A transdisciplinary approach to teaching citizen science in a primary classroom

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Abstract

This paper reports on a transdisciplinary approach to science with a Year 4/5 class incorporating citizen science through the Birds in Backyards project. This transdisciplinary approach created opportunities for student engagement through science, mathematics, design and technology, humanities and social sciences (HASS), arts and English, while also creating meaningful connections to nature and the local environment.

Introduction

Activist Jane Goodall (2014) acknowledges the work of young people trying to repair waterways, replant wildlife corridors and restore vegetation and wrote that these actions teach children that they can make a real difference. Through being empowered to take action, Goodall noted that children were energetic, developed problem-solving skills and were committed to protecting wild animals. Creating a space for children to learn about these issues, she argues, is critical for producing future sustainability and nurturing environmental thinkers. Goodall (2014) advises that we all have a role to play in bringing about change. It is the cumulative efforts of all members of the community, no matter how small, that will contribute to major changes in the world. In a primary school setting, incorporating environmentally based citizen science projects is one way to spark students' interest in science. Such projects can involve students in authentic experiences such as monitoring vulnerable or invasive species, diseases or threats, and changes to habitats over a span of time (Buchanan et al., 2019).

Science, particularly 'Science as a Human Endeavour', provides opportunities for educators to introduce sustainability projects to help students develop an awareness of the world around them (ACARA 2022). Citizen science projects enable students to learn the roles of scientists in the community and engage in hands-on, authentic science that often leads to exploration of nature in their own environment.

The focus of this paper is a transdisciplinary approach to planning that uses multiple learning areas to build the field of knowledge and authentic citizen science projects to make science and learning engaging and exciting. An overview of citizen science and transdisciplinary approaches to teaching is provided at the beginning of the paper. We then describe the key phases of planning and teaching and outline the ways in which six curriculum areas are included in the transdisciplinary approach. The six curriculum areas of science, mathematics, technology, HASS, English and the arts are integrated in a detailed case study of a Year 4/5 classroom's whole-term curriculum that centred on birds.

Citizen Science

Dickinson and Bonney (2012, p.1) describe citizen science as 'public participation in organized research efforts'. Citizen science research projects are conducted around the world and involve countless numbers of citizens who are willing to use their free time to help scientists gather data for their projects. Citizen science is not new; it dates back to the nineteenth century with bird surveys conducted in Europe (Drennen, 2021). In modern times, the internet is abundant with scientific projects on environmental issues that citizen scientists can participate in by collecting local data on behalf of research teams (Dickinson & Bonney, 2012). Citizen science projects are usually sizeable, with researchers inviting people from the community to help collect data. This is due to the research zone either being too large for one researcher to cover or the scale of the project (Simpson, 2013).

From a teaching perspective, citizen science projects can be seen as an opportunity to involve students in real science projects. Students can also learn the science skills of observing, questioning, identifying, categorizing and investigating in an authentic science context. Authentic, nature-based projects, such as those involving citizen science, can create pathways for students to develop naturalistic intelligence, a nature connection, a relationship with their local community and an enjoyment of science learning (Paige et al., 2020; Louv, 2008; Comber & Nixon, 2013; Wells & Trimboli, 2014).

Paige, Lloyd and Smith (2019) list some rich examples of citizen science projects conducted with South Australian schools, including Operation Blue Tongue (2007), Operation Possum (2008), Operation Magpie (2009), Operation Spider (2010), Operation Koala (2015/16), Cat Tracker (2015/16) and Water Literacies (2017). In these citizen science projects, students collected data about local community issues and, as noted by Paige et al. (2018; Paige, Haggerty & Comber, 2022), felt valued for their contribution. Other examples of Australian citizen science projects, discussed by Renshaw (2019) and Gorton (2021), include entomological studies of bugs, butterflies and moths. The Bug Project motivated students to form a lunchtime bug club. The Butterfly and Moth Project ultimately led student citizen scientists to discover a new species of moth (Gorton, 2021). These projects are rich examples of how to encourage primary school students to develop enthusiasm for science and their environment.

