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The Affordance of Place in Developing Place-Responsive Science Teaching Pedagogy: Reflections from Pre-Service Teachers

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ABSTRACT

Despite being increasingly popular within broader educational discourse, place-responsive pedagogy is less apparent in science teacher education. This paper investigates the perspectives of pre-service teachers in a science education course informed by place-responsive pedagogy in a Bachelor of Education (primary) program at an Australian regional university. The place-based study belongs to longitudinal research that examined the impact of the modified science course hallmarked by university–school partnerships and science lessons conducted by pre-service teachers with children from rural and regional schools in Gippsland, Victoria in a wetland and school ground setting. The study and science course were framed by Somerville's (2010) Q4 place pedagogy framework as constituted by the three elements of the storyline, embodiment, and cultural contact zones. Using this framework, we examine how pre-service teachers view and understand the affordance of places for teaching science. The study employed a document analysis of coursework essays as well as follow-up semi-structured interviews with two pre-service teacher cohorts (wetland and school ground). Findings indicate that pre-service teacher's exposure to place-responsive frameworks helped build their awareness about the affordance of place for science teaching. Challenges associated with taking science beyond the conventional classroom are also identified and discussed.

KEYWORDS

Teacher education; science education; pre-service teacher; place; place pedagogy; outdoor teaching; affordance

Introduction

Despite its popularity and theorization within broader educational discourse, place-responsive pedagogy scholarship (Gruenewald, 2003; Mannion & Lynch, 2016; Renshaw & Tooth, 2018; Smith, 2013; Stewart, 2020) is less represented in the science education and science teaching field. Nevertheless, the broader literature highlights science education researchers and science teacher educator's active engagement with the concept of place and its pedagogical capacity (Buxton & Provenzo, 2011; O'Connor, 2016). Like other teacher educators seeking place-based pedagogical interventions in science teacher education (O'Connor, 2016), we similarly underwent the process of reconceptualizing a science education course in a Bachelor of Education (primary) program in an Australian regional university. Our aim was to incorporate new ways of thinking about and practicing science teaching to strengthen pre-service teachers' (PSTs) future capability and confidence to teach science

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in primary schools. Our research aligns closely with other science educators who modified their practice to create better learning outcomes for PSTs (Lederman & Lederman, 2015) and address PSTs' lack of confidence to teach science (Jones et al., 2016; Kenny et al., 2014).

A conventional science-method course in Australia normally consists of theory-based lectures (focusing on curriculum and pedagogical perspectives on science education) and practical tutorials (where PSTs do hands-on science activities and conduct small-scale mock teaching to each other). While the new iteration maintained some original elements, such as lectures on science pedagogy and some classroom-based tutorials, significant modifications, were made to both lecture content and tutorial organization (see details in the section 'Contextualizing the study"). The innovation of the overall course structure was the several partnerships we developed with local primary (elementary) schools. Each partnership was made up of key stakeholders, including in-service teachers, PSTs, children, and ourselves (see Author Q5 & Author, 2018 which focuses on partnership impact). We also introduced the conceptual framework of place and its associated theories and practices, including 'place-responsive pedagogy" (Renshaw & Tooth, 2018; Somerville, 2010), which involved PSTs teaching science to local primary school students in local places, as informed by their local conditions and nuances (Gruenewald, 2003; Smith & Sobel, 2010). The notion of "responsive" is a key theme throughout our teaching and research and refers to the "nature of engagement with particular places" through personal connectedness (Renshaw & Tooth, 2018).

Building on earlier longitudinal research that examined the impact of the science partnership with one participating school (Authors, 2018), and which theorized the process of creating the new science course via a reflexive self-study (Authors, 2019), this paper explores how the affordance of different places—a wetland and school ground environment—influenced the development of place-responsive science teaching pedagogy among two science education PST cohorts. Within this study, the key term "affordance" is concerned with how PSTs understood and worked with the environmental attributes of the two study sites to generate possible teaching and learning action (Gibson, 1979; Raymond et al., 2017) with primary-aged children. In applying the lens of affordance to our place-based science research, we seek to gain greater insight into how PSTs came to understand the enabling qualities of the two sites for the purpose of teaching science. Based on this, the study was guided by the overarching research question: How does the affordance of place influence the development of place-responsive pedagogy among pre-service science teachers?

The following sections of the paper include an extensive literature review and an explanation of key methodological considerations that lead the reader toward a set of interesting findings which emphasize how PSTs' perceptions of science teaching significantly changed from their engagement in place-responsive pedagogy.

Literature review

Outdoor learning: definitions and correlations to science education

Outdoor learning is associated with experiences that occur beyond the confines of the conventional classroom in places, such as school grounds, community gardens, wetlands, and other local places that foster children's relationships with natural environments Q6 through familiar and unfamiliar phenomena (Bowker, 2007; Dillon et al., 2006). Such places are the starting point for meaningful learning through a sustained engagement with people

and places (Beames et al., 2012), particularly when informed and guided by pedagogical practices that link and integrate learning to the curriculum (Dillon et al., 2006). Notwithstanding the substantial interest of many teachers wanting to engage their students in learning beyond the conventional classroom, research suggests that many do not have the skills or confidence to do so (Beames et al., 2012; Comber, 2016; Skamp, 2009). Such barriers are reflected in wider calls for teacher education programs to develop PSTs' knowledge, skills, and pedagogical judgment (Horn & Campbell, 2015) as a way of increasing and enabling confident engagement with *real life* or realistic learning in the outdoors (Beames et al., 2012; Beames & Ross, 2010; Ernst & Tornabene, 2012; Higgins et al., 2013).

