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'Operation Magpie': Inspiring Teachers' Professional Learning Through Environmental Science

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Abstract Operation Magpie was a citizen science project that involved the community in collecting data about magpies. This article describes one aspect of the project from an education perspective. The study began with a collaboration of teacher educators, environmental scientists and a local radio station. After an initial workshop with 75 teachers, three teacher educators met regularly with 13 primary teachers who each volunteered to plan and teach a unit of work on birds. Meeting regularly in focus groups, the teachers shared their pedagogical strategies that supported students to connect with their local environment. Findings include the importance of focused professional learning for teachers through ongoing, needs-based support during the planning and teaching of the unit, and the innovative ways that teachers approached the unit. One unexpected finding was that teachers tended to identify student learning in terms of the English curriculum rather than the science curriculum.

Conway (2005, as cited in Dempsey and Arthur-Kelly, 2007) reports that teacher professional learning should not only support teaching and learning activities within a school, but it should also 'enhance teacher skills by addressing the gaps in those skills' (p. 137). This article describes an approach to professional learning that engaged primary teachers in developing the confidence to plan and then teach environmentally based science. The approach complements one of the key tenets of the Teaching for Effective Learning Framework Guide (Department of Education and Children's Services, 2010), which states that 'Teachers learn together by sharing their thinking, practice, programs and responses to students' work' (p. 18).

The professional learning program involved a small group of teachers meeting regularly to develop an inquiry-based approach to teaching, and it is the impact of the professional learning experiences that incorporated science, environmental education and connecting students to the natural world that is central to this article. An underlying principle of inquiry-based education is an emphasis on active learning and on developing the learners' skills and abilities (posing questions, planning investigations, critical thinking), as well as on conceptual understanding (Bell, Smetana, & Binns, 2005;

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Hofstein, Navon, Kipinis, & Mamlok-Naaman, 2005; Luera & Otto, 2005; Martin-Hansen, 2002). The approach used in Operation Magpie involved teachers and their students collecting data about birds, in particular magpies, in the school environment and local parks, and then submitting their observations to an online survey. The article begins with a short description of the status of primary science in Australian schools, and an outline of Citizen Science. This is followed by a summary of the study, which involved regular meetings with three groups of teachers to share their practices. The article concludes with key findings.

Background

Teacher educators and teachers alike argue that today's students need to be eco-literate, 'knowing how the world works, and therein knowing how to preserve and maintain the environment' (Cutter-Mackenzie & Smith, 2003, p. 502), and scientifically literate. Scientific literacy includes being 'familiar with the natural world and recognising both its diversity and unity' (Hodson, 2003, p. 645). Yet it has been well documented that primary teachers struggle to teach environmental education, and science in particular, citing lack of time, limited content knowledge and limited confidence about what to teach and how to teach it (Appleton, 1997; Goodrum, Hackling, & Rennie, 2001; Cutter-Mackenzie & Smith, 2003; Skamp, 2008; Fleer, 2009; Dawson & Moore, 2011; Vasconcelos, 2012). The need to improve science learning experiences in primary schools within Australia is rarely contested, and the Australian Government is currently emphasising teaching and learning in science, as well as in English, mathematics and history (ACARA, 2011). The purpose of this study was to encourage primary teachers to plan interactive learning experiences in science, by focusing on a 'nature-based' science topic as the basis for planning. While it might be considered common practice for primary teachers to teach the biological sciences, as Tytler (2007a) reported, and as this study found, planning the learning outcomes for science is sporadic at best and is rarely given high curriculum status. Akerson and Hanuscin (2007) have identified the need for 'ongoing professional learning experiences' for teachers (p. 654). With a similar goal in mind, the approach to professional learning in this study established a community of practice that provided a sustained and supported learning experience for the teachers. From the outset these teachers understood that they 'were able to bring (their) expert judgment to bear on how change might best be implemented in (their) own context and practice' (Loughran 2010, p. 201).

Such was the concern about science education that in 2007 the Australian Council for Educational Research (ACER) commissioned a report on the status of science education in Australia. The report (Tytler, 2007a) acknowledges the complexity of teaching science, and more particularly the dilemma for teachers when faced with several recommended approaches, including an inquiry-based approach, a socio-scientific approach or an open investigative approach. For this study, Operation Magpie adopted a socio-scientific approach to constructing curriculum, being issues-based in connecting students to the natural world. As Louv (2008) identified, many children, particularly those living in urban areas, do not connect strongly with their natural world.