Transdisciplinary approaches to teaching

Wilson and Lloyd (2010) define transdisciplinary pedagogy as using multiple disciplines for students to understand an issue so they can work creatively on a solution. Common aspects are that the unit of work is issue-based and incorporates multiple disciplines to expose students to many ways of knowing, heightening the way students think, discern and encounter knowledge. Taking the idea of 'science literacies across the curriculum' is what a transdisciplinary approach entails (Skamp & Preston, 2021); breaking down the walls between learning areas to develop literacies across the curriculum, inside and outside of the classroom. For example, Wilson and Lloyd (2010) claim that when using a transdisciplinary approach, students develop critical thinking skills that can be applied to their schoolwork. They believe the focus problem, whether ecological or social, should not be related to any one discipline but that all disciplines should be drawn on to address the problem, enabling students to develop problem-solving skills that can be transferred across learning areas.

The unit of work included the Birds in Backyards Project to enable involvement in an authentic science project. The theme of native birds was woven through all learning areas to build students' field of science knowledge. An intention of the next section is to document pedagogy that improved student engagement in science, and improved attendance and engagement in learning. Taking a transdisciplinary approach, focussed on citizen science, provided an authentic science learning experience and encouraged the use of outdoor spaces (referred to as our outdoor classroom). Tapping into nature spaces in the school and local community was a cost-free resource used to promote a love of nature and lifeworld connections to science learning. The outdoor classroom served as a 'hook' to engage students in science, and to provide interesting learning that encouraged students to attend school. The citizen science project created a space for continued engagement in science, in school and beyond.

Birds in Backyards: A transdisciplinary unit of work

The lead author created a transdisciplinary unit of work centred on the Birds in Backyards Project, which she undertook with a Year 4/5 class in the northern suburbs of Adelaide, South Australia. The 5E science framework for planning (Australian Academy of Science, 2021) was employed to create an in-depth unit of work that was built from students' prior knowledge across disciplines. The 5E framework comprises the following aspects: 'Engage', 'Explore', 'Explain', 'Elaborate' and 'Evaluate' (Bybee, 2015). The learning was planned and implemented through the STEM learning areas of science, technology, engineering (design and technology) and mathematics The teaching and learning focus went beyond STEM to also include HASS, English and art. The unit of

Table 1: Timeline of the transdisciplinary unit of work and topics taught.

5E Model		Subjects	Layered Learning
Week 1	Engage	Science	Prior knowledge activity-annotated bird diagram Introduction to bird identification charts and scientific tools for bird observations
Weeks 1–7	Explore	Science	Completing bird surveys for Birdlife Australia
Weeks 1–16		Science, Literacy	Research opportunities to focus on student directed inquiries often resulting from fieldwork observations
Weeks 2–4		Science, English	Question storming, research and book making
Weeks 1–16		Art	Art — starting with book covers and ending with various projects requested by students
Weeks 5–11	Explain	HASS, Science	Bird investigation
Weeks 4–16		English, Science	Daily reading lessons using environmental texts
Weeks 8–12	Elaborate	Mathematics	Mathematics: data and graphing
Weeks 9–16	Elaborate, Evaluate	Design and Technology	Engineering through ideals of biomimicry Inventions and presentations
Week 12	Evaluate	Science	Post knowledge activity: Draw a labelled bird diagram
Weeks 4, 8, 12, 16	Evaluate	English	Letters to Kangaroo Island pen pals

work was introduced in layers of learning to build the field of knowledge with students. For example, the bird survey was introduced during the explore stage whereas the bird investigation was introduced in the explain stage. Table 1 provides a timeline of the unit of work, including a brief description of the key learning and the weeks taken to complete the learning experiences.

Nature-based learning opportunities help students to make stronger connections to the natural world (Charles & Louv, 2020). Therefore, this unit focussed on exploring spaces within the school such as the school oval, the butterfly garden and the playground as well including the nearby wetlands. After each outdoor experience, time was allocated for students to raise questions and investigate to satisfy their curiosity. This ensured engaging learning opportunities for all ability levels were provided. Students were also required to share their observations and knowledge with the class. As a result, discussion was a key learning focus in this unit. A comprehensive concept map outlining the connection across and between the different learning areas is provided in Figure 1.

It is used as a visual aid to enable the educator to plan and connect learning opportunities to the unit of work. In the next section, an overview of the key learning intentions of each learning sequence is provided and examples of student experiences are described.