Such learning opportunities have been embraced by science educators seeking to extend and enrich PSTs' science teaching in outdoor local spaces and places (Adams & Branco, 2017), as well as via field excursions (Carrier, 2009; Djonko-Moore & Joseph, 2016; Kendall et al., 2006). In parallel with challenges highlighted earlier about teacher resistance in taking learning outdoors, taking science outdoors is largely dependent on teacher attitude, confidence, and competence (Eick, 2012), a notion highlighted in Carrier et al.'s (2014) study that found teachers' traditional pedagogical views and practices about outdoor learning as peripheral and less effective than classroom-based learning as a major barrier to pursuing science outdoors. One solution to this way of thinking was advanced in a study that called for teacher educators to be better equipped to model outdoor pedagogy to prepare a new generation of graduates to teach science in the field (Feille, 2017).

Place-responsive pedagogy: definitions and correlations to teaching science

The scholarship of place-responsive pedagogy (Renshaw & Tooth, 2018), also known as place-conscious pedagogy (Gruenewald, 2003) is represented across wider education discourse (Comber, 2016; Mannion & Lynch, 2016; Somerville, 2010), including outdoor education (Wattchow & Brown, 2011, 2016), and teacher education (Blatt & Patrick, 2014; McInerney et al., 2011). Specifically, it involves exploiting the pedagogical affordance of local places through acknowledging the cultural, environmental, and broader context of place (Gruenewald & Smith, 2008; Smith, 2013). A central tenet of place-responsive pedagogy is its emphasis on the particularities or attributes of the place where teaching and learning occur (Renshaw & Tooth, 2018). It is children's engagement with the physical attributes of local places, e.g.,, neighborhood sites, schoolgrounds, gardens, water catchments, as well as urban (built) environments that become the "the central texts for teaching and learning" (Smith, 2013, p. 213). According to Gruenewald, these diverse places are centers of experience that offer the pedagogical capability to teach us about "how the world works, and how our lives fit into the spaces we occupy" (Gruenewald, 2003, p. 647). More recently, educational theorists and practitioners have applied a new materialism lens to place pedagogy discourse (Mannion, 2019; Somerville & Author, 2015). Central to these post-humanist critiques is the concept of assemblage, a term that recognizes the amalgamation of or connectivity between people/place/more than human entities, with the understanding that no one entity is privileged, as illustrated in Rautio's (2013) study that focused on the intra-actions between children and the stones they carried in their pockets: each entity—child and stone—being changed because of the exchange.

Within wider educational scholarship and practice is place-based education (Corbett & Gereluk, 2020) that recognizes natural local sites and their associated ecosystems as key learning sites (Bowers, 2002; Gruenewald & Smith, 2008), which generate specific place-based knowledge through embodied place encounters (Duffy, 2015). Historically affiliated with the broader discipline of outdoor education and learning outdoors, place-based education features are contained in environmental studies, service learning, and work-related programs in schools (McInerney et al., 2011) and as well as in the discipline of science education, particularly in the USA (Adams & Branco, 2017; Buxton & Provenzo, 2011; O'Connor, 2016; Semken & Butler Freeman, 2008).

While the premise of place-oriented teacher education encompasses many outdoor learning principles, its focus is concerned with preparing PSTs to be more attentive to the specificity of places or place communities (Cormack et al., 2008), via nuanced pedagogical opportunities (Renshaw & Tooth, 2018). How place informs curriculum and pedagogy is illustrated across several studies in teacher education. For example, Mannion and Lynch's (2016) work examined how teacher educators can design curriculum in sensitive ways to enable place-responsive approaches in the field of outdoor education. Similarly, an Australian study used Somerville's (2010) place pedagogy framework to re-frame primary curriculum through place-based sustainability in a local wetland and local neighborhood (Author, 2014), while another Australian study featured Smith and Sobel's place-community-based framework (Smith & Sobel, 2010; Sobel, 2004) to inform PSTs' learning with local art, sustainability, environmental science and botany experts in a wetland setting (Author, 2016). In America, Blatt and Patrick's (2014) research focused on using the concept of the place to gauge how PST's earlier place interactions contributed to their current perceptions about the importance of taking students into the outdoors as graduating teachers. The authors found that although most PSTs had positive beliefs about time spent outdoors, as well as the importance of taking students outdoors for learning purposes (based on their earlier experiences), only a small percentage mentioned the memory of school-based outdoor learning.

This literature provides a valuable overview of the contribution of place-based and outdoor learning approaches within education more broadly, as well as in science education. Less evident, however, is how science teacher educators and researchers have applied and critiqued the notion of "affordance" within their place-based teaching and research. In addressing this gap, our research seeks to examine the pedagogical affordance of place as understood by third year PSTs in a science education course in a Bachelor of Education (primary) program at an Australian regional university. We acknowledge the early work of James Gibson (1979), who coined the term "affordance" as the "possibility for action" provided to an individual by an environment—including the substances, surfaces, objects, and other living creatures that surround the social actor. Affordance, argues Gibson (1979), is explicitly concerned with "something that refers to both the environment and the animal … The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill" (p. 127). Affordance, as understood in this study, is not therefore a property or quality residing in either the object or subject, but rather, a focus on the expressive meaning that can occur within a given place and/or across places via the attributes of the features of those sites (Raymond et al., 2017).

Theoretical framework—place and place-pedagogy

The study was framed by the overarching research question: How does the affordance of place influence the development of place-responsive pedagogy among pre-service science teachers? We were substantially drawn to Margaret Somerville's (2010) place pedagogy framework that investigates the mutual constitution of people and places as constituted by the three elements of the storyline, embodiment, and cultural contact zone, as illustrated below:

- our relationship to place is constituted in stories and other representations,
- place learning is embodied and local, and
- deep place learning occurs within a contact zone of multiple contested stories (p. 326).

