International Journal of Technology and Design Education (2023) 33:775–792
https://doi.org/10.1007/s10798-022-09758-x

'Bush kinders': developing early years learners technology and engineering understandings

Chris Speldewinde[1] · **Coral Campbell**[1]

Accepted: 18 May 2022 / Published online: 29 August 2022

Abstract
Developing a knowledge of design and construction technology and engineering is often overlooked in favour of 'digital' technology such as tablets and computers. By taking children outdoors into nature, removing tablets and computers as well as artificial and synthetic materials and replacing them with only what nature provides, children become attuned to developing STEM knowledge through play with natural materials. This knowledge often develops through teacher support and at times by default, as children experience the constantly changing landscape of the natural environment. The development of children's understandings of 'nature's' technology and engineering provides an opportunity for further investigation of nature-based early childhood education and care settings. Through research conducted at four Australian bush kindergartens, this paper presents data from photographs, interviews and observations undertaken of twelve teachers and over one hundred and twenty children. It responds to the research question, how do early years learners develop their understanding of technology and engineering by engaging in nature-based learning? The research was undertaken using ethnography, a useful method in nature settings as the approach enables a deep understanding of how children develop their understandings of applying technology and engineering over time. The data demonstrate the benefits preschool children can gain from learning and being 'in' and 'with' nature and the important role bush kinders play in supporting children's technological and engineering literacy. Findings reveal that through their participation in bush kinder, children can develop technological and engineering knowledge.

Keywords Technology · Engineering · Bush kinder · Nature-based learning · Early years education

✉ Coral Campbell
coral.campbell@deakin.edu.au

Chris Speldewinde
christopher.speldewinde@deakin.edu.au

[1] School of Education, Faculty of Arts and Education, Deakin University, Geelong Waurn Ponds Campus Locked Bag 20000, 3220 Geelong, Victoria, Australia

Introduction

Young children at play often take interest in the world around them (Edwards & Larson, 2020). Forest kindergartens and nature schools are one avenue for children to access nature and the outdoors to develop understandings of the world around them (Warden, 2015). Forest schools have been well established in the UK and across parts of Europe including Scandinavia for over fifty years (Knight, 2016). Recently, the 'forest school' approach has been taken up in growing numbers in Australia and has been influential, along with outdoor education traditions and preschool play-based teaching approaches into 'bush kindergartens' (colloquially known as 'bush kinder') (Christiansen et al., 2018). With Australian conditions in mind, bush kinders provide opportunities to foster children's biophilia or love of nature and allow children to develop noticing skills attuned to the world around them (Speldewinde et al., 2021a). Bush kinder sessions take place in a variety of settings such as open and wooded parklands, paddocks, and beaches with four- to five-year-old children. They operate in almost all, but the most extreme weather conditions. Bush kinders have been shown to expose children to a range of science learning opportunities associated with concepts incorporating physical, chemical and biological sciences (Campbell & Speldewinde, 2020) at a time when children's STEM learning has been at the forefront of policy maker's considerations (Campbell & Speldewinde, 2018). While STEM learning in the early years has been a focus of numerous studies, and specific science learning in bush kinders has been the subject of limited research, little consideration to date has been identified examining how children apply and experience design, technology and engineering.

What became apparent during this research at four bush kinders is children's capacity to apply only what nature provides to build understandings of technology and engineering. It leads to what children experience as 'designerly play' (Baynes, 1984; Fleer 2021). Engineering, in its broadest sense, applies a design process to solve a problem. Engineering encourages cooperation between children (Preston, 2021) and thinking and design behaviours when children play with artificial items such as blocks and Lego (Bagiati & Evaneglou, 2016). It has been observed that behaviours exhibited by professional engineers such as identifying needs, setting goals, solution testing, problem solving, and design synthesis are comparable in children (Preston, 2021). Yet, what is also apparent is that often technology and engineering are neglected in the broader STEM discourse and lack the prominence of science and mathematics in teaching and learning in early childhood (Albion et al.,, 2018; Pantoya et al., 2015). Technology is often seen as an 'add-on' or digital technology takes precedence over other forms of technology learning and becomes integrated into other disciplines (Campbell & Jobling, 2014).