Engage stage

Educators are encouraged to include a prior knowledge assessment/activity (as part of the Engage phase) to discover student alternate conceptions and find the starting point for the unit of work. Additionally, the Engage stage includes hands-on activities to spark interest in the topic. The prior knowledge task for this unit of work involved the students constructing an annotated bird diagram and a list of known facts about their chosen bird. This diagram was then used to ascertain their understanding of physical characteristics of birds and was later used as a reference point for assessment as the students were tasked with completing an annotated bird diagram again later in the unit (see Table 1, Week 12 Evaluate). Both diagrams (defined as 'pre' and 'post') were analysed to show each student's conceptual development across the unit of work. Figure 2 below is an example of a student's completed prior knowledge task. As evident in the figure, a student demonstrated understanding of a basic shape of a body and included legs, beak and feathers. A nest with eggs is included, a worm as food source and the setting is a tree branch. The pre-test indicated a basic understanding of bird features. This can be extended through research opportunities, inclusion of multiple exposures to bird-related texts and bird observations to provide insight into the science of birds. This was added to the Explore stage and

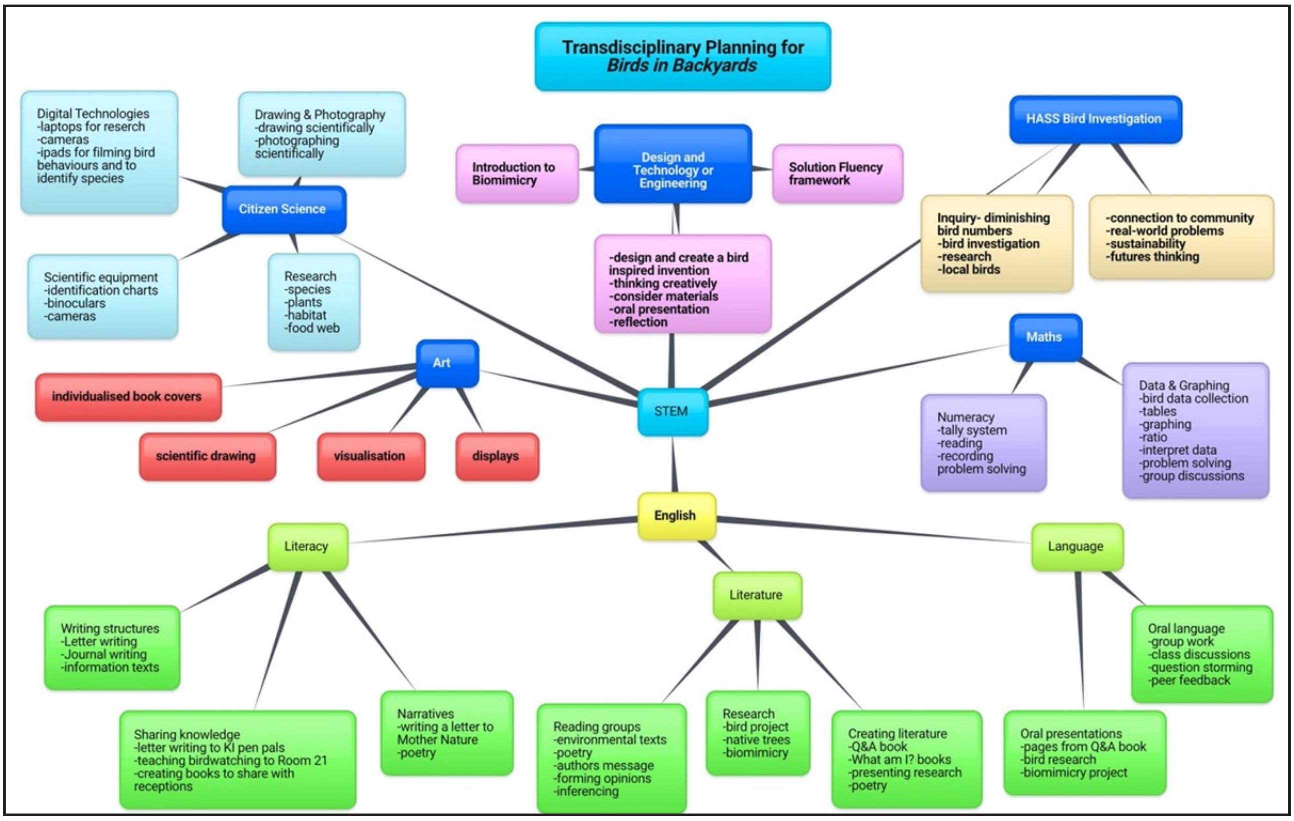


Figure 1: Transdisciplinary concept map showing connections between areas of learning covered.

investigated further during the Explain stage.