According to Somerville, the place is a productive pedagogical framework because it creates a way of thinking about the materiality of place and its "grounded physical reality" (2010, p. 330). Within her premise that we are all embedded in local places wherever we exist, Somerville argues that places are not necessarily physical, bounded, or stable, but rather constructed through relational and temporal activities, a process Massey (2005) refers to as *throwntogetherness*, which generates unfolding and overlapping events and stories in place. Viewed in this light, place transcends any subject discipline, such as environmental education (Renshaw & Tooth, 2018) or outdoor recreation (Wattchow & Brown, 2011), and is more concerned with negotiated and unfinished stories that take into consideration the ontologies of place that encompass ideas of contestation, relationships and culture (Somerville, 2010).

While many of these broader considerations informed our re-conceptualization of the science education course, Somerville's place-pedagogy framework scaffolded both the science course and PST's learning in ways that enabled their capacity to think about and practice science teaching through the lens of place or more specifically, to confidently ponder the question, what is possible in this place (Sobel, 2004)? Further, the framework served as a valuable analytical tool in the study, determining how PSTs recognized and engaged with the affordance of place when teaching science in two unique outdoor settings.

Contextualizing the study

The study occurred in the region of Gippsland, Victoria, and involved a university partnership with two public regional and rural primary (elementary) schools which enabled science teaching opportunities for PSTs.

Science teaching in a wetland setting: regional school

The first PST cohort worked with teachers from a regional school to develop a set of *tuning-in* wetland-based science lessons on the topic of *Adaptation* delivered to children in a one-day (4 h) event. In the initial weeks of the university science course, in-service teachers provided an introductory lecture on inquiry-based learning that informed the development of PST's lessons, which served as a launching pad for children's inquiry-based projects back at school. Early in the science course one of the teacher educators gave a lecture on Somerville's (2010) place pedagogy framework, and in the third week of class PSTs, in-service teachers, and

Photo 1. Wetland (photograph by authors).

teacher educators participated in a reconnaissance field trip to the wetland to explore potential teaching sites. Working closely with the question: What and where are the possibilities for teaching the theme of *Adaptation* at the wetland site, PSTs were encouraged to consider specific wetland features, e.g., grasses, shrubs, water, animals, birds, etc., that might inform their lesson (see Photo 1). On the actual teaching day with children, in-service teachers and teacher educators observed lessons and provided PSTs with brief on-site feedback.

Science teaching in a school ground setting: rural school

Course processes and procedures described above were repeated for the second PST cohort who developed and delivered science lessons to children in a rural school ground (see Photo 2). PSTs in this cohort chose their own science topics based on the Victorian Curriculum. Their reconnaissance day involved exploring the school's outside grounds where lessons would occur. As with the above cohort, PSTs determined suitable teaching locations that supported scientific concepts such as push and pull, gravity, erosion, bugs and insects, gardening with seeds, in sites such as an oval surrounded by established trees and shrubs, constructed play areas, wooden benches, small vegetable gardens, and a large, uncovered sandpit. Due to inclement weather on the teaching day, all groups used alternative sites such as the school's gym, undercover areas, and general classrooms. The change of location required significant adaptation of original lessons which challenged most groups, largely

Photo 2. Rural school ground (photograph by authors).

because they could no longer work with physical attributes on which their lessons were based. This issue is explored later in the paper.

Methodology

The place-based case study methodology involved considerations about PST viewpoints, thoughts, values, and meanings (Denzin & Lincoln, 2003) about the affordance of place-responsive teaching. Given the pedagogical significance and affordance of the wetland/school ground teaching sites within the study, the place-based methodology enabled us to explore a "string of concrete and inter-related events" (Flyvbjerg, 2011, p. 301) that infiltrated all aspects of the science course and its associated field experiences.

Participants

Participants in this study were made up of PSTs within the School of Education who were enrolled in a primary science method course in different semesters in the same year. Participation in the study was voluntary. Forty-eight PSTs (17/50 in cohort 1 and 31/58 in cohort 2) gave permission for their course work essays to be used as data; 15 PSTs (7 in cohort 1 and 8 in cohort 2) consented to take part in face-to-face interviews with their lecturers (the coauthors). To have a data set that represented the cohorts as closely as possible, we conducted all 15 interviews and analyzed all essay data available to us.

Table 1. Questions for the reflective essay task.

Beginning of course (Weeks 1–3)	Mid-course (Weeks 5–8)	Post-science teaching (Weeks 11–12)
How did your experience as a science learner help you to understanding what science is, and how it is taught in primary schools?	What concerns do you have about teaching at the wetlands/school ground?	Did you make good use of the wetlands/school ground in your teaching? How?
How do you feel about teaching science?	What concerns do you have about teaching science to children?	What is the influence of "place" when teaching science?
	Reflecting on your course learning so far, what understanding will you bring into your wetlands/school ground lesson plan?	How do you feel about teaching science after the wetland/school ground experience?

Data collection and analysis

As highlighted in Table 1, the essay task informing one element of the data collection was framed in three stages across a 12-week course. This involved PST reflections at the commencement and midway points of the course, as well as after the wetland/school ground teaching experience. The interview data set (audio-recorded and transcribed) provided specific responses to Table 1 questions and served as a source of triangulation with the reflective essays (Creswell, 2009).

