6, N6, J5). For example, in the perceived "weirdness" (H4) of yellow crazy ant behaviour and the common talk of "acid being sprayed out of bottoms" (T4) when learning about the negative effects of yellow crazy ant populations.

It is also likely that the motivation to join the STEM academy was a response to the teacher-centred approach to teaching science in the students' mainstream classrooms. The students appeared to respond well to the more student-centred approach to learning in the STEM academy. One of the teachers suggested this when explaining that students do not get to experience such enthusiasm and excitement in their everyday learning. According to YT:

> [T]hey are enthusiastic [because] it's a hands-on approach. The things they do are different and new and exciting and they get really enthusiastic about the technology.

The WTMA scientist (GWTMA) involved in the collaboration also noted that in the work they do with schools generally:

> [Y]ou get that initial element of kids being released from normal classes for something exciting and new.

The science teaching and learning done in the STEM academy is by its nature much more socially constructivist, placing students at the centre of the science investigations and allowing them more participation in their own learning.

Three interview participants were considering a future career in science and saw the STEM Academy as a stepping stone. M3, J3, and J5 saw a link between learning science and what they wanted to do in adult life: "Marine Biology", "Engineering", and "something technology-related", respectively. It is uncommon for primary school children to have fully formed career aspirations, but the seeds for a career choice are possibly sown in these early years. Certainly, the WTMA scientist involved in the collaboration (GWTMA) saw it this way in arguing that:

> [I]t's not too early to be exposing them to the idea that there's jobs and careers in this stuff... making them aware that there's pathways for them to go down.

First Nations students involved in the STEM academy have many STEM-related employment avenues open to them as well as being involved in "caring for Country"; that is, working in paid employment and taking responsibility for local tracts of land in Traditional Custodian roles.

The role modelling done by the WTMA scientists during the Yellow Crazy Ant project is also closely related to students' aspirations for careers in science. KWTMA, from the perspective of the students, put it this way:

> [Y]ou know, there's a fellow there [male WTMA scientist] who looks like me or there's a girl there [female WTMA scientist] that looks like me. This doesn't look like it's something that's necessarily extremely difficult to achieve to become a staff member or a yellow crazy ant team.

Research Question 1: Impact on Students' Scientific Knowledge and Skills

The pre- and post-test science test scores did not show a statistically significant difference (Table 4). However, the focus group interviews point towards the development of students' scientific knowledge and skills through participation in the PBCSP, including a noticeable use of scientific language when talking about their experiences with the yellow crazy ants.

When students were asked to describe what they had learned about yellow crazy ants, they incorporated several terms, as part of their everyday vocabulary, that would be unexpected for students of that age. For example, one of the most common responses (five students) was to use the term "invasive species" when referring to the ants.

Another example of such language use is a statement from J1, who said:

> Yeah, like I think it was *ethanol*. And when the bugs fall into the trap, you know, you get to see all the types of bugs without the rotting. Coz they're *preserved*. Yeah.

The italicized words mixed with J1's everyday language choices mark the beginning of a more scientific vocabulary. Further examples of language choices used by the students that indicate skills and knowledge learned or at least beginning to be mastered include "waypoints" (J5); "differentiate" (M3); "super colonies" (H4, A3); "lures" (R6); "neutralization", "substance", and "prey" (J5); and "life cycle" (J1).

The responses also provided insights into the project's impact on students' scientific skills. Twelve students identified aspects of the project they found engaging, such as setting traps, using a GPS device to identify trap locations, and identifying ant species. The field surveys conducted during phase three of the project allowed students to practise scientific skills, such as posing questions, planning and conducting investigations, and writing a scientific report to communicate their findings. T6 described, again in a mix of everyday discourse and a more formal scientific language (in italics):

> There's like a certain procedure to do like a *report* on what's happening and where your crazy ants are, and that if you don't follow the *right procedure*, you are not [going to] get a *good findings*. So everything had to be like a *fair test*.

The teachers also saw a growth in science knowledge and skills, particularly "inquiry skills". KT observed a change in PBCSP participant students in her class, noting:

> Their inquiry skills like posing questions I think has developed a lot more, like they're starting to ask... why does this happen? How does this happen? Because our science unit was so different to what they have been doing in STEM, like the content knowledge is a bit different, but they've definitely acquired those inquiry skills and we are an explicit teaching school. So in science [classroom science] there's not like a whole lot of opportunity... you know, day-to-day to do those things. So, it's really nice that they put their five cents in when they are thinking these higher order thoughts, which is great. Yes, they're more into investigations and problem solving.