Further engaging students, the next lesson introduced the bird identification charts, binoculars, cameras and iPads. Instructions on how to record scientifically was explicitly taught. This was followed with a walk outdoors to explore the school environment, sit within nature to watch the bird activity, and experiment with the tools. In the classroom, the students were introduced to the Birds in Backyards bird survey. This exposure to environmental science excited the students and they were interested to learn about bird species on school grounds: the spaces they inhabited; the food sources they derived from trees, plants and grasses; and the change in bird activity as the seasons changed.

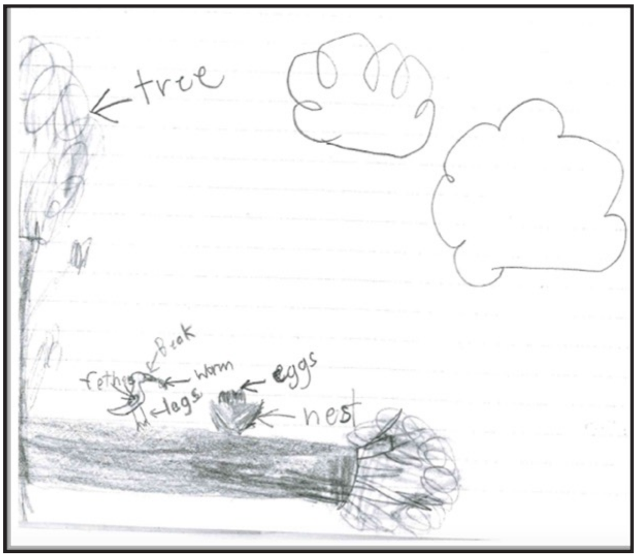
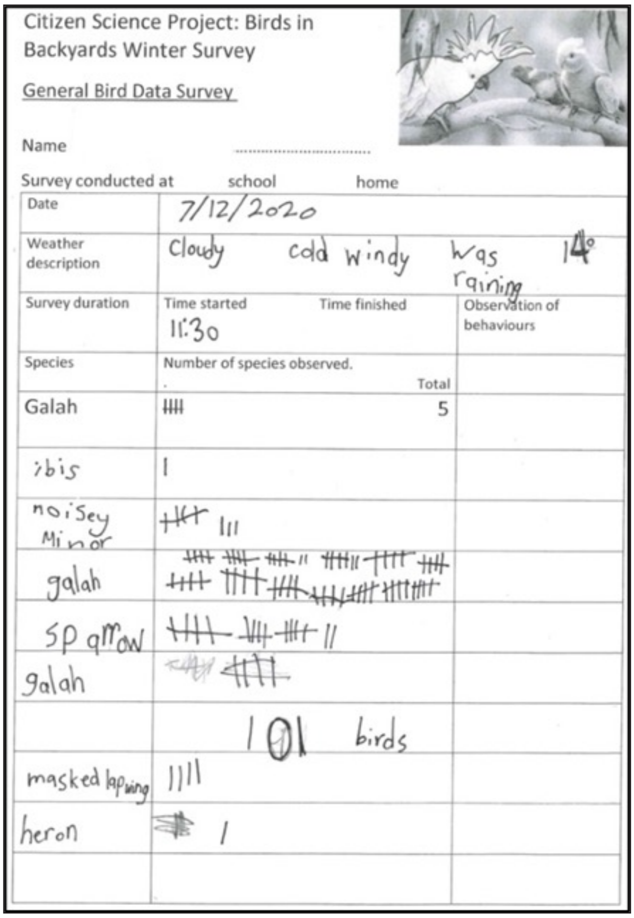


Figure 2: Pre-test annotated bird diagram.

Explore stage

The Birds in Backyards citizen science project, as previously noted, required students to engage in fieldwork (e.g., complete weekly bird surveys within the school grounds, discuss and research answers for student's inquiries resulting from the fieldwork) and as such this made up the majority of the Engage and Explore stages. As part of the Explore stage, students were taught to observe bird species and record bird numbers and behaviours on a bird survey sheet. They were provided with scientific tools, such as binoculars, and taught how to use bird identification charts, binoculars, cameras and iPads to record scientifically. Figure 3 is an example of a completed bird survey observation and data collection of birds sighted on our school oval. In completing these observation sheets, students were required to provide a description of the weather, the survey commencement time, and use a tally system to record bird sightings and note behaviours. On the back of the survey there were four questions for students to record. They were observations of aggressive interactions, native plants birds fed on, birds bathing, and any weird and wonderful things the backyard birds had been up to. This was part of the data Birds in Backyards scientists were collecting.