This paper seeks to add to literature dealing with the teaching of technology and engineering disciplines in Australia. Three vignettes, as exemplars of four-year-old children's play events with sticks in bush kinders, are provided here to demonstrate technology and engineering learning. These vignettes are three of many of other similar events we observed whereby children utilised pieces of wood fallen from trees for play. While we acknowledge instances of teacher involvement in the data, as teachers often apply their judgement to move in and out of play situations as they see the need, the focus of this paper is the children's actions. It is the examples of children's developing understandings of technology and engineering that allows us to respond to the research question: what opportunities exist for children's learning of technology and engineering in bush kinders? The vignettes provided

here, interpreted by this paper's authors, give an understanding how technology and engineering are applied in the environment allowing for deeper understandings of what is available to foster children's love of technology and engineering. A general discussion of these vignettes was held with the teacher at the time, but this did not have a focus on technology or engineering.

Technology education in Australia refers to both the design and digital technologies (ACARA, 2021). Both forms of technologies are influenced by, and influence society and are positioned within specific identified contexts of engineering, systems, food and materials production and technologies specialisation (Albion et al., 2018). Children, to develop understandings of the world around them, need to be provided with opportunities to engage with technology, designing and producing familiar objects, services, or environments. For the purposes of this paper, technology is defined as a human activity, one that is process-focussed, as well as product oriented (Albion et al., 2018, p.14). Technology is a problem-solving and solution-creating approach adopted by humans to meet their needs and improve lives (Albion et al., 2018).

Technology's application in early childhood (the significant properties which allow learning) apparent within these settings, as well as the impact of individuals within the setting, forms part of the consideration here. This is important as technologies have been found to 'play a crucial role in both enriching and transforming societies, and in the management of natural and constructed environments' (Victorian Curriculum and Assessment Authority [VCAA], 2015).' Here the focus deviates away from the use of digital technological devices such as iPads, tablets and similar electronic devices in nature settings. Rather we examine technology resources found in nature and their application in engineering through children's play in nature settings. Items such as fallen tree debris, sticks of varying size, and how sticks are manipulated and applied by children in bush kinders, provide the context to develop deeper understandings of technology and engineering. Using vignettes, we demonstrate the value of bush kinders in early childhood technology and engineering in children's experiences and subsequent learning. Fieldwork observations of children at play are applied in this paper to understand how technology learning occurs in bush kinders to consider how the environment (bush settings) contributes to children's learning.

Understanding technology and engineering in early childhood

Central to guiding learning in early childhood education are the encouragement of creativity, curiosity, and initiative (Fox-Turnbull, 2019, p. 78). These attributes, along with engagement with and development of 'cultural heritage values, traditions, language and knowledge, to be reflective and to work collaboratively' all form critical elements of technology and engineering practice. Fox-Turnbull (2019, p. 79) notes that the teaching of technology has commonalities and is often focussed on the 'made-world' and its exploration. Understanding technology from an early age is beneficial as it pervades 'every area of human existence where people use and develop tools, machines, materials, techniques, and processes for solving problems and reaching set goals in order to fulfill human needs and aspirations' (Turja et al., 2009, p. 354). The definition of technology in kindergarten settings, catering for children 4–5 years old, is reliant upon early years (pre-primary school level) technologies curriculum documents (Victorian Curriculum and Assessment Authority

[VCAA], 2015) and the pedagogical approach often adopted in early years teaching and learning commonly termed play-based learning.

A focus on process is valuable when considering technology and engineering. Process allows for solution development (ACARA, 2015) and for children to design, think, and modify. Even at the stage of early childhood, children have been observed as engineering learners (English & Moore, 2018) where learning engineering is 'the design of tools, structures, and systems within the associated constraints' (McGarvey et al., 2018, p. 56). Design itself has an important role to play in technology and engineering early years education. Fleer's (2021) study of children drawing gives attention to the notion that narrative based role playing by young children generates opportunities for play involving design. Baynes' (1984) notion of 'designerly' play is characterised by three components, 'configuration (the arrangement of props), situation and story'. By extension, design leads to opportunities for technology and engineering play through the props, the situation, and the story (Baynes, 1984). Children have been observed to apply their imagination through designerly play to problem solve during play and play amplifies the children's designerly thinking (Fleer, 2021).