Research Question 2: Impact on Students' Attitude to Science

Quantitative data revealed a statistically significant improvement in attitudes towards science following participation in the PBCSP (Table 2). The qualitative data sheds further light on the possible reasons for this positive change in attitude.

One possible reason was the way science was presented to students, such as the innovative practices and technologies utilized in this project, for example, using a GPS device to track and monitor the ants and ways of luring them into the traps.

Ten interview participants talked about the real-world nature of the yellow crazy ant problem and the proximity of this problem to their homes. Their comments indicated that the students were thinking more widely about the role of science in society. By being a part of the eradication programme and being valued by the WTMA team, they saw themselves as solving a real-world problem and being able to make a difference. For example, M3 said:

> I mean that yellow crazy ants are bad for environment. I mean that if there is more the yellow crazy ants they can move the other animals and the other animals, which I mean animals that are native to Australia. If yellow, crazy ants eradicate all of our native species, then what is there left to Australia? There's nothing more special because some animals are unique to our area of life (M3).

The positive attitudes towards science because of participation in the PBCSP had flow-on effects for some students into other areas of school life. KT observed:

> There has been an impact on attendance, especially the times when they have STEM, they want to be here and they want to participate. And so they come to school to join in.

A WTMA scientist, GWTMA, involved in the project also noted:

I think that was really good at getting students enthused and engaged in what's been going on in our project and to make them interested in learning more and opening their eyes up to what STEM is.

Related to changes in attitude towards science is data suggesting that the students learned that science is a social endeavour, that is, work that is done in teams and something to talk about and share with others. M3 and J3 indicated that participation in the STEM academy and working on the yellow crazy ant project prompted them to reflect on how they related to others in their group. M3 reflected:

(I) learned to be a better teamwork person, to work better in a group, cuz normally I work solo.

J3 said when others in her group got distracted, she:

[K]ind of learned how to like control my feelings, um, not to yell at them or anything.

Directly because of participation in the PBCSP, many students went home and eagerly shared what they had been doing with parents (e.g., J3), siblings (e.g., J1 and A3), and even their everyday teacher (KT). Talking voluntarily with others, such as family members and teachers who were not present about their science learning, indicates an attitude change; the students were excited about learning science.

GWTMA noted the sharing with interest:

There's a range of benefits for us. First off, if I look at it purely from a program point of view where we're talking about getting community recognition of yellow crazy ants. So... we're getting the message to the kids who then take it home to Mum, Dad, Auntie, Grandma, Granddad.

KWTMA added:

When you educate a school student, they take it home to their parents and they take it home to their grandparents and their aunties and their friends. And so we're not just educating the student, we're educating the broader community. And as you are no doubt aware, when the kid is passionate about something, they'll make their family passionate about it. And it's helped us to reach a wider net than we would traditionally.

For this reason, the WTMA sees their work with young people in schools as far more effective than some of their other community meeting points, such as their special stalls in shopping centres where only the "already converted" come up to speak. As KWTMA suggests, young children are more likely to talk about their learning to family when excited about it.

Discussion

This study set out to examine the impact of the PBCSP on student participation in science through involvement in a "real-life" science project. Specifically, our aim was to investigate the impact of the PBCSP on students' scientific knowledge and skills as well as their attitudes towards science. The findings concerning the impact of PBCSP are encouraging. Data analysis shows a significant improvement in attitudes towards science, a positive impact on students' attitudes towards science, and increased scientific knowledge and skills. These results can be attributed to certain characteristics inherent in PBCSP: subject relevance and the project's engaging and collaborative nature.

The study's project connected students to a nearby environmental issue, involving them in learning about the impacts of an invasive ant species on local ecosystems close to their homes. Presentations by First Nations rangers about how to use traditional knowledge to "care for Country" alongside scientific inquiry helped model for students the bridging of cultural and scientific knowledge, thus making a deeper connection to the subject matter possible. These findings are similar to what other researchers found; that integrating relevance into learning sparks students' interests and acknowledging diverse cultural backgrounds enhances engagement (Lemke, 2001; Grueneweld, 2003; Lyons, 2006; McKinley, 2016).