Citizen Science Project: Birds in Backyards Winter Survey

General Bird Data Survey

Name ....

Survey conducted at school home

Date	7/12/2020		
Weather description	Cloudy cold windy was raining 14°		
Survey duration	Time started 11:30	Time finished	Observation of behaviours
Species	Number of species observed.	Total	
Galah	卌	5	
ibis	I		
noisey Minor	卌 III		
galah	卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌 卌		
sp arrow	卌 卌 卌 II		
galah	卌		
	101 birds		
masked lapwing	IIII		
heron	I		

Figure 3: Bird survey data collection.

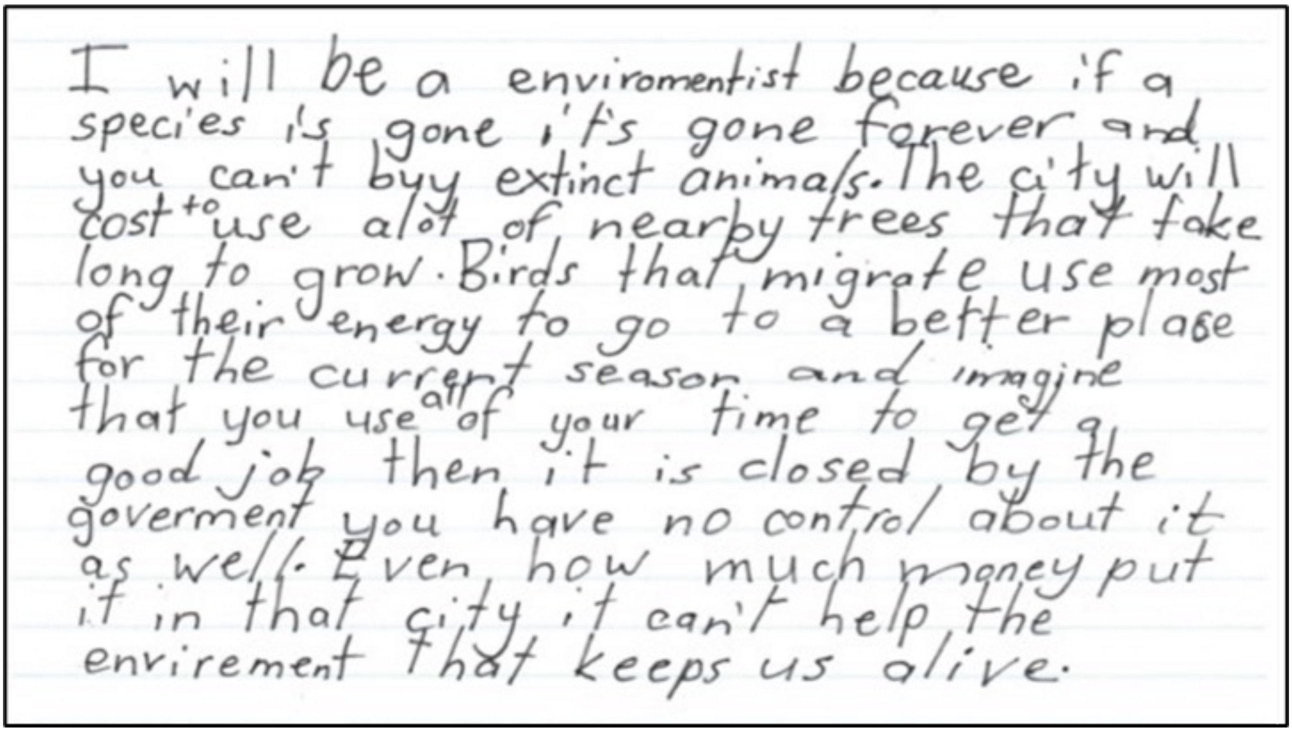
A main objective for the Explore phase was that the classroom climate was designed to be reflective of a scientific community. This meant that sharing ideas and working collaboratively was expected practice. Research-Based Learning (Table 1, Week 2–4, Explore stage, English lesson, question storming), was applied to create an opportunity to build the field of bird knowledge. Question storming enabled students to ask any question about birds that intrigued them. Students were paired and they began researching to find answers to their assigned questions. Students were given choice regarding the method of presentation of this work. Their options were recording in their workbooks, creating posters, or making a book. Students nominated to create a book. During the Explore phase, a total of seventy different questions were researched by the students. Each pair typed the question at the top of a page and the answer at the bottom. For example, at the top of the page the question was, ‘Why do birds lay their eggs in trees?’ The answer was then written at the bottom of the page: ‘Birds lay their eggs in trees because the animals on the ground will probably eat the bird eggs’. The students then illustrated the page with a nest in a tree and birds flying about. Cross curriculum connections were embedded authentically. For example, during an art lesson, students illustrated their work. The research was then placed into categories of interesting facts, diet, habitat, communication, features, movement and endangered. Then it was bound to make a book. This was an opportunity for students to share their work with the school community and as a result the book was then placed in the library.

