A Framework for Supporting the Development of Botanical Literacies in Early Childhood Education

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Abstract

Although young children in Early childhood education (ECE) in Australia are often involved in learning in outdoor natural environments, research on their knowledge and attitudes towards plants is limited. Botanical literacies in young children involve developing knowledge and curiosity about plants, formulating questions about plants, and critically and ethically thinking about plants and their environments. This study explored young children's knowledge and attitudes of the flora in the native bushlands on their school grounds. A total of 41 children, aged five to eight from two schools in Western Australia were involved in the research over one school year. Fortnightly visits to the school bushlands with the lead researcher involved bush walks, informal and formal conversations about plants, children creating drawings, maps and taking photographs, as well as visits from local Indigenous people to share Indigenous knowledge of the plants. The data were analysed using content analysis and a revised version of (Uno, American Journal of Botany 96:1753–1759, 2009) levels of botanical literacies. The results of this research led to the development of a framework for developing botanical literacies in ECE.

Keywords Botanical literacies · Plant knowledge · Mosaic approach · Map-making · Environmental education · Early childhood

Résumé

Bien que les jeunes enfants en éducation de la petite enfance (EPE) en Australie soient souvent engagés dans l'apprentissage dans des environnements de plein air naturels, les recherches sur leurs connaissances des plantes et leurs attitudes envers celles-ci sont limitées. La littératie en botanique chez les jeunes enfants fait intervenir le développement de la connaissance et de la curiosité envers les plantes, la formulation de questions sur les plantes, et la pensée critique et éthique sur les plantes et leurs environnements. Cette étude explore les connaissances et les attitudes de jeunes enfants sur la flore du bush indigène situé sur le terrain de leur école. Un total de 41

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enfants âgés de 5 à 8 ans dans deux écoles d'Australie-Occidentale a participé à cette recherche au cours d'une année scolaire. Des excursions fortuites dans le bush de l'école avec la personne responsable de la recherche ont été l'occasion de promenades dans le bush et de conversations informelles et formelles sur les plantes. Les enfants ont créé des dessins et des cartes et ont pris des photographes. Ils ont aussi reçu des visites de personnes indigènes locales pour partager les connaissances autochtones sur les plantes. Les données ont été analysées par analyse de contenu et par une version révisée des niveaux de littératie en botanique d'Uno, *American Journal of Botany* 96:1753–1759, 2009). Les résultats de cette recherche ont conduit à l'élaboration d'un cadre pour le développement de la littératie en botanique en EPE.

Resumen

A pesar de que los niños pequeños de preescolar en Australia a menudo participan en actividades de aprendizaje en ambientes naturales, sus conocimientos y actitudes hacia las plantas no han sido investigados a fondo. La educación botánica para niños pequeños incluye incentivar el desarrollo de conocimiento y curiosidad, formulación de preguntas y pensamiento crítico y ético sobre plantas y su medio ambiente. El presente estudio explora el conocimiento y las actitudes de niños pequeños sobre la flora presente en jardines nativos de su institución de enseñanza. Esta investigación contó con la participación de 41 niños entre los 5 y 8 años en dos diferentes instituciones educativas de Australia Occidental durante un año escolar. El líder de la investigación visitó los jardines nativos de los planteles educativos realizando caminatas por jardines naturales nativos y conversaciones formales e informales sobre las plantas. Los niños crearon dibujos, mapas y tomaron fotografías; también recibieron a visitantes indígenas locales quienes compartieron su conocimiento sobre las plantas. La información se analizó utilizando un método de análisis de contenido y una versión revisada de los niveles de contenidos educativos botánicos de Uno, *American Journal of Botany* 96:1753–1759, 2009. Los resultados de esta investigación condujeron a la creación de un marco de enseñanza de contenidos educativos botánicos para estudiantes de preescolar.