Current approaches to teaching require an expanded range of teaching strategies and a move away from traditional transmissive teaching practices. Two frameworks that have been helpful in supporting the teachers in this study to plan sequential inquiry-based learning experiences are the Interactive Teaching Approach (Faire & Cosgrove, 1993) and the 5Es Teaching Approach (Australian Academy of Science, 2007; Bybee, 2002). Both approaches support constructivist principles of learning by incorporating student-led investigations and strategies which assist students to develop deep conceptual understandings. As Tytler (2007a) states: 'pedagogy, in a re-imagined science curriculum, will need to be more varied, more supportive of students' agency through more open tasks, increased discussion and negotiation of ideas, and involve more varied settings' (p. 66). Operation Magpie provided teachers and students with the opportunity to work in varied settings such as outside of the classroom and in the local park. The need for varied learning settings is supported by Rennie (2006), who suggests that our challenge as educators is 'to turn around the disinterested majority by making it worthwhile for students to learn science in a meaningful way' (p. 6). She argues that achieving this involves bringing school science and the out-of-school science community much closer together. Possibilities could include involving students, their families and friends in visits to institutions such as museums and environmental centres. In this article we suggest that another strategy is to engage students in the real life collection and analysis of scientific data in the schoolyard (Cronin-Jones, 2000), and in their local community, through participation in a citizen science topic.

There are numerous school and community-based projects in which citizens are encouraged to participate in ways that contribute to education for sustainable development, both formally and informally (Davies & Webber, 2004; Tilbury, 2004); for example, the Ecology Inquiry Project (Rosenszayn & Assaraf, 2011). In this article we focus on teacher professional learning through a citizen science project, which also involved two of the project's urban ecologists. Citizen science is an approach whereby professional researchers engage the community to collect data within a cooperative framework of research and education (Cooper, Dickinson, Phillips, & Bonney, 2007; Fitzpatrick, 2007; Phillips, 2007). It is a valuable research method that enables a large-scale collection of data over both time and space, and in places that are normally inaccessible to researchers, such as home gardens.

By their very nature, Citizen Science programs must involve a bilateral exchange of information. The involvement of the community (nonprofessional scientists) in the pursuit of science is advantageous for both scientists and the public who are involved. Once information has been collated and analysed, scientists disseminate the findings of the study in order to maintain public engagement. In return, the public are informed of scientific results and engaged in the outcomes through ownership of their contributions. In this way, the public enhance their understanding of the scientific method and of the natural world, and deepen their connection with decision-making processes regarding natural resources (Evans et al., 2005; Gouveia, Fonseca, Câmara, & Ferreira, 2004; Phillips, 2007). Citizen Science projects can be augmented in two ways. First, community-wide data that addresses the attitudes of the participants is collected and collated. Second, and in conjunction with the first process, the projects are expanded to include educational materials for school-based projects.

Because these projects are designed to be instances of experiential education (Brossard, Lewenstein, & Bonney, 2005, p. 1102), this approach has the potential to successfully engage both teachers and learners, as well as help learners develop connectivity to their natural world. Promoting the place and relevance of science outside of the classroom is one way to develop students' understanding and enhance their ability to make informed decisions. Providing learning experiences in which students make observations and record data in authentic settings, such as their local environment, is consistent with curriculum statements written in the newly drafted Australian Curriculum for Science (ACARA, 2011), in South Australia's Society and Environment curriculum (Department of Education and Children's Services, 2004), and in the Statements of Learning for Science (MCEETYA, 2006). The latter declares that students should experience 'other forms of individual and collaborative investigation such as field work, the use of models and simulations, examination of second-hand data, or information research' (p. 5). Thus, projects which are associated with initiatives such as Citizen Science may provide one way of achieving Tytler's 're-imagining of science education' (2007a). For teachers, involvement in an environmentally focused project may be an attractive strategy for introducing scientific concepts in the classroom.

While some efforts have been made to assess the impact of Citizen Science programs on adult participants, there is a paucity of data analysis and therefore limited determination of the value of such programs in schools (Brossard et al., 2005). Thus, this school-based study on Operation Magpie adds to the literature about citizen science and its place in education.