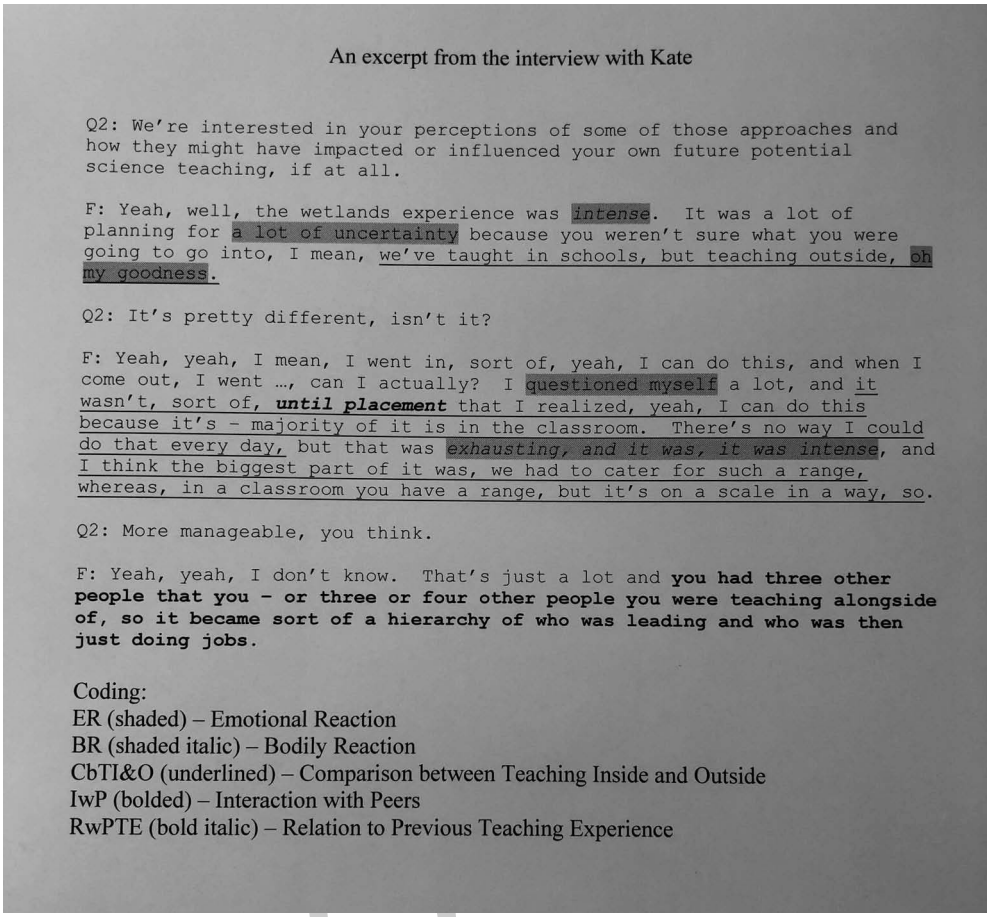
Both the reflective essays and interview transcripts were examined using a thematic analysis method, which included six phases as suggested by Braun and Clarke (2006). The analysis process was iterative (as opposed to linear) in that there was constantly moving back-and-forth between the phases. Phase 1 involved becoming familiar with the data by reading and re-reading the text. Initial codes were then generated in Phase 2. The initial coding consisted of a very broad range of codes; some were combined and rearranged, while others emerged as major components to form themes in Phase 3. Table 2 lists some major codes used in the analysis (as the initial codes were very broad, the list is not exhaustive). Figure 1 provides an example transcript showing the coding scheme in use. Once the candidate themes were formed, they were reviewed in Phase 4, particularly in relation to how they could be adopted to answer the research questions. In Phase 5, instead of giving new names to the themes, we categorized them based on the theoretical framework of the study, i.e., Somerville's (2010) three place pedagogy principles. As a result, in reporting (Phase 6), the findings were presented in relation to (a) storyline, (b) embodiment, and (c) cultural contact zone, together with excerpts as support evidence from each cohort, as highlighted in the Discussion section. Table 2 also provides a further clarification of the rationale behind the formation of the themes.

Ethical considerations

The study was granted ethical approval by our university's Human Research Ethics Committee. At course completion, invitations were sent to all PSTs requesting consent to analyze their reflective essays and participate in a follow-up interview. Waiting until the finalization of course results before accessing and generating the data meant we avoided risks associated with perceived favor due to study participation.

Table 2. Coding scheme.

Name of Code	Definition	Relevant element(s) in the analysis framework to form themes
RwPTE	Relation with Previous Teaching Experience	Storyline—how the new experience can be integrated with PSTs' own previous teaching experience to form a pedagogical storyline.
RwPLE	Relation with Previous Learning/ living Experience	Storyline—how the new experience can be integrated with PSTs' own previous learning/living experience to inform the formation a pedagogical storyline.
ER	Emotional Reaction	Embodiment—how place learning involves emotional engagement of the PSTs.
BR	Bodily Reaction	Embodiment—how place learning involves physical engagement of the PSTs.
ICP	Internalized Concept of Place	Embodiment—how new understanding of place is imagined and reflected based on physical engagement with actual place.
IwE	Interaction with Environment	Storyline—how the exploration of the environment helped to form a pedagogical storyline. Cultural Contact Zone—how different ways of interacting with material environment influenced PSTs' cultural practice (teaching and learning in this study).
IwP	Interaction with Peers	Cultural Contact Zone—how ways of interacting with peers were negotiated in PSTs' cultural practice (teaching and learning in this study).
IwIT	Interaction with In-service Teachers	Cultural Contact Zone—how ways of interacting with in-service teachers influenced PSTs' cultural practice (teaching and learning in this study).
IwS	Interaction with Students	Cultural Contact Zone—how ways of interacting with primary school students were negotiated in PSTs' cultural practice (teaching and learning in this study).
CbTI&O	Comparison between Teaching Inside and Outside	This code could be relevant to any of the elements, depending on the nature of the aspects compared. It is an example of the initial codes, some of which were combined and rearranged in Phase 3 of the analysis process, based on their relevancy to the three elements in the theoretical framework.