Introduction

Direct experience in, and with, nature aims to address concerns about the diminishing human relationship and experience with non-human species and the rapidly declining biodiversity on Earth (Beery & Jørgensen, 2018; Chawla & Gould, 2020). It has been argued that a reduced human experience with nature is directly linked to the loss of biodiversity (Suzuki et al., 2008) and that furthermore, regular time in nature during the early childhood years may counteract this decline in biodiversity as children build knowledge, relationships and empathy for non-human species (Barrable, 2019; Beery & Jørgensen, 2018; Chawla & Gould, 2020; Suzuki et al., 2008), including plants. A recently proposed framework for early childhood environmental education suggested regular time in nature should involve engaging children with beauty, compassion and mindfulness (Barrable, 2019). A separate study suggested

environmental education should combine both knowledge of flora and fauna and connectedness to nature (Otto & Pensini, 2017). To date, little research has been undertaken in Australia about the environmental knowledge that young children have about flora from their time in nature; their botanical literacies. Understanding children's botanical literacies may provide valuable insights for enriching the curriculum. In 2009, Uno developed a botanical literacy model to recognise varying levels in knowledge, understanding and behaviours towards botany. This research uses Uno's (2009) model for exploring botanical literacies in Early childhood education (ECE) and the conditions under which botanical literacies could be supported in early childhood programs.

In Australia, in 2019, an important policy document was promulgated by the Council of Australian governments (COAG) to set important educational goals for children's education across the Australian states. This document was the *Alice Springs (Mparntwe) Education Declaration* (Council of Australian Governments, 2019). It emphasised that learners should be active and informed members of their community. The Declaration builds on a number of initiatives by the Australian Government in education that include: the *Early Years Learning Framework* (EYLF) (Department of Education & Training, 2009); the *National Quality Standard* (Australian Children's Education and Care Quality Authority, 2012); and the *Australian Curriculum* (Australian curriculum assessment and reporting authority (ACARA; 2010). Each of these initiatives has highlighted the importance of environmental responsibility for young children and led to the introduction of *Education for sustainability* (EfS), a movement in Australia designed to provide children with more access to local natural learning environments including bush schools and learning 'on Country' (Elliott & Chancellor, 2014; Inoue et al., 2016; Jackson-Barrett & Lee-Hammond, 2018; Sofa, 2014). The intention is to provide children with authentic opportunities to have direct experiences in nature, learn to care for the environment and develop attitudes for sustainability (Brown, 2018), which will empower students to tackle complex environmental challenges as adults.

Botanical Literacies

'Plant blindness' is the inability to recognise not only plants and their names, but also their importance in the ecosystem and accompanying beliefs that plants are inferior to humans and animals and are merely a resource to be consumed (Wandersee & Schussler, 2001). The consequences of a decrease in levels of understanding of botany and an increase in cases of 'plant blindness' could have detrimental effects on sustainability and the care of our planet (Villarroel & Infante, 2014). The term 'botanical literacy' was proposed by Uno (2009, p. 1753), building on previous work on biological literacy as a part of the science curriculum for undergraduate students in the United States (Uno & Bybee, 1994). Biological literacy, as proposed by Uno includes formulating questions about nature; creative and critical thinking; evaluating information; as well as making strong ethical decisions around biological issues (Uno & Bybee, 1994). Progressive stages in the development of botanical literacy were proposed by Uno (2009) as four hierarchical levels which address

an individual's understanding of botanical terms and concepts. The term 'literacies' instead of Uno's (2009) 'literacy' has been purposefully used in this paper to represent the idea that young children have diverse ways of knowing, thinking, doing and being including indigenous knowledge (Anstey & Bull, 2018) and multiple modes for expression and representation of understanding, explained as 'Multiliteracies' (Anstey & Bull, 2018; Hesterman, 2013).

Uno's (2009) model and the four hierarchical levels of learning appear to draw on the well-known model, *Structure of the observed learning outcomes* (SOLO) taxonomy (Biggs & Collis, 1982). This model has been applied in early childhood educational research to demonstrate how young children's learning and understanding of concepts on various topics increases in complexity over time. A revised version of Uno's (2009) botanical literacy based on Biggs and Collis' (1982) SOLO Taxonomy is used in this research to inform data analysis in this current study and is presented in Table 1.

Botanical Literacies in Early Childhood

In many cultures, children's botanical knowledge has been passed down from a family member, such as a parent, carer or grandparent (Jiménez-Balam et al., 2019). Contemporary research reflects this basis of knowledge across generations, although it mentions that social changes in many families and communities have resulted in less plant knowledge being passed on to children in more recent times (Wyndham,

Table 1 Levels of botanical literacy, adapted from the model proposed by Uno (2009)