The Study

In South Australia, urban ecologists in collaboration with a local radio station have conducted state-wide Citizen Science 'Operations' over three years: Operation Bluetongue, Operation Possum and Operation Magpie. Towards the end of Operation Possum our small team of science teacher educators became involved in the educational aspects of Operation Possum, when we were invited by the urban ecologists to evaluate teacher involvement. The evaluation found that although some teachers were enthusiastic about the project, many of them did not fully utilise the resources provided by the urban ecologists, and often lacked direction in their teaching of the topic. Thus, we collaborated with the urban ecologists to develop a range of strategies and materials to support teachers involved in Operation Magpie. As magpies are a common bird in South Australia, this made an ideal topic to promote environmental science because birds are tangible and fit within the realm of children's experience (Chawla & Cushing, 2007).

The researchers used two strategies to engage teachers in Operation Magpie: (1) via widely advertised workshops, and (2) through participation in one of three Operation Magpie focus groups. Each strategy is briefly described below, but the data we report here was collected from those teachers who volunteered to participate in the focus groups. The research investigated the impact of participating in the Operation Magpie focus groups on the teachers' confidence to plan for and then implement an interdisciplinary topic which focused on students collecting and representing 'real' data in their local environment.

Professional Learning: Workshops and Websites

Prior to the formal data collection phase of Operation Magpie, we employed two key strategies to raise awareness of the project and foster teacher confidence and expertise in implementing Operation Magpie in their classrooms. First, an Operation Magpie website was developed (Barbara Hardy Centre, 2009), which provided teachers with an exemplar unit of work, a list of teaching resources, a link to the community-wide data collection survey, and scientific information about magpies. Second, a two and a half hour interactive workshop about Operation Magpie was conducted in three different metropolitan locations after school hours, in Term 2. The workshops were led by three teacher educators and one urban ecologist. Seventy-five teachers attended the workshops. Each workshop modelled a constructivist approach to teaching and learning using two frameworks: an Interactive Teaching Approach (Faire & Cosgrove, 1993) and the 5Es Approach (Australian Academy of Science, 2007; Bybee, 2002). As such, a range of strategies were used with the participants, including pre and post drawings of magpies, using binoculars to observe birds, studying some stuffed birds, using ornithological texts to identify bird species, generating questions about birds or magpies which were then categorised into research-based or inquiry-focused activities and, reviewing resources.

One of the broader goals of Operation Magpie was the collection of scientific data about the sightings, location and behaviour of magpies in their local area, and the submission of that data to urban ecologists via an online proforma. This data collection phase was to be conducted over a 6-week period and was open to any interested members of the public, including school teachers and their students. This aspect of Operation Magpie was also introduced at the workshops, thus assisting teachers in planning towards this phase.

In addition to the workshops, three focus groups were subsequently established. The primary purpose of the focus groups was to support the professional learning of teachers as they shared their experiences of planning and teaching an inquiry-based science unit revolving around Operation Magpie. From the viewpoint of the researchers, the focus groups provided an opportunity to monitor the impact of Operation Magpie on planning and teaching.

Professional Learning: Focus Groups With Teachers

Thirteen of the seventy-five teachers who had attended the workshop expressed an interest in participating in a focus group. Three focus groups were established in accord with teacher proximity, and the teachers were invited to volunteer their school as a meeting venue. The number of teachers in each focus group was limited to five to encourage networking, promote free-flowing conversations and to foster collaborative sharing of ideas and resources. The teachers taught students from reception to year six that is, from 5- to 12-year-olds, and came from a broad range of experiences and backgrounds, including public and private schools, a teacher of English as a Second Language, a teacher librarian, an early years educator who used a blog to communicate with parents, a final year preservice teacher, nonclassroom-based teachers and, teachers on 1-year contracts.

By mutual agreement, the focus group meetings commenced in the second term of the four-term school year. This allowed time for participants to develop their units of work prior to the official launch of Operation Magpie in Term 3. Although the teachers were offered teaching release to attend the three 2-hour focus group meetings, they preferred to meet after school hours due to the complexity of school timetables and the pressure of curriculum delivery. Each of the focus group meetings was attended by two teacher educator researchers, one to lead the discussion, the other to take notes. Conversations were tape recorded and transcribed, and the recordings were used to validate the notes taken. The teachers were then emailed a copy of the notes to ensure their views were accurately reflected and to provide them the opportunity to expand or remove any comments.