An excerpt from the interview with Kate

Q2: We're interested in your perceptions of some of those approaches and how they might have impacted or influenced your own future potential science teaching, if at all.

F: Yeah, well, the wetlands experience was *intense*. It was a lot of planning for a lot of uncertainty because you weren't sure what you were going to go into, I mean, we've taught in schools, but teaching outside, oh my goodness.

Q2: It's pretty different, isn't it?

F: Yeah, yeah, I mean, I went in, sort of, yeah, I can do this, and when I come out, I went …, can I actually? I questioned myself a lot, and it wasn't, sort of, ***until placement*** that I realized, yeah, I can do this because it's – majority of it is in the classroom. There's no way I could do that every day, but that was *exhausting, and it was, it was intense*, and I think the biggest part of it was, we had to cater for such a range, whereas, in a classroom you have a range, but it's on a scale in a way, so.

Q2: More manageable, you think.

F: Yeah, yeah, I don't know. That's just a lot and **you had three other people that you – or three or four other people you were teaching alongside of, so it became sort of a hierarchy of who was leading and who was then just doing jobs.**

Coding:
ER (shaded) – Emotional Reaction
BR (shaded italic) – Bodily Reaction
CbTI&O (underlined) – Comparison between Teaching Inside and Outside
IwP (bolded) – Interaction with Peers
RwPTE (bold italic) – Relation to Previous Teaching Experience

Q25 Figure 1.

Findings

The overall findings indicate that PSTs were able to negotiate their teaching practice by interacting with the human and non-human features of a place; however, the extent to which a personalized place pedagogy was formed depended on the level of individual engagement with the place and the particularities afforded by the place. In this section of the paper, findings are presented in three categories in accordance with the theoretical framework for data analysis: storyline, embodiment, and cultural contact zone.

Storyline

In this section, we present stories from PSTs about their learning in relation to pedagogical possibilities afforded by two places—wetland and school ground. The place has its own material features which inform its pedagogical capacity and the story it tells (Somerville, 2010). In this sense, it was a journey for each PST to explore the existing story of the place, to reshape, and be part of the story by intermingling with the material features—humans and non-humans alike—to then tell the new story of the place in their reflections.

In the wetland

Esther's narrative is a story of her teaching, serving as an example of how the PSTs interpreted the material features of the wetland environment, which became part of their teaching story as the material features of the wetland were gradually examined and incorporated into their teaching story:

> We started it off by allowing the students to realize the environment that they were in. .....for example, there were the sounds of birds chirping,. ....They then went toa bird hide, where you view the birds, and we started a mild discussion on what some of the things that animals required in order to sustain their living within that environment. ..... Then it went on to a hands-on activity where they got to use various items and pretend that they had the bird's beak, ...We also used sticks and leaves, flower, nuts, like quitea few objects from the surrounding area, so they could get more of an idea of what the birds have to go through to find food, or even to use as nesting or housing.

Both the essay and interview data suggest that, although to a different extent, PSTs utilized the wetland features in their teaching. However, the pedagogical significance of place, particularly in relation to teaching science in that specific context did not occur without its challenges. As Grace revealed:

> The activity, . . . which was to have them [children] find one bug .....[that they] wanted to draw and label. But we thought that they could do that in a classroom; ..... then we thought of the iPad, but they didn't really want to use them.I thought because we were so close to the mud that was just too enticing, ... Let's go play in that.

In Grace's example, the PSTs originally thought about the idea of drawing a bug and using some digital tools, which they then realized students could ordinarily do in a classroom. The materiality of the place, such as the mud, was not so obvious in their thinking, but gradually it became the context of their teaching.

In the school ground

All PST groups associated with the rural school designed lessons suitable for teaching in the school ground. Some groups focused more on the activities, such as ball games, that simply required a bigger space and would not be possible to organize inside a classroom; while others sought to incorporate the particularities of the site, such as the facilities in the playground. For example, Stella's group conducted an activity related to *erosion*, coming up with an idea that made use of an existing school ground feature, as seen on their first school visit:

> We had no idea when we first started. We went in there with an open mind and wanted to really find something that we could [do] with the environment. We found the sandpit [that] had started to erode from all the rain that they'd been having, and we started by talking about erosion. The rain had gone through and you could see the kids had sort of probably made rivers and whatever and the water had started to really run through it and so there was sort of – little islands and we thought we could work with that and say, this is what the rain makes.

Avery's teaching narrative triggered her own memories and meaning of playing in the dirt as a youngster, linking those memories to a new story of place meaningful to her and her students. Significantly, this new story acknowledged the place as having a history. In this way, PSTs themselves became place-makers and part of the ongoing story of the place:

> I remember doing little projects and I was outside when I was little, I used to love counting ants and digging up the dirt and things like that, like I love all that sort of thing, and kids love it. In

> particular we tested the soil . . . and found out that soil under this shed would be perfect for growing potatoes .....[We made a] connection with the children that this land wasn't always a primary school, before it might have been a paddock, it might have been someone's home, you never know what that land was before, I really liked that connection we made.

Embodiment

In this section, data highlight PSTs' sensorial and emotional reflections about the physical environment, including coming to know and becoming aware of place as a pedagogical platform for embodied learning. As a result of their bodily engagement with one place, some PSTs started to internalize the concept of place as a pedagogical setting, including its potential in other places, as highlighted in this section.