Botanical literacy level	Knowledge, understanding and behaviours evident
Nominal level	Individuals can identify and name terms that relate to botany. They may not be able to clearly define or describe the terms and they may have misconceptions of the terms
Functional level	Individuals can use botanical vocabulary and define terms correctly, but responses may be memorised and not deeply understood. This may be due to learning from books, school or television but not being personally involved in hands-on learning
Structural level	Individuals can understand botanical concepts and explain these well in their own words and how they are connected. They possess procedural knowledge and skills for undertaking botany themselves Individuals are intrinsically motivated to learn more and formulate questions about nature, which they investigate through botanical inquiry processes
Multi-dimensional level	Individuals understand the place of botany, within biology as a science as within the world as plants are vital for life Individuals know the nature and history of plants and can explain the interactions between the botanical and biological world and life on Earth Individuals are curious and formulate questions about nature, which they investigate through scientific inquiry processes, which involve creative and critical thinking Individuals can make ethically sound decisions on botanical and biological issues

2010). Unless a desire to learn more about plants arises as an older child or adult, children generally develop their limit of botanical understandings by the age of 9 years (Cooper, 2009). This highlights the importance of ECE as a vital time for children to learn about plants. Hence this research seeks to illuminate our understandings of the levels of botanical literacy among some young children in Western Australia, as an indicator of a broader trend among Australian children.

With social changes resulting in more grandparents and parents working and less opportunity for children to gain knowledge from extended family (Brown, 2018), the responsibility of teaching basic scientific knowledge of plants is frequently left to schools (Patrick & Tunnicliffe, 2011), where teachers have also been found to be lacking in plant knowledge and not prioritising the teaching of botany, with curriculum demands focusing on other subject areas (Kaasinen, 2019; Patrick & Tunnicliffe, 2011). International studies indicate that teachers have insufficient levels of botanical literacies to be able to teach relevant botanical information to their students (Cooper, 2009; Kaasinen, 2019). A study of the botanical literacies of four, first-grade teachers in the United States found that none of the teachers had sufficient botanical literacies to teach their students and the majority could not recognise toxic or poisonous plants in their schoolyards (Cooper, 2009). The teachers also reported not feeling confident to teach botanical studies to their students, because of this lack of knowledge, and suggested that curriculum resources for teachers may improve this confidence (Cooper, 2009). Furthermore, a recent Finnish study investigated the plant knowledge of 754 primary school students and 17 teachers, concluding that neither students nor their teachers recognised local plant species very well (Kaasinen, 2019). The study we present in this paper adds to the small number of studies that exist internationally on school student's botanical knowledge and is the first to explore botanical literacies in young children in an Australian school setting.

In many Indigenous cultures, including Australian Aboriginal and Torres Strait Islander cultures, plant recognition and the knowledge of the uses of native plants has been passed down through generations for the continuance of knowledge about food, medicine, tools and other spiritual significance (Hansen & Horsfall, 2016; Taylor, 2013; Wyndham, 2010). In some Indigenous communities, such as the Mayan communities, children hold strong plant knowledge for medicinal plants through the traditional learning method of *Learning by observing and pitching in* (LOPI) (Rogoff, 2014) and helping family and community members forage and garden with traditional plants (Jiménez-Balam et al., 2019). In respect to Australia's Indigenous peoples and considering the Australian Curriculum priorities for Aboriginal and Torres Strait Islander Histories and Cultures (Australian curriculum and reporting authority [ACARA], 2010), it is important to address Indigenous knowledge and names for plants when teaching children about the native plants in the Australian environment. Tsing (2005) explains that the science of botany and the botanical naming of plants was perhaps the first effort at a global knowledge base within the sciences. Unfortunately, the introduction of a global naming system and its use as part of a programme of colonisation, has largely been ignored and has replaced Indigenous knowledge and plant naming practices (Tsing, 2005). Educating children on the Indigenous names and uses for Australian native plants is a priority if we

are to decolonise knowledge and embrace Aboriginal and Torres Strait Islander languages, histories and cultures in our curriculum when teaching with plants in early childhood.

The Current Study

Although there have been international studies that have investigated the plant knowledge of young children and adults using a range of methodologies, there has been no previous study that has examined the botanical literacy of young Australian children. The research is informed by the model proposed by Uno (2009) and uses multi-modal participatory methods to engage children in the research.

The aim of this study was to generate a framework that could inform understanding of the development of the botanical literacies of young children. The research investigates botanical literacies of young children recruited from two early childhood classrooms in a metropolitan area of Western Australia and conducted across a 12-month period in 2020.