Each of the three focus group meetings had a specific purpose. The first meeting discussed possible approaches to planning and teaching a unit, during which time the teachers described their school and classroom context and their initial plans for Operation Magpie. At the second meeting the teachers brought examples of resources they were using and then shared their progress thus far. Lesson plans, ideas and resources were swapped and further needs identified. At the third meeting the teachers self-evaluated their progress, fully described their lesson sequences, shared more ideas, identified 'significant' events or moments that they would write about, provided examples of students' work, and then discussed future needs and interests in planning for science.

Collecting Data About Professional Learning

The study focused on the professional learning of the 13 focus group teachers. The teachers were asked to consider how their participation in Operation Magpie had assisted the learning and teaching process. The overarching question that guided the research design was: What impact did participating in the professional learning experiences provided by Operation Magpie have on teachers' confidence to plan for and implement an interdisciplinary topic about magpies?

To address the overarching question, six focal questions were used as the basis for discussions during one or more of the focus group meetings. These questions were:

1. What planning and teaching had the teachers undertaken for Operation Magpie?
2. What (if any) significant moments occurred during Operation Magpie?
3. What did students learn during Operation Magpie?
4. What data did students collect, and use?
5. Were the students now more interested in their local environment?
6. How had delivering this topic enhanced the teachers' pedagogical practices in science?

The teachers' responses were audio taped and written notes were taken by one of the two attending researchers. In addition, examples of teacher planning and students' work were shared, and noted.

Analysis and Findings

Students' work samples, teachers' plans and focus group meeting transcripts were analysed against the overarching research question about the teachers' professional learning experience. The analysis showed that those teachers who had involved their class with Operation Magpie beyond merely completing the public-use, online survey, who had used the project's support materials, and who had sourced supplementary resources found it to be an extremely beneficial approach to planning for student learning. While a number of common themes emerged, it was clear that there was wide variation in how teachers plan and teach environmental science, based largely on managing school-based priorities. These themes, attributed to the teachers' professional learning experiences, included evidence of: varied pedagogical practices and approaches to planning for learning; student learning, which included 'significant moments' that demonstrated the impact of their teaching; increased teacher awareness of the range of available support materials; increased student interest in their local environment; and greater teacher confidence in teaching science. Each of these themes will now be discussed in further detail.

Varied Pedagogical Practices

The introductory workshops modelled an interactive approach to learning and teaching, during which the teachers explored their own prior knowledge about magpies, conducted a series of exploratory activities, generated questions for further investigations and, discussed how their questions might be answered. In addition, the ecologist provided background information about birds, and specifically magpies, for the teachers.

All of the focus group teachers attempted some elements of an interactive approach to learning and teaching, and they provided numerous examples of how they had become more confident in using this approach to teach science; for example, Jen commented:

> [At the end of the unit] I asked the students to write everything they had learned about magpies and some other questions they would like to answer. I collated these and then they had to work in pairs to check whether they were

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> correct or not and whether they knew this was correct from [their] observation or research ... More discussion followed this. (JSFG3)

The teachers also noted that the approach readily involved the integration of other learning areas such as Mathematics, English, and Society and the Environment. For example, Heather had planned for her ESL students to learn how to condense text into key points, and to write in paragraphs and sentences. However, when trying what was for her a new teaching strategy, she found that the students became so enthusiastic about magpies that their need for a wider vocabulary became apparent and they developed word lists as well as questions for investigating. They researched the questions and incorporated the answers into computer-generated brochures.

It appeared that many of the units developed by the teachers were flexible in nature. That is, as students became more engaged with the topic, their curiosity and questions required the development of particular skills and, in some cases, the unit changed direction. For example, one teacher involved her five year old students in co-writing a daily blog diary that focused on the students' observations and experiences during the unit. Another teacher stopped during a PE lesson and switched to a science lesson when magpies appeared on the oval. As one of the teachers wrote:

> We incorporated it [Operation Magpie] into our study of animals and habitats. We used information on the web-site about magpies — students [became] interested in facts that they were unaware of and became better at identifying males/female /young. (S#7)

Planning for Learning

There was ample evidence that the focus group teachers had immersed their students in the project in very different ways and for varied lengths of time. Not all of the teachers had their own class, and so while some teachers integrated the magpie topic with other learning areas throughout all of Term 3, others held weekly lessons, or used an intensive block of time.