As Ballard et al. (2017) also found, the project's contextual and experiential learning components also improved students' interests in STEM fields. The students collaborated with one another and scientists on a scientific investigation to solve a "real-world" problem in their community. In other words, the students had opportunities for direct engagement with their local environment, thus providing a tangible example of how science can be used to understand and address community-specific issues.

The collaborative nature of the project also contributed to positive changes in students' attitudes, enabling students to discover science as a social endeavour and develop teamwork skills. Students also noted feeling a sense of ownership and empowerment through collaboration with scientists and First Nations rangers. This sense of ownership is important for developing positive attitudes towards science, especially for students who might otherwise feel marginalized in traditional science classrooms (Gallay et al., 2021).

Mentorship and guidance provided by the WTMA scientists before and during the yellow crazy ant project, including teaching GIS and mapping skills, survey methods, the importance of First Nations culture, the role of detection dogs, and field excursions demystified the scientific profession, potentially making the idea of pursuing a career in STEM more attainable. This is especially true for students from low socio-economic backgrounds, who may not often be exposed to professional networks and career opportunities in STEM fields (Archer et al., 2014).

Participant students also increased their science knowledge and skill development, including how to use scientific tools (e.g., GPS) and techniques (setting up lures) to collect data, pose scientific questions, plan and conduct investigations, collect and analyze data and write a scientific report to communicate their findings. These skills are fundamental competencies in scientific inquiry emphasized in the *Australian Curriculum: Science* (ACARA, 2024). Teachers reported that the PBCSP had a noticeable impact on students' science inquiry skills and higher-order thinking, as well as increasing teamwork, communication, and problem-solving skills, which are essential for success in STEM careers but are often underemphasized in traditional classroom settings (Department of Education and Training Government, 2016).

The role played by passionate teachers cannot be overestimated in PBCSP because the support of school leaders fosters an environment where such projects can flourish (Gracey, 2018). The school leader in this study was very supportive of the STEM Academy, the facilitating teacher, and the yellow crazy ant initiative. The WTMA and the researchers were warmly welcomed into the school and reported that the PBCSP has opened up conversations with other schools interested in such collaborations.

One of the limitations of this study was the small sample size and limited to students who joined the STEM academy. Another limitation is that the findings are specific to the context of the study and, therefore, may not be generalizable to other situations.

Conclusion

The research results indicate potential benefits for primary school students when involved in a PBCSP such as the one reported here. Study findings show an identifiable development in students' science knowledge and positive attitudes towards science due to involvement in the PBCSP resulting from their collaboration with WTMA scientists in eradicating *Yellow Crazy Ants* in Far North Queensland. The success of the collaboration can be attributed, in part, to students and scientists achieving their own goals within the project. The involvement of the students gave the WTMA scientists a valuable conduit into the community for awareness raising about an invasive species that they otherwise would not have had.

This was due to the interest raised in families about *Yellow Crazy Ants* by students returning home and talking excitedly about what they had been doing at school. Likewise, the involvement of the WTMA scientists in the school enabled the school to better meet their science curriculum and teaching and learning obligations to students by enabling students to work on a real-world, locally contextualized environmental problem that the school's behaviourist approach to science pedagogy otherwise would not likely afford.

Although the increase in science knowledge and positive attitudinal change was limited to those students participating in the STEM academy, the research results indicate that students who returned to their classes talking excitedly about their learning have positive flow-on effects in terms of increased numbers joining the STEM academy. Future initiatives might capitalize on these flow-on effects and consider how science could be taught differently in mainstream classrooms based on the PBCSP model.

Author Contribution Authors 1 and 3 gathered the data and conducted the initial analysis for this study with input from author 4. All authors contributed equally to the writing and revising of the manuscript.

Funding Open Access funding enabled and organized by CAUL and its Member Institutions.

Data Availability Not applicable.

Declarations

Ethical Approval and Consent to Participate The authors received consent from all participants for inclusion in the study and dissemination of findings. The consent was approved by the James Cook University Human Research Ethics Committee, approval number H8719. Approval was also granted by the Queensland Department of Education.

Conflict of Interest The authors declare no competing interests.

Disclaimer This publication does not necessarily represent the views of the *Queensland Department of Education*. Information has been presented in a way that is sensitive and respectful of cultural, religious, and other differences amongst research participants.

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