In the wetland

Even though the appreciation and enjoyment of the teaching experience became apparent for PSTs at its conclusion, feelings of anxiety before it were common among PSTs, as summarized by Kate:

> It was a lot of planning for a lot of uncertainty because you weren't sure what you were going to go into. I mean, we've taught in schools, but teaching outside, oh my goodness.

Grace's narrative reflects mixed feelings, as represented by her reaction in having to leave the confines of the school and classroom. As presented in the following excerpt, on one hand, she expressed a feeling that was *awful* due to an asthmatic reaction to the weather conditions; on the other hand, she described the day as *interesting* and *fantastic* as a result of the amount of learning she had experienced:

> I had an interesting day. I left the day feeling awful. I had a little cry during the day. Mostly I think that was because I was getting sick .....I have asthma and the weather outside was just affecting me .....The day was fantastic, I reckon the learning there that happened for me was more just an understanding of how different it is outside and the factors that I didn't even consider. ..... you don't think about much the wind and the cold is going to affect you because you are so used to being in the classroom and be like sheltered from the elements.

Based on their bodily engagement with the site, some PSTs were able to internalize place as pedagogical. By way of example, Ella stated that the wetland was not just a vehicle for teachers to bring in course content, but that the place itself can *be* the lesson, which is a key intention of place-based pedagogy. She explained:

> I used to think place was about .....supporting whatever science you were teaching. But now I think I worked out that place can actually guide that science, and it doesn't necessarily have to be a supporting element that you bring into that lesson, it can actually be the lesson.

When thinking about *the place* more generally, PSTs started to consider the potential of different places, including local parks, gardens, and reserves. The idea of mixing up the learning context was highlighted by Esther who made clear:

> It would be beneficial, to actually get the students out of the school, into some type of excursion that they could actually benefit from ..... Aside from getting just a school view, they're actually going out into the world, they're actually viewing the things that could occur and could be associated to science.

In the school ground

Compared with the wetland cohort, feelings of anxiety were not so evident among the school ground cohort. Instead, PSTs anticipated the excitement that might accompany the outdoor learning experience, even though they also expected a certain level of a new challenge that could be raised by outdoor teaching. Caitlin's comment was typical among this cohort:

> I also found it interesting that we are to teach outside of the classroom. I feel like this is something that can scare a lot of teachers as they don't have the same control and environment as within their classroom. I feel teaching outside can give us lots of new opportunities for teaching science and could also help to further engage students as it will be exciting to get outside of the classroom.

PST observations of their own as well as children's bodily encounters with the school ground provided an important vantage point from which to observe the sensorial outcomes of the lessons throughout the day. These observations enabled them to move beyond the conceptual planning phase of their teaching to witnessing the tangible outcomes and experience of the lesson, as indicated by Mia's experience:

> It was pissing down rain that day. They [the kids] loved the rain, they were loving all the mud and stuff and getting dirty but it's just like trying to teach in those conditions. It was hard but they enjoyed it and we feel like we made an impact because they were thinking critically and creatively about how they could filter their water in a correct manner, not just using the stuff that we had provided. They were going around and exploring their environments and using bark and all these, silly things but they were thinking about it. It was good I really liked it. It was just very cold and very wet.....I think I could see where I was, I could actually visualize it happening, the activity happening whereas beforehand we were just kind of planning it and we hadn't really seen it going to come together.

When recalling her teaching experience, Mia repeatedly mentioned the wet and cold weather conditions. Obviously, this bodily reaction was not an element that could have been factored into the lesson during the planning phase. Associated with the sensorial memory was the feeling of satisfaction aroused by facilitating children's learning and observing how children enjoyed the *mud, the dirty*, and the *rain*. Although these sensorial and affective experiences may not be observed as embodied learning, we can see from the final part of Mia's reflection (based on her bodily responses to the place), she was able to "visualize" the fullness of the lesson in the place, where all of pieces of the lesson plan—the environment and the leaners—made more sense. Visualizing place-based teaching processes is an important step toward internalizing the concept of place as a pedagogical site.

When thinking about place-based pedagogy more broadly, PSTs were able to make comparisons between inside and outside the classroom within the school environment, as a highlight by Violet's observations:

> Well, I think it is a lot different having them out in the yard rather than the classroom, because I guess they see the classroom as the place where you're sitting down, you're working, you're focusing on what it is. But when they're in the yard it seems like they're more comfortable. Maybe it's a bit more relevant to them. Or just being outside, being able to see these – our natural environments.

Cultural contact zone

In this study, the two settings became the critical space where PSTs interacted between themselves, university lecturers, school students, and in-service teachers. In this section, we focus on PSTs' interactions with children, which was significantly emphasized in PSTs' reflections.

In the wetland

The wetland teaching experience provided an opportunity for PSTs to directly interact with children and to observe how they learnt beyond the confines and constraints of the conventional classroom. By way of example, Esther observed behavior management strategies to be different in the wetland as opposed to the classroom environment:

> A lot of us haven't had a chance to actually manage a class which is outside of a classroom environment .... Once they're out . . . they do sort of relax a little bit more. In terms of classroom management, you may need to implement different strategies or tactics to handle that.

Because the wetland environment was unusual to both PSTs and their primary school students (the site was less familiar to PSTs than the children, many of whom had visited the site before), what counted as appropriate behavior management needed to be negotiated. Kate offered an example of having to quickly adjust her teaching for disengaged students:

> There were about three of them that disengaged, and they went, 'this is boring', and that's when they started running to the water and playing up. So, we had to do something, otherwise we were going to have a day of yelling at kids to come back and stuff like that.