There was variation in the teachers' approaches to planning and developing a unit of work. Although one aim of the project was to encourage teachers to teach science through an environmental lens, not all of the teachers used preplanned, science-based outcomes as the vehicle for conducting Operation Magpie. A number of the teachers used English as the starting point. For example, note-taking skills were the focus in Karin's unit on birds, and her students used bird books to study a species of bird and produce a story-board. Karin also used the state government's Natural Resource Management Board resources about birds and their flight paths in the South Australian Coorong region. She used data collection as part of her mathematics program and the students developed codes to describe birds in the yard when they sat on gym mats to observe birds from their 'spot'. Peter's unit of work focused on student observation and data collection about birds in the local school neighbourhood. While he seemed to be one of the few teachers who had clearly identified desired science outcomes in advance of the unit being taught, the majority of the teachers could readily describe their students' science learning that had occurred by the end of the unit. This was aptly demonstrated when five of the focus group teachers presented their pedagogical stories at the annual state science conference.

Like Karin, the majority of the teachers took their students outside to observe magpies or other birds at some stage. For some, 'magic spots' were used, at which individual students or small groups selected a place where they felt safe and could quietly observe birds. Other teachers also took their students on excursions, whether to a local park, or to the Botanic Gardens. These experiences were then often linked to artwork and literacy-based tasks. For example, in Cathy's unit there was a strong environmental connection with a nearby conservation park and consequently her unit linked the school's commitment to management of this local park with the bird theme. The students conducted a sensory awareness walk during which time they were 'dropped off' at 50-metre intervals to develop their observation skills. After this visit, they chose a bird or other animal to study and produced projects, poems and reflective prose.

Pre-service teacher Stephanie and her mentor teacher used a literacy focus for their unit. The students observed magpies and drew diagrams. However, Stephanie found that students had to be taught how to observe and how to collect data. The students then studied birds' silhouettes and discussed the variation in birds' features, including feet, beaks and colours. They completed a reading comprehension sheet about birds.

School-focused events were another influence on the planning of the interdisciplinary unit; for example, Deb commented:

> Many of the books shortlisted for early childhood [in Book Week] featured birds. These books and the art and literacy topic activities they inspired were an excellent introduction to the topic on birds. (DCFG3)

And, as others said:

> It's got to fit with whatever you do. Everyone is different. (KSFG3)

> It fits with English, that's why we did report writing. (HSFG3)

> All children, R-7, participated in observation and data collection. Year 7 children entered data online and classes undertook a unit of work on magpies. (S#10)

Student Learning

Several teachers presented students' work samples, which demonstrated that their students had developed content and process knowledge. This evidence included research-based reports about birds, writing tasks that involved poetry and descriptive reflections about observations, diagrams of birds, graphically presented data with conclusions, and online survey data. It was evident from the teachers' conversations that the students had developed many skills, as well as increasing their knowledge about bird features and about magpies in particular. Vicki identified two of the learning outcomes as:

> Children were able to identify the characteristics of local birds and make the connection with their habitat, food etc. (VCFG3)

Another teacher wrote that her Reception/Year 1 students:

> ... would refer to the bird chart when unsure of a bird they had seen. One mother commented on how much her children had learned and was impressed they knew the names of a lot of birds. (S#4)

When commenting on her shy ESL students, Heather said:

> The children developed authority and expertise. They felt empowered to share knowledge. Some of the children now enjoy telling teachers in the school what they have learned about birds — they became an authority! (HSFG2)

Common themes emerged around the capacity building of students and in particular their skills in thinking and working scientifically through using their senses. Skills that needed to be explicitly taught and which had been modelled in the Operation Magpie

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workshop included: observing (looking and listening), the ability to use new equipment such as binoculars and stopwatches, the ability to collect and use data and, for some, the translation of the data into graphs and charts. As one teacher found, some of the planning needed to have been more focused:

> Overall, the students said they would have taken part in Operation Magpie [on-line survey] at home in the holidays had the lesson on recording happened before the holidays and not after. (S#2)

However, on further analysis it became apparent that the focus for the assessment of student learning rested largely upon assessing nonscience-based outcomes, with English outcomes frequently cited. It was not evident that all of the teachers had a clear idea of the science outcomes they wanted their students to achieve *prior* to teaching the unit. The science outcomes that were identified seemed to be more of a post unit consideration rather than a guiding focus. For example, teachers described how their students had increased their vocabulary and developed their ability to describe observations, but while samples of pre and post drawings of magpies showed an improvement of students' abilities to add details such as position of legs or number of toes, there was little indication of skill development in accurate scientific labelling or body representation. This suggested to the research team that the strategy of asking students to draw pre and post diagrams as a means of assessing learning is not well understood by teachers and requires further in-service, as does developing strategies for assessing student learning in science.