Methodology

Research Design and Recruitment

This research used a multi-site case study design (Yin, 2014). It involved two ECE classrooms recruited from two different schools. This design offered an opportunity to study two ECE classes in-depth, across different school contexts, to investigate the botanical literacy of young children. The first author made fortnightly visits to each class across a school year, of one to two hours duration. A total of 16 visits were made to each class across four terms of the school year. The original research design was to have 20 visits to each class, however four visits to each class were cancelled due to a state-wide lockdown period for COVID-19 during the second school term. Due to the large amount of data collected across the completed visits, the researchers did not feel this gap in data collection has affected the outcome of the findings. Data were collected on children's current knowledge about plants in their school's *bush space*. In Australia and New Zealand, the word, *bush*, has a specific vernacular meaning, referring to natural environments that are largely uncultivated and mainly untouched by human intervention, and which usually have wooded areas with trees and scrubs but not dense forest.

The participating schools were independent private schools on the outskirts of Perth, the capital city of the state of Western Australia. School A was situated inland in the Perth hills, and backed onto a large regional nature reserve. School B was situated two blocks from the beach in a small suburb south of Perth. The schools were chosen because each school had access to natural bushland on the school campus. The availability of these bush spaces facilitated this research, as well the inquiry-based pedagogies implemented in these schools.

This research used the Mosaic Approach and a process of scientific concept mapping. Clark and Moss (2011) developed the Mosaic approach as a way of creating a composite picture of children's ideas by piecing together drawings, maps, photographs, child-led tours and conversations. Our study used these methods as part of a 'pedagogy of listening' (Edwards et al., 2012) to children's ideas and knowledge about plants. Through this pedagogy, we were able to focus on listening to the children's theories and insights about plants, as well as hear their thoughts about the connections that were meaningful to them. Following this initial elicitation of prior knowledge, an inquiry-based learning approach was used to support the development of botanical knowledge by the children while in the bush space.

The research is also situated within the pedagogies of *Forest Kindergartens* (Elliott & Chancellor, 2014; Knight, 2013) and *Nature-based learning* (MacQuarrie et al., 2015; Sobel, 2014) by ensuring that the children had a consistent and on-going relationship with a specific natural place. Regular visits across the year enabled an emerging awareness of seasonal and botanical changes and empathy for the natural environment. Local Indigenous Elders visited each class once during the research year to share with the children Indigenous perspectives about the plants growing in their local bush space.

Participants

There were two classrooms involved in this research, one in each of the two participating schools. There was one pre-primary classroom of 17 children (aged 5–6 years) and one Year 2 classroom of 24 children (aged 7–8 years). Written consent for the research was sought from the principal, teachers, parents and children and verbal assent was sought from each child during every visit. Children were able to choose not to participate.

The teachers of the two participating classes were both female, early childhood educators with more than 10 years of teaching experience. They were also the educational leaders of early childhood education in their respective schools. During the data collection with children, these educators were present and active in the conversations and in the visits to the bush spaces. Both educators had previously taken children to the same bush spaces regularly in their teaching for nature play, exploratory and free play, but not for intentional teaching about plants.

Data Collection

Aligned with the research question and supporting the agency of children in the research process, the Mosaic Approach (Clark & Moss, 2011) was adopted. Through each piece of data collected from the children (like a piece of a mosaic), more depth was added to our understanding of children's botanical literacies. This mixed-methods, qualitative approach involved the use of tours, map-making, drawing, photography and concept mapping, including children's work and audio narratives from the children's explanations of their work. Interviews with the educators were conducted before the data collection commenced with the children, as well as at the end of the

data collection period. Interviews with educators included questions about children's plant knowledge. Throughout the data collection, we sought to elicit rich information that acknowledged children as capable and competent research participants and maintain the focus on young children as collaborators in the research, alongside their educators and the researchers (Clark, 2011; Edwards et al., 2012).

Data Analysis

For critical reflection on the children's botanical literacies, a thematic analysis was used to identify emergent data themes (Clarke & Braun, 2016). The data from each visit was read and re-read as a means of familiarisation. Notes and spreadsheets were kept of interesting patterns, inconsistencies, and contradictions. The educators collaborated with the lead author to check and cross-check the data. The second and third authors were involved in discussions to confirm the themes identified in the data. Children's work and narratives were categorised based on the significant aspects of their statements in terms of new botanical knowledge, understandings, and behaviours. Codes were generated for these categories and then refined as more data were collected and analysed.