Building on this, Mary noted how mutual and shared learning occurred for both teachers and students in the wetland. She told us:

> It was really, really interesting to hear the different opinions and different ideas of the students . . . and I think we learnt nearly more from the students about the wetland environment than we were trying to introduce them to, which just broadened our scope of learning even further.

In the school ground

In the school ground, PSTs also observed a similar level of high engagement from children and therefore observed fewer behavioral issues. They also described children getting overexcited, as recalled by Violet:

> With the kids being out of the classroom I think they were quite engaged..... I feel like there weren't that many behavioral issues..... But it was interesting, there were a couple of times where kids were just a bit too excited and a bit over the top.

The importance of acknowledging children's nuanced school ground knowledge and how it might be factored into future lesson planning was a common theme from the school ground cohort. For example, Mia explained:

> I wouldn't know everything about the school yard because I don't go out and play there. . . . And obviously they all know their little nooks and everything. So, if I was to plan a Science activity, ...I would ask them 'where do you think the best place in the school would be to conduct this activity?'.....They've got their own experiences to draw on and so do I. So, I feel like learning from their experiences and their knowledge is going to benefit me more as a teacher. I'm going to understand them better as a learner.

Kaylee similarly alluded to the influence of children's familiarity with school ground features and its association to learning as indicated:

> We're in their sandpit that they play in all the time especially being the younger kids, it's a really, really familiar environment. So automatically their ownership over any activity that you do there is up and their engagement in it is up because it's their area, so they then want to feel like they're the masters of that area. So, if you come in and say, "well we're introducing this new thing that changes how you think about it"– yeah, I found that they were a lot more engaged than what we'd anticipated if we'd done it somewhere else.

Discussion

In discussing the above findings, this section highlights the comparison made between the two different places (wetland/school ground) and presents the similarities and differences as themes in relation to the three conceptual principles: storyline, embodiment, and cultural contact zone.

Theme 1: storying a place into a science teaching pedagogical framework could be achieved by encompassing the particularities of human and non-human features of a place

Realizing the potential of place as a pedagogical site involves deep immersion in that environment, and actively making connections between the place and the science teaching requirements. To this end, Somerville (2010, p. 330) argues, "place is productive as a framework because it creates a space between grounded physical reality and the metaphysical space of representation". To some extent, PSTs negotiated familiar and taken for granted teaching strategies (e.g., transmission pedagogies) alongside new and innovative approaches, such as making meaningful use of the *mud* and the *sandpit* as they attempted to draw on the physical features of place in their teaching plans. Grace's account (in the wetland) reveals how the place itself, in the end, facilitated the children's embodied learning. The same was true with the school ground groups who emphasized unique school ground features when configuring their outdoor lesson (as seen in Stella's case).

Storying a place, that is, incorporating its human and non-human history and features into a particular disciplinary pedagogical framework (such as science teaching) requires educators to have special and deep knowledge of that place. Wattchow and Brown (2011) proposed four elements for a place-responsive pedagogy: "being attentive in the place, storying place, spending time apprenticed in place, and representing and communicating place experiences" (p. 182). The science course design allowed some degree of PST practice according to these elements, although compared with long-term deep engagement with a particular place, these opportunities were short-term and somewhat fragmented. From PSTs' reflections, we observed them becoming more attentive to the materiality of each place, determining how the material features might be used pedagogically. To some extent, PSTs also incorporated human sense-making in developing their teaching stories, e.g., Stella's group noticed the school children might have played a lot in the sandpit, hence, they could build on that knowledge in their teaching by factoring in children's prior experience or knowledge. Additionally, Avery's personal memory of her earlier outdoor experiences was woven into her present-day teaching activity, assisting her to imagine the

history of the land. These scenarios are examples of how PSTs became part of the unfinished (and ongoing) story of a place, through interacting and teaching with the materiality of the place, which enabled new meanings of the place to them and their students.

Theme 2: the different affordance of each (wetland/school ground) place triggered different bodily place engagement across the two cohorts

Somerville (2010) emphasizes that embodied learning starts from immediate bodily responses to a place. In our study, the immediate bodily responses included both sensorial and emotional engagements with a particular place. In both settings, PSTs experienced outdoor weather conditions (windy, cold, rainy, etc.) and feelings of anxiety, uncertainty, satisfaction, and enjoyment. This outcome can be linked to the relevance of experiential engagement with a physical place, whereby people make sense of the place by experiencing it, making meaning out of it and forming bonds or attachment to it (Adams, 2013). We have acknowledged that the short-term nature of engagement did not enable the PSTs to form any deep and meaningful bonds or intimate attachment to the respective places. However, PSTs' reflections demonstrated the importance of creating such opportunities, even in a fragmented manner, which enabled them to engage with a place, to feel the place, so that they can develop the ability to image or to borrow Mia's expression, to "visualize" (see the previous section) the type of pedagogical practice that could occur in a particular place.

The data highlight less anxiety and uncertainty among the school ground cohort (e.g., Caitlin) compared to the wetland cohort (e.g., Kate). This may be because, compared with the wetland, the generic school ground context was more familiar to the PSTs, hence, it provided more obvious locations and possibilities. Even though the PSTs worked hard to explore new ways of presenting and imbuing new meaning into the school ground environment, they appeared more comfortable than the wetland cohort who faced a less familiar environment. Another possible reason could be related to the different affordance of each place. As mentioned, there was a heavy rain during the school-based event. Had this occurred in the wetland setting, all activities would have been canceled. However, as the school provided a range of undercover shelters, most PST groups managed to alter their lesson plans to fit into the new indoor environments. The flexibility and possibility of offering alternative solutions to the weather conditions may have contributed to the lower level of anxiety toward uncertainty.