Significant Learning Moments

Operation Magpie inspired many teachers and students to learn more about birds and magpies. The teachers were able to provide numerous examples of significant learning moments; for example:

> Watching the kids work so well in groups using binoculars, timer and recording sheets; listening to the conversations of the kids as they watched the birds; their genuine interest and annoyance when the birds flew off; the lack of behaviour issues due to student and teacher engagement. One boy in a Year 4 class was so interested in bird watching that I invited him to join a Year 6/7 class for their science lessons for 2 weeks. He was there at the beginning of each lesson and was welcomed by the older students. He blended in and asked great questions. His teacher, who happily let him join the older class due to his interest, said he would come back from the extra science lessons beaming. (S#2)

Another teacher described how engrossed the students became:

> A child camouflaging hat and face with foliage so that the magpies wouldn't notice him during observation; children devising hand signals to alert each other of a bird's position or behaviour; bird calls being used to attract birds and, children telling me 'Shhhh!' during an observation session! (BCFG2)

Teaching Resources

The focus group teachers were unanimous that their knowledge of the available resources, not only for teaching a unit based on magpies but also for teaching in general, had increased. This increased awareness was in part due to the resources shown or used by the research team (books, lesson plans, fact sheets, models on loan from the Nature Education Centre). However, the teachers independently sourced and then shared many other resources, including internet sites, local government departments, the state's Department of the Natural Environment and Heritage materials, museum loan collections and relevant fiction books such as *Magpie Island* by Colin Thiele.

The teachers also acknowledged their limited understanding of key environmental and scientific concepts and their desire to have greater access to expertise/assistance. They appreciated having an ecologist at the initial workshop and requested more 'expert' input for future projects.

Student Interest in Their Local Environment

The teachers provided many examples of increased student interest that flowed into the classroom. For example, items were regularly brought into class by students, including nests and feathers, and there were many stories of sightings and bird behaviour. Parents also commented on the projects' impact on their children at home. Teacher's comments included:

> Yes, students often come up to me on yard duty and let me know the whereabouts and actions of our local magpies. More stories of magpie visitors to their homes are coming to school. Engagement, questions, interest and recall of facts during class is high. (S#2)

> Yes, if they see a magpie they tell me, they discuss if it's male, female or a baby bird and often mention what it was doing. New bird nests that have fallen onto the ground are still coming into the classroom. (S#4)

> Children began talking more about birds in school/yard and their gardens. While on camp we observed many different birds at Victor Harbor and many students were genuinely interested, asking sensible questions. (S#7)

Other examples illustrated how students were able to make the connection between the school-based topic and their home environment:

> Children brought in photos of magpies from their backyard, others had nests in their back yard which were photographed and brought into class. Children found different types of bird nests and brought them into the classroom. (S#4)

> About five students brought abandoned nests from home and from relatives, and descriptions of the parent and baby birds were given. Commonly used bird terms help students to communicate what the behaviours were. 'Show and Tell' sharing became a session where anecdotal stories could be individually shared. (S#9)

Confidence in Planning and Teaching Environmental Science

Each of the focus group teachers enthusiastically described how their involvement in the project had developed their confidence and interest in teaching science through an environmental lens; for example:

> Operation Magpie gave me a framework for a successful unit of work. The workshop, material and team meetings supported and inspired my teaching of the unit. A good model. I will do this unit again. (DFG3)

Some of the teachers also believed their teaching had been enhanced; for example, Ron commented:

> I enjoyed it. We do this bird and local environment each year but this topic allowed us to focus more on birds and the use of the school grounds and local area. (S#6)

Barriers to Teaching a Unit of Science

Although the focus group teachers had volunteered to be part of the project and remained committed to it throughout (no teachers dropped out), a number of obstacles still arose for some. For example, because of the Australian Government's focus on literacy and numeracy, the teachers believed that every topic taught in school required the inclusion of some literacy and/or numeracy outcomes, and as such, environmental science-based outcomes tended to be ignored in the initial planning phase. Existing school-based requirements also influenced the degree to which some of the teachers could engage their students in the topic. For example, one of the schools was involved in the International Baccalaureate program and science was not being taught that term; another school had a focus on maintaining the local national park, thus the unit was oriented towards that theme, with a reduced focus on collecting data about birds. Another obstacle to the teaching of an ongoing unit of work was that three of the teachers were either on contract or were nonclassroom-based teachers who therefore had limited regular contact with the students. Even so, each of these teachers was able to adapt to the circumstances and involve their students in Operation Magpie.