An understanding of the botanical knowledge that the children developed across the year could also be ascertained. While such information was gained from the educators' interviews, it was also possible to make a direct comparison of children's initial concept maps and drawings at the beginning of data collection with their concept maps and drawings created in the final visit to the classrooms on what they knew about plants at the end of the school year.

To systematically analyse the qualitative data in terms of botanical literacies, a revised version of Uno's (2009) levels of botanical literacies was developed based on Biggs and Collis' (1982) *Structure of the observed learning outcomes* (SOLO) Taxonomy. This was applied as an analytical tool since no model seemed to exist for measuring botanical literacies in ECE. The SOLO taxonomy (Biggs & Collis, 1982) has previously been used successfully in early childhood and primary education research to demonstrate how young children's learning and thinking develops in complexity over time. The SOLO Taxonomy, however, only looks at knowledge, whereas Uno's (2009) model provides indicators such as curiosity and intrinsic motivation, which the researchers felt important to keep as a basis for understanding young children's botanical literacies.

Children's contributions in various written formats through concept maps, map-making, drawings, photographs, and audio-taped explanations from all visits were scored on a scale ranging from 1 (Nominal level) to 4 (Multi-dimensional level) using the levels of botanical literacy proposed for early childhood education as presented in Table 2. Scores could be calculated to differentiate different levels of learning and knowledge about the qualities and complexities of the children's botanical literacies. This process enables quantification of the level of change in knowledge across the school year by the children.

Table 2 Levels of botanical literacy for early childhood education

Nominal (some ideas)	Functional (many relevant ideas)	Relational (linked ideas)	Multi-dimensional (extended ideas)
Names 5 or less plants Some misconceptions about botany	Names more than 5 plants Memorises facts about botany but not well understood	Explains plants and concepts in own words Undertakes botany without prompting Curious and intrinsically motivated	Explains plants as a part of a larger eco-system Curious and intrinsically motivated to understand botany Makes ethical decisions relating to plants

Results

In this section, we present the results derived from the data collection that address the research question: ‘What framework might support the development of botanical literacies in young children?’ Three themes were identified in the analyses of the data. The first theme related to plant names and identification; the second theme focused on understandings about plants, such as their needs and relationship to the environment and the animals; and a third theme about children’s behaviours and attitudes that explored how children interacted with the plants.

Plant Names and Identification

In the first visit to the classes, a concept mapping session was conducted, eliciting children’s prior knowledge about plants. In the first class group of 17 children in a pre-primary class (5–6 years), knowledge was based on fruits and vegetables that the children eat, and children named eight food-plants and five other plants, of which four were native to Australia. The second group of 24 children in Year 2 school class (7–8 years) named three food-plants and 11 other plants, of which three were native to Australia. Only one child across both groups could name more than five plants. While this child was in the pre-primary class, he explained that he gained his knowledge from his mother as they lived on a farm. Thus, 40 of the 41 children displayed nominal levels of botanical literacy. In both schools in the bush spaces at the time of the first visit, the native Marri trees were flowering. This tree is one of best-known, large trees of South-Western Australia. In both classes, the children referred to this tree as a ‘honey-tree’, reflecting the strong honey smell of the flowers. One child explained that she called the tree this name because her family had one at home and her mother called it the ‘honey-tree’. None of the children had heard the tree called a ‘Marri’ tree.

In both groups of children, there were other names for plants that described the physical attributes of the plant that all children in that group would use. These were like a community/class name generated for a tree or plant, similar to the ‘individual landmarks’ referred to in previous research using the Mosaic Approach (Clark & Moss, 2011; Waller & Bitou, 2011). Examples of these names were the ‘spiky bush’ and a ‘stink bug tree’ in the bush space for the pre-primary children. In the bush space for Year 2 children, there was the ‘Y tree’, which the children loved to climb.