Explain stage

Guided and modelled reading lessons based on environmental texts such as books on birds, rainforests, gum trees, bugs, etc., were used to increase knowledge of birds. Environmental texts were used during this time to understand habitats, bird adaptations and body structures, bird migration and sustainability issues. Addressing sustainability, integrated curriculum connections between science and HASS, was prioritised with a focus on a local community sustainability issue — the demise of small birds in urban spaces. This linked the information being learnt during guided reading with the small bird investigation. The unit focus on sustainability of habitats required students to learn about feather uses, beak mechanics and feet shapes used for eating, climbing, nesting, and habitats and food sources during migration. Students used this knowledge to present a poster and oral presentation to their peers, demonstrating their understanding of the adaptations required for the different bird species to live sustainably within their environments.

This thread of sustainability is evident throughout the unit of work. Following bird adaptations, the next step was to explain the importance of protecting birds and their environments. This was introduced as a role play activity called Coorong City. The first stage of the Coorong City role play activity included a debate to either ‘build’ a city in the Coorong or ‘protect’ the area as a bird sanctuary. During the second stage a game was played. Students represented the birds and as they were eliminated from the game, they re-entered the game as tourists, trucks, etc. Over time, as the Coorong City was built, the birds’ food sources and habitat were slowly destroyed and the birds died or stopped coming to the Coorong. Students discovered that their decisions impacted on the birdlife.

One student reflection (Figure 4, below) acknowledged bird extinction, years for trees to grow, the amount of energy birds use during migration, and the outcomes from the destruction of bird environments learnt throughout the unit



I will be a enviromentist because if a species is gone it's gone forever and you can't buy extinct animals. The city will cost to use alot of nearby trees that take long to grow. Birds that migrate use most of their energy to go to a better plase for the current season and imagine that you use all of your time to get a good job then it is closed by the goverment you have no control about it as well. Even how much money put it in that city it can't help the envirement that keeps us alive.

Figure 4: Student summary reflection on the Coorong City role play.

of work. The student compared bird migration and environmental damage to getting a good job then having it shut down by the government. This showed a depth of thought and reflection as the student applied this environmental disaster to the lifeworld disaster of a job loss, a phenomenon often experienced in this community.

Elaborate stage

Design and technology complement the learning from the Explain stage enabling students to transfer their bird knowledge into another learning area. The unit of work includes opportunities for students to communicate their learning to the wider community in a variety of ways, for example, as pen pals and during assembly. Several unplanned lessons within the unit of work provided flexibility, enabling student-led inquiries to be researched or space for student-requested activities, giving students a voice in their learning.

Biomimicry, engineering inspired by aspects of the natural world, was introduced in the Elaborate stage of this unit of work to further expand on students' knowledge of bird adaptations. This was introduced through the *Design and Technology Curriculum*, where students were prompted to create a bird-inspired product that showed their understanding of bird mechanics or behaviours. The design phase of this learning experience required students to create a labelled diagram of their idea. The production stage included making a model of the idea. Students then made an advertising poster, completed an oral presentation, and wrote a final reflection of the process.

The transdisciplinary unit also included journal writing, letter writing, listing bird behaviours on the survey, recording mathematical bird data and providing explanations of inventions. Additionally, the variety of oral presentations throughout the unit of work contributed to the development of oral language and communication skills. Students were also given the opportunity to write to a pen pal living on Kangaroo Island. This activity enabled students to foster a community connection as well as improve letter writing skills, to practice communication skills, and as an opportunity to share their learning experiences.