Summary Comments

This study focused on assisting teachers to plan an experientially based unit of work which engaged students with science, and in particular with their local environment. It has previously been found that many children, particularly those living in urban environments, do not connect strongly, if at all, with their natural environment and this can lead to what is termed a 'nature-deficit disorder, resulting in human alienation from nature' (Louv, 2008, p. 36). In this study the teachers' responses indicated that focusing on an iconic animal species that was readily found in and around schools and homes motivated and engaged them and their students. This supports the findings of Tytler (2007b) and Chawla and Cushing (2007) who emphasise the importance of experiential learning for students, and of Bouillion and Gomez (2001) who found that by developing school–community links, the students 'enhanced their learning in ways that were both meaningful and intellectually challenging' (p. 896).

The teachers who attended the workshops and who then became focus group teachers were motivated by meeting with like-minded colleagues to share resources and new practices, and to reflect on incorporating aspects of an inquiry-based approach into their teaching. As a consequence of this they commented on how they had increased their confidence towards using more inquiry-based practices in future lessons. Thus, a key finding is that regular and negotiated support can assist teachers to develop their pedagogical practice. This finding is consistent with that of Sinnema, Sewell, and Milligan (2011), who found that when teachers are supported to try new practices and to collect and share evidence 'through sustained, collaborative professional learning' (p. 258) they are more likely to maintain these practices. By blending an engaging topic with elements of a largely unfamiliar pedagogical approach, the teaching of an environmental science unit on birds was enhanced. Such an approach supports the work of Van der Valk and de Jong (2009), who report on their success with 'guided scaffolding'; and of Bell, Smetana, and Binns (2005), who reported that teachers need to 'first understand inquiry-based learning to be able to implement true inquiry-based learning in science activities' (p. 33). Thus, one implication for projects that support teachers' professional learning is that not only do they need to incorporate activities which assist teachers to identify the elements of inquiry-based learning, they also need to include activities which enable the teachers to practise and familiarise themselves with these skills before introducing them to their students.

A second key finding is the influence and impact of school and local or national education system requirements on projects such as Operation Magpie. In this study, the need to include literacy and numeracy outcomes in the units of work dominated planning, and at times seemed to focus planning away from environmental science-based outcomes. This suggests that some primary teachers might not recognise the integral nature of language to school science and indicates a need to discuss this when planning science-based units with teachers. While Tytler (2007a) argued that a governmental focus on accountability 'can lead to overly specific assessment practices in science that, while reliable, are low level' (p. 54), in this study it was notable that the increased accountability required in some key areas of the curriculum — literacy and numeracy — led to a depleted focus on other areas, namely science. Linked to this is the third key finding that teachers need assistance to identify which learning outcomes to focus on when they plan a science unit. This suggests that as well as running workshops that focus on an engaging topic, and on strategies for learning, it would also be useful to incorporate activities that involve teachers in identifying the relevant science outcomes and appropriate assessment strategies, rather than assuming that the connection is automatically made. This approach could then be followed up in focus group discussions whereby ideas and evidence of student learning could be shared and discussed. Integral to this is the need to raise teacher awareness of the range of strategies that can be used to assess student learning. As Towndrow, Tan, Yung, and Cohen (2010) found:

> policy changes provide new benchmarks for science assessment pedagogies. Developing pedagogical practices in light of policy changes is demanding in the current landscape of rapid educational change. (p. 128)

Projects such as Operation Magpie provide only one solution in addressing the complexities associated with the teaching of primary science. However, by connecting teachers through targeted, sequenced, professional learning activities in which they plan, teach, share and evaluate a unit that involves children interacting with nature, a positive step can be taken in addressing teachers' confidence and pedagogical content knowledge in science. If professional learning programs can incorporate localised focus groups which encourage teachers to share their experiences, then projects such as Operation Magpie may entice more teachers to teach inquiry based science as well as to connect their students with their natural environment.

Keywords: professional learning, environmental science, Citizen Science, pedagogy, primary education

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