During the different seasons across the year in the bush spaces, new flowers emerged, catching the attention of the children with excited calls of ‘*Mrs B., come and see, there is a new flower!*’ from the children. To support the identification of these new flowers, the lead researcher brought along a book for the class which was a colour-coded book identifying local native flowers obtained from the local botanical gardens. The children in both groups successfully used the book to find the flowers in their bush spaces and identify them. Once the plant was identified, the children took a photograph of the plant and we made a keyring of photographs of the plants and flowers in each bush space with the names of the plants on the back of the photograph. Each time new plants appeared, new keyrings were added with

photographs of the flowers and these were used by the children on every visit to the bush spaces, like a game of ‘Where’s Wally’^(TM) for local flowers. These resources supported a significant growth in the children’s knowledge and plant identification. In the final class visit to the bush spaces with each class, when we were concept mapping and reviewing the children’s plant knowledge, the children were collectively able to name 20 native plants in the pre-primary class and 26 native plants in the Year 2 class. This was a big improvement on the initial 4 native plants for the pre-primary children and 3 native plants for the Year 2 students, lifting the knowledge base for the children out of the nominal level for botanical literacies.

Understandings about Plants

When the children shared a ‘fact’ during the concept mapping stage, the teacher or the researcher asked the child, ‘How do you know that?’. Overwhelmingly, the children identified that the knowledge came from something they had experienced at home; had been told by a parent or grandparent, reflecting learning by the ‘Learning by Observing and Pitching In’ (LOPI) method, described by Rogoff (2014). It also might have been something seen on television or a movie, for example, one child explained ‘*learned about nutrients from the Lorax movie*’.

During the concept mapping phase, one of the Year 2 children stated: ‘*You don’t need to water succulents*’. The researcher guided the children to look around the classroom at the many succulents the teacher had on display on the windowsill and throughout the room. The researcher asked the children ‘What about these plants, do they need water?’ The children almost unanimously explained that those plants in the classroom were fake and therefore did not need watering. The teacher exclaimed that the plants were real and was amazed that the children had not realised this. It is possible that as the plants were for aesthetics and the children had never seen the plants being watered or discussed the plants as part of the curriculum, they had assumed them not to be alive.

The map-making sessions with the children provided a method for demonstrating children’s increased understanding over time about how nature is connected to the world; how animals and insects are connected to flowers and trees; how humans are connected to plants for food and shelter; and how the weather affects their bush space. The children’s individual maps in the final phases of the project were more elaborate than their previous drawings with the inclusion of birds, animals, play areas, flowers, grass, the sun and the rain. The difference between the pre-primary children’s drawings from the initial visit by the research when they drew what they knew about plants and when they drew the map in the final phases of the research were vastly different. The plant drawings were generally of single element and the maps were a tangle of trees, paths, rocks, logs and flowers, depicting the bush space. In previous research, using map-making with 3- and 4-year old children, map-making demonstrated children’s understandings of the relationships between elements in the space which the children were mapping (Beasley, 2015).

On the 12th research visit to each classroom and schools, a local Indigenous Elder visited the children and explained Indigenous uses of the plants specific to each

school bush space. The children learned how to make string from grasses and about how medicines could be made from some of the plants and trees. The Indigenous Elder also told the children a Dreaming story involving the native plants. For Australian indigenous peoples, Dreaming stories are the oral stories of Indigenous Australians that explain the origin of the universe and workings of nature and humanity. Subsequent to this visit, the children were observed using these skills during their play. One child in the pre-primary class demonstrated a deeper understanding of his interconnection with nature by taking sap from the Marri tree and applying it to his eczema every time he visited the bush space after the Indigenous Elder's visit, as the Elder had explained this was one of the tree's medicinal uses.

Children's Behaviours and Attitudes

After the research introduction to the children in Week 1 of the project, which was described to the children as 'finding out what children know about plants', they were eager to share the names of plants they knew. During the first visit of concept mapping and drawing-telling, the children used rich sensorial language to explain plants. This was more evident for the pre-primary children than for Year 2 children but it was evident in both groups. During the concept mapping, real plant items were used by the researcher as prompts for children to share their knowledge. The children touched, observed and smelled the pieces of real plants. The children spoke about the smell of flowers and the colours and visual appeal of the flowers. Some pre-primary children shared comments like: '*This smells like Rosemary*'; '*Smells like honey*'; '*I am going to draw me sniffing the flowers*'. From the Year 2 children, some responses were: '*Flower petals can contain colour*' and '*Your paper smells after you rub it with a flower*'. The children demonstrated an interest and curiosity in plants and an excitement to share with others what they knew, fitting with the highest level of botanical literacy model described as the multi-dimensional level.