Flexibility is important with a transdisciplinary approach to keep students motivated and extend learning. This is evident when, after completion of a bird survey, students requested time to research answers to their questions resulting from the observation. For example, which trees are the best food source? To encourage both scientific and mathematical data interpretation, students compared their bird survey data. They used this data to create graphs during mathematics lessons. Many opportunities to problem-solve and think critically occurred. For example, when students created picture graphs, the large number of birds recorded required students to problem-solve. The students decided on a 2:1 ratio and how to represent half a bird in their picture graphs,

Figure 5: Post-test annotated bird diagram.

showing confidence in their mathematical skills. The outcome was that students were independently thinking mathematically and learning through problem-solving and discussion.

Evaluate stage

Representations are an important vehicle to gauge student understanding. Models, diagrams, illustrations, etc., throughout the unit of work are valuable representations for the evaluation of student understanding. Formative assessments included contribution to class discussions, participation in activities, team and pair work, student journals, letters, artworks and oral presentations. Ability to transfer knowledge from one learning area to another provides evidence of depth of knowledge.

Research enabled students to build their own knowledge. Evidence of the research can be found in student journals, during class discussions, and in self/peer evaluations. Repeat experiences of birdwatching enabled students to develop their own bird identification techniques. For example, students began identifying birds by colour, underside patterns during flight, and some students laid on the grass to take 'mind pictures' as the small birds flew over them. Evidence of a particular student's intellectual growth (compared to her initial diagram, Figure 2) is found in her second annotated bird diagram of a pink and grey galah (see Figure 5) where she recorded three feather types, left and right wings, toes and claws, and adjustment to alternate conceptions. This suggested growth in her ability to identify body parts and wing dynamics, to draw with accuracy, to label scientifically and understand science concepts. This is a scientific representation that show growth in students' understanding of science.

The design and technology task was used in the Evaluate stage to assess students' ability to transfer

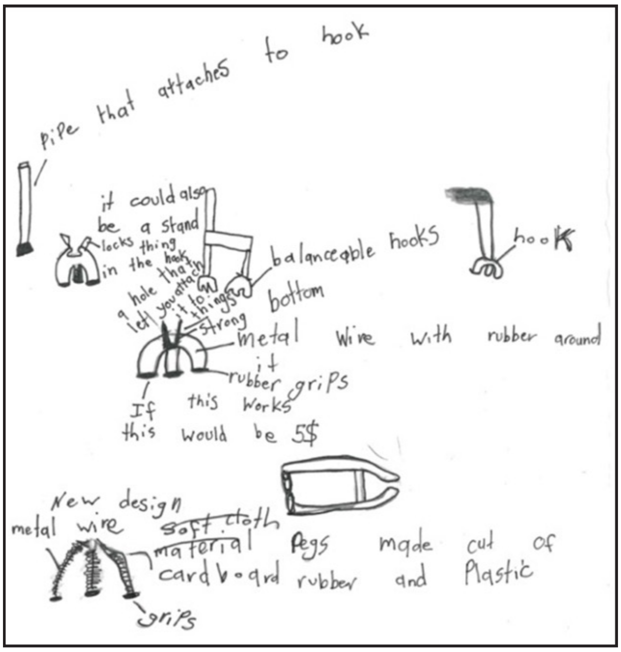


Figure 6: Walking stick balancer created by two students.

their knowledge into a bird–inspired project. Figure 6 is an example of one of the products 'designed' by the students. It is a clip-on walking stick claw, designed by two students collaboratively. Their design was based on the claw structure of a bird of prey, showing an understanding of biomimicry. The students showed multiple views of the design and how each section worked. They made changes to their choice of materials, showing contemplations and reformulation of ideas. These two students were also able to explain their ideas during their oral presentation providing evidence of transferring their knowledge of bird adaptations.

Throughout this unit of work, the arts became a spontaneous way of showing understanding and was used across learning areas. For example, students requested to decorate the classroom window with cockatoos flying in a V formation seen during their bird survey observations (see Figure 7). Evidence of understanding through representations are valuable ways for students to show the depth of knowledge built and should be included when assessing evidence of student knowledge and understanding.