Early childhood learning frameworks (Early Years Learning Framework (EYLF) and Victorian Early Years Learning and Development Framework (VEYLDF)) highlight children's learning related to "exploration", "creativity", "collaboration" and "problem-solving", in the context of connecting with people and technologies (Campbell, 2010). Both frameworks (DEEWR, 2009; DEECD, 2009) seek to advance of children's learning and development from birth to eight years and support early childhood professionals to collaborate with each other and with families to achieve common outcomes for all children. Further to this, the VEYDLF (DEECD, 2009, p.26) notes that pre-school children "use play to investigate, imagine and explore ideas". They additionally "apply a wide variety of thinking strategies to engage with situations and solve problems and adapt these strategies to new situations" (DEECD, 2009, p.26). The validity of technology and engineering as a learning area that needs further pursuit is captured in the early years where children "understand that people use creative, imaginative and inventive thinking to help them meet human needs and wants" (DEECD, 2009, p.26). Similarly, young children often "play with and manipulate materials/ ingredients in both a free and focussed manner to foster development of their design and technical skills" (DEECD, 2009, p. 27). Worthy of consideration is how nature-based learning environments such as bush kinders contribute to understanding the value of developing children's understandings of technology and engineering.

Bush Kinders: a place to learn technology and engineering skills

Bush kinders are an Australian approach to nature education (Cumming & Nash, 2015). Bush kinders often occur in urban, peri-urban and regional settings which include open paddocks (fields), wooded parklands (at times referred to as 'the bush' in Australia), along with public reserves and beaches. They take place in almost all-weather conditions, except for extreme conditions such as storms or excessive heat (Campbell & Speldewinde, 2018). They are distinguishable in the context of Australian early childhood teaching and learning, with variances in the physical outdoor learning spaces as well as the affordances and opportunities that are available for learning (Campbell & Speldewinde, 2020; Christiansen et al.,

2018). Previous bush kinder research (Speldewinde et al., 2020) highlights the range of pedagogical approaches that guides teachers' practice and the growing field of nature pedagogy or nature-based learning that provide opportunities to observe the 'natural methods and practice of working with nature (and how they) that sit within a set of values' (Warden, 2015, p. 35).

Young children have been found to have the capacity to notice what nature provides (Harvey et al., 2020) which is important when considering how children can locate and apply the technology and engineering skills available to them. Children's noticing allows them to observe and understand the technology and engineering available to them in nature (Speldewinde et al., 2021a) Harvey et al., (2020, p. 3) propose that children can reconnect with everyday nature surroundings, in spaces that focus on 'the intrinsic value of ecological systems within urban settings'. Kaplan et al., (1989) also note the accessibility of nature spaces as they provide opportunities for children to reconnect with nature in urban settings. The characteristics described here are often reminiscent of those that occur in bush kinders which facilitates children's nature play.

In addition to the context of the outdoor learning space of the bush kinder, a relationship exists between children's outdoor play and teaching practice (Mawson, 2014). Seasonal changes, natural phenomena, chance meetings with wildlife or domestic animals, local access issues, and physical elements of the territory, can support children's nature learning. Outdoor spaces such as bush kinders can provide opportunities for teachers to foster children's play and learning with only what nature provides; for example, loose materials such as fallen leaves and sticks, and fixed natural structures such as trees although not part of the 'made world' can be resources that can be applied as technology tools that lead to children's experimentation with engineering. This 'loose parts' theory, often associated with learning in the outdoors (Nicholson, 1971) provides a connection to children's creativity which is an expected part of technology education as well as other areas of the curriculum such as science and mathematics in the outdoors. Applying loose parts creatively for play is valuable as artificial