During the map-making session in Week 2 with the Pre-Primary children, many of the children were excitedly cautioning the researcher to watch out for the 'spiky plants' and many of the children chose to mark these on their maps. The spiky plant was a native plant growing in abundance in their bush space that often scratched the children during their play. Similarly, the Year 2 group had cacti growing in their bush space and these also were a prominent feature of many of the children's drawings, as well as a popular topic of discussion during the map-making tour. The cacti were so interesting to the children that the teacher needed to re-direct the children back to that task of drawing but the children continued to tell tales of their 'dangerous' encounters with cacti. The children's interest in both the spiky plants and cacti was demonstrated through their actions, conversations and drawing, again in line with the Multi-dimensional level of botanical literacies in ECE.

During the third week, the researcher gave the children the opportunity to share questions they had about plants and what they would like to know. For both groups, this session demonstrated an enormous amount of curiosity from the children. All children in the group had questions to ask, some more than one. The pre-primary children had basic plant related questions such as '*How does a seed grow?*' and

'How is a flower made?'. The Year 2 group had specific questions about Banksia trees and cacti that were in their bush space, including *'How does the banksia pod know when to open?'*.

This curiosity grew through the year and in the final educator interview with the pre-primary teacher, she explained that recently when the children were playing a sport on the oval, a child spotted a seed. The child announced their finding and the children gathered and initiated their own inquiry into what the seed was from; where it came from; and what was inside. This was followed by a decision by the children to decorate their class Christmas tree with seed pods from the ground in the bush space, instead of using baubles and tinsel as classes had chosen in previous years. The teacher commented that it seemed a curiosity and passion for botany had become embedded in this class.

Discussion

In this section the findings of the study are discussed in relation to previous research and implications for theory, policy and practice will be suggested. This research provided significant insight into these young children's botanical literacies. Unlike previous studies, this work sought children's voices through a variety of modes and blended the scientific practice of concept mapping to identify what students already knew (Akçay, 2017) with the Mosaic approach, including map-making (Clark & Moss, 2011). Our research also emphasised the curiosity, excitement and engagement of young children when learning with plants and flowers. An early childhood model of botanical literacies can build young children's curiosity about the natural world.

Review of Key Findings

Across the research project, the children were able to demonstrate traits from all levels of botanical literacy described in the model by Uno (2009). If we were to look only at the initial concept mapping and drawing-telling, then children's knowledge would only fit a Nominal level of understanding, because they could identify very few names and terms that related to botany and they did have some misconceptions on the meaning of these terms. Their level of engagement was also only moderate in the early stages of the project. Year 2 children demonstrated more understanding at the Functional level, than the pre-primary children, when they shared their 'facts' and explained these ideas had been learned from family members or movies, such as 'The Lorax'.

Children's experiences in the map-making session and the visits by the Indigenous Elders were important to the research because these experiences, subsequently, enabled children to understand the interconnections and interactions between the botanical and biological world, and life on Earth. These activities supported children's understanding at the highest level of botanical knowledge, the 'Multi-dimensional level' (Uno, 2009). By Week 3, questions asked by the children had begun

to manifest behaviours that aligned with this highest level of botanical literacy. The children were becoming more curious and able to formulate questions about nature such as ‘How does the Banksia pod know when to open to let go of the seed?’. We found Uno’s (2009) levels of botanical literacy to be a useful framework as a guide of what to observe and document in relation to young children’s knowledge about plants. We have also recognised that on completing this picture of children’s current botanical literacy levels, this model could be used as a basic guide for planning the curriculum to improve botanical literacy in early childhood.

In ECE, there is a significant emphasis placed on the importance of hands-on sensory experiences for children’s learning and development (Beery & Jørgensen, 2018). This aligns within the nature-based learning model as children touch, smell and observe the flowers and plants within the environment as part of their direct experience with nature, which Beery and Jorgenson (2018) explain is vital for confronting the extinction of biodiversity. In a recently proposed framework for early childhood environmental education, Barrable (2019) suggested that during regular time in nature, children need to engage with the beauty of nature, cultivate compassion and practice mindfulness in nature. This echoes the findings of our study, where children were engaging their senses for exploration and developing an awe and respect for the beauty of the plants in the space, including choosing seed pods for their Christmas tree decorations instead of baubles and tinsel.

Sensory awareness was a theme we uncovered through this study in relation to children’s botanical literacies that was not identified in Uno’s (2009) levels of botanical literacies. Before the skill of naming and identification of plants begins, we propose that children need to establish a relationship with plants and flowers that is built over time through regular hands-on contact with nature. From our findings, we suggest that a botanical literacies framework for ECE requires a strong foundation of regular time (at least, fortnightly) in nature involving hands-on experiences with plants and flowers.