Theme 3: different place affordances may prompt different ways of conceptualizing place pedagogically for the PSTs

Bodily engagement can also be used methodologically to construct new stories of place (Somerville, 2010). To this end, the place can become symbolic, and the embodiment of place can also be an internalized sense of place. PSTs' embodied experiences resonated with principles of a new materialist framework proposed by Mannion (2019), in which educational goals are generated "through practicing, relating and becoming entangled with more-than-human elements and processes" (p. 9). When *a place* becomes a concept that transcends the physical boundaries (that acknowledges human-human and human-non-human interactions), PSTs start to realize its broader pedagogical potential.

In the wetland, PSTs' reflections tended to consider diverse types of outdoor environments, such as local parks and reserves , were compared with a school environment. Whereas for the school ground cohort, PSTs seemed to focus more on school ground sites, making comparisons between what is possible inside and outside the school classroom. It appears therefore, PSTs were more able to extend their pedagogical considerations to a place with similar features. This finding implies the need to further explore the pedagogical opportunities afforded by diverse places that could be offered to PSTs to expand their place-based experience and help with the conceptualization of diverse place-responsive pedagogies.

Theme 4: PSTs negotiated their teaching practice differently in the respective places as cultural contact zone

The cultural contact zone can be interpreted as a space where "individual or group actions, Q8 experiences, intentions, and meanings are drawn together spatially" (Seamon, 2014, p. 12). In our study, the cultural contact zone was represented in two ways. The first was working with differences between university and school culture: the second was related to managing pedagogical considerations such as moving from the conventions of classroom learning to outdoor learning. In terms of their different physical constructions, the wetland was built to emulate a natural marshland while the school ground was purposely created to suit the educational play needs of a rural primary school. With these purposes in mind, PSTs' tapped into the ways they could make new pedagogical meaning from the respective sites. As shown in Esther, Kate, and Violet's stories, in both settings children's behavior was shaped and re-shaped by the outdoor learning environment which was different from the conventions of a normal classroom.

From the data, we noticed the different ways the two cohorts negotiated their practice in the respective places. For example, the wetland promoted greater mutual learning whereby PSTs and students explore together and learn from each other (as in Mary's case). Whereas in the school ground, PSTs saw themselves either as a learner (e.g., Mia) learning from student's experience or trying to put new meaning in a place that students were more familiar with (e.g., Kaylee). This highlights the possible discrepancy of place affordance on the formation of PSTs' pedagogical thinking. The wetland was a new environment for both PSTs and most of their students. PSTs and students created new meaning (knowledge) about, and familiarity with the wetland. In learning together, the power relationship between teacher and student shifted, as did the learning process, which tended to be shared and mutual.

In the case of the school ground, some researchers note children's nuanced knowledge because of extensive time spent in such places (Somerville & Author, 2015). Given this, both Mia and Kaylee acknowledged children's affinity with, and ownership of the place, therefore contributing to higher levels of school ground attachment. Mia responded to this in her role as a learner, which elevated the students to a more powerful and respectful position about their school ground experiences of place-making, whereas Kaylee created rapport with her students by trying to reconstruct and add new meaning to the place children were familiar with. These observations align with Comber's (2016) contention that learning in local landscapes involves "real and embodied people, negotiating relationships and resources in complex and dynamic ways" (p. xv). The comparison of the two settings is examples of how cultural practice (represented as pedagogical formation in our study) can be shaped by the affordance of places and their specificity.

Conclusion: the pedagogical affordance of different places

The study's findings bring to attention the pedagogical affordance of place in science teacher education. The overarching concept of the place opened a plethora of ideas and new possibilities within place-oriented science pedagogy. In exploring data from two distinctive settings, we set out to better understand the influence of place affordance on the development of PSTs' place-based science pedagogy. Findings show that place nuances can provoke different place-responsive thinking. As such, place-learning can involve different storylines that can be shaped and reshaped, diverse levels of embodiment to be experienced, and the process of teaching and learning negotiated in different ways. Renshaw and Tooth's (2018) edited book highlights diverse place-responsive pedagogies, each based on the distinctive aspects of the material affordance of specific places where the authors established deep engagement over a long period of time. The findings of the present study are a timely reminder about the ways we might design ongoing coursework that can expose PSTs to diverse places so that they have opportunities to enrich their pedagogical repertoire by making a comparison of the "contrasting materiality of the locations" (Renshaw & Tooth, 2018, p. 1).

While we appreciate the wider limitations of this small-scale study, its findings are an important contribution to the increasing international uptake and interest in place pedagogy thinking and practice. We also appreciate that place pedagogy is a long-term process which cannot be fully realized through a limited experience, such as what our students experienced. In relation to this, Mannion and Lynch (2016) identify three stages of place-responsiveness: place ambiguity, place sensitivity and place essential. Most of our PSTs started from a stage of pre-place-ambiguity where they had limited place-responsive awareness, as demonstrated by their anxiety and concerns at the beginning of the course. The place experiences offered in the science course however provoked new considerations about how we think about curriculum and pedagogy in science education. Both essay and interview data indicated a spectrum of PSTs' understanding from place ambiguity (planning outdoor lessons) to place sensitivity (attentiveness to features of a place). As we continue to develop our science course, we are inspired to pursue "place essential" approaches (Mannion & Lynch, 2016) in our teaching, where *place becomes the lesson* via longer-term engagement.

Considering the gaps regarding the lack of place-oriented/place affordance in science teacher education, including its potential to better prepare future graduates to utilize local sites for place learning in their future teaching, further studies might pay attention to increasing PSTs' application of place pedagogy principles in diverse local places.

Disclosure statement

Q1 No potential conflict of interest was reported by the authors.

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