Reflections on Transdisciplinary Planning

The unit of work had a strong emphasis on place-based connections and the natural environment and provided opportunities for students to share knowledge with others. Including community connections in learning teaches students to value and respect their local environment (Buck et al., 2016). In this unit, the students became scientists, naturalists, researchers, communicators

Figure 7: Window display of V formation.

and formed a community of learners. Learning incorporated the world around them, and this made learning interesting and relevant. Local community experts were unable to visit the school due to COVID restrictions, but students became the experts when sharing their learning experiences with their Kangaroo Island pen pals, at assembly and with other classes.

Benefits of a transdisciplinary approach

Analysis of this unit of work shows that the richness of the transdisciplinary approach enabled science literacies to develop across the curriculum. This richness occurs when the science learning is used to create artworks, to make connections to geography, write persuasive texts, or as a component of a mathematics topic. The immersive requirements of a transdisciplinary approach enables the combination of disciplines to allow deep knowledge to develop. Time was allocated for students to investigate their own inquiry questions that resulted from different learning experiences. This developed their research skills and led to robust discussions, collaborative working, and building their willingness and confidence to share knowledge. Students experienced the work of real scientists and were learning to build a community that worked scientifically.

Planning a transdisciplinary unit of work is complex and time consuming, however, it enables depth of learning as well as the flexibility to change and incorporate student requests. Students were building knowledge through robust discussions, making connections to their lives, and as researchers. Students were taking the learning into their own hands by requesting new learning opportunities. They were excited to learn and wanted to be at school. Importantly, students of all abilities were able to actively participate. Students participated in several science-based environmental projects during the year and thrived in having an authentic focus for reading and writing. The learning was connected to the place students lived and the school they attended, providing a personal connection to learning and as a result discussions were rich, factual, and engaging. These outcomes are rewarding and an example of good primary science.

Planning for the transdisciplinary approach meant that students learnt about birds through multiple disciplines. The different subject areas overlapped on the teaching timeline enabling rich science learning to happen 'in the moment'. Nature triggered their interest, and the Birds in Backyards project provided a purpose for learning. The students connected to their learning on a personal level, deep science knowledge was built, and conceptual understandings developed.

Challenges to a transdisciplinary approach

The educator's first transdisciplinary unit of work can be used as a blueprint for future units to be planned. However, it is important to acknowledge that transdisciplinarity is not easy to plan for, especially when planning, and timeframes, have to be regularly adjusted. For example, in this unit of work, connections needed to be made across the curriculum and opportunities to weave the citizen science topic throughout the unit had to be found and planned for. This, like any integrated approach to STEM, as discussed by Anderson & Li (2020), is time consuming.

As well as investing time in planning meaningful connections, consideration also needs to be given to creating the right type of classroom culture. A classroom culture of working like scientists meant students needed to learn to work positively in teams. This needed to be explicitly taught, and on occasion, some behaviours were challenging. Beginning each new project, students were allocated different partners to encourage positive communication between students and the sharing of information.

The initial plan was for the Birds in Backyards unit of work to be a ten-week unit of work, however, it extended an extra six weeks through students requesting new directions/lines of inquiry. This was a positive outcome, as students were engaged and motivated to learn more. Another example of self-motivation was evident with students who missed bird watching and data collection lessons due to attending reading support lessons. These students requested a catch-up session as they had missed out. The school timetable has many challenges, for example, Non Instructional Time lessons, Literacy support for small groups of students, and cultural lessons for Vietnamese and Cambodian students.

Concluding Comments

Creative educators need to look for pathways to develop students as critical and creative thinkers who will one day be the custodians of our world. If we, as teachers of science, really want to engage students in schools, then it is imperative that we connect learning to students' lifeworlds. Citizen science provides this lifeworld connection and the nature experiences connect students to their local community, helping to make science relevant and interesting. It is evident that children can develop key science understanding, which connects to other learning areas such as mathematics, design and technology, Art, English and HASS. Incorporating citizen science projects provides authentic learning experiences, robust classroom discussions, and hence meaningful connections to students' lifeworlds Throughout this unit, the students were highly engaged in their learning and having fun in a high-expectation learning environment with a safe and accepting classroom culture.

About the Authors

Bernadette Haggerty is currently a primary school educator. Bernadette's research interests are in environmental science, culturally responsive pedagogy, place-based education and connecting children to nature. She completed her Master of Education in 2022 using her passion for citizen science as the basis for her research. Bernadette was the winner of the 2019 World Education Forum South Australian Educator's Award, and in 2021 received the Sustainable Schools Educator Award for South Australia.

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