The importance of the role of an interested adult also became obvious during the collection of the data. Although the children were engaged and curious through the research, it was the researcher who led the children and educators to the bush space and inspired the exploration of plants through questions and conversations. This aligns with several previous studies which suggested a child’s interest in nature can be lost if a passionate, interested adult is unavailable with whom to share nature experiences (Sobel, 2014; Wilson, 2009; Wyndham, 2010).

Implications and Directions for Future Research

In visualising botanical literacies in early childhood, the following graphic (Fig. 1) represents our findings and suggestions for how botanical literacies could be developed with young children. While Uno’s (2009) model assessed current knowledge, understanding and behaviours of college students, this model for ECE explains a framework that would support ideal conditions for developing the botanical literacies for young children.

Fig. 1 Framework for developing botanical literacies in ECE

The findings from our research suggest that the ideal framework for developing young children's botanical literacies includes combining regular time in nature with a botanically interested and passionate adult, who enables curiosity and wonder through hands-on and sensory learning with plants and local Indigenous knowledge. Visiting nature regularly allows young children to notice the subtle changes in nature through the seasons with their senses. Regular visits with nature and the inclusion of Indigenous knowledge and botanical literacy development supports the ideas of Otto and Pensini (2017) who suggested that nature-based education is most effective when it focuses on the promotion of knowledge about flora and fauna as well as real contact with nature. The role of the adult is vital in prompting initial inquiry, providing resources for children's research and exploration, and sharing in the excitement of finding something new in nature.

Implications of this research for policy and practice suggest schools and educators should engage young children in regular time in natural environments throughout

each school year. Schools could identify educators, community people and local Indigenous people who are passionate about plants and botany to lead conversations and inquiries about plants while in the natural spaces. The ideal conditions formulated from this research for developing botanical literacies in ECE provide insights for enriching the curriculum. There are also implications in this research for Initial teacher education (ITE) programs in eliciting an interest in plants and developing botanical knowledge, including Indigenous perspectives.

It should be noted that the two participating schools already had bush spaces in their school grounds. The framework could be easily modelled by other schools with bush or forest spaces, but this is not a common feature of many schools in Australia or internationally. This may affect the ability of framework to be generalised across other ECE settings.

Future research in this area should focus on applying the framework for developing botanical literacies in ECE in a wide variety of settings and measuring the effectiveness on young children's development of botanical literacies. In addition, it would be beneficial to add to the research on *Education for sustainability* (EfS) by researching the link between the levels of botanical literacies in young children and their sustainable beliefs and attitudes.

Conclusion

This article has demonstrated the Mosaic approach is an effective approach to explore the botanical literacies and plant knowledge of young children in conjunction with the scientific practice of concept mapping. In this case, multi-modal 'listening' enabled children to express their knowledge, ideas and curiosities about plants in a variety of ways, which broadened the educators' and lead researcher's understandings of the children's botanical literacies and raised the level of botanical literacies visible in young children.

The results of this research have led to the generation of a framework for developing botanical literacies in ECE. This framework provides a means through which to engage children as active participants in their own learning through hands-on inquiry. Regular time in nature with an interested and passionate adult can encourage curiosity and wonder from children and engage children in inquiry questions. Indigenous knowledge of local botany deepens children's understanding and connection with plants, leading to higher levels of botanical literacies and increased knowledge, understanding and more positive attitudes about sustainability.

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Data availability Upon request we are prepared to send relevant documentation or data in order to verify the validity of the results presented. Sensitive information in the form of confidential or proprietary data will be excluded.

Declaration

Conflicts of interest The authors declare that they have no conflicts of interest.

Ethical approval Ethics was approved by the Human Research Ethics Committee at Murdoch University as project number 2019/ 170. Wording of approval was: “OUTRIGHT APPROVAL Approval is granted on the understanding that research will be conducted according the standards of the National Statement on Ethical Conduct in Human Research (2007), the Australian Code for the Responsible Conduct of Research (2007) and Murdoch University policies at all times. You must also abide by the Human Research Ethics Committee’s standard conditions of approval (see attached). All reporting forms are available on the Research Ethics and Integrity web-site.”

Consent to participate Consent to participate was gained in writing by the schools principals, teachers, parents and children involved in this research in writing. The consent form was approved by the above ethics committee as a part of project number 2019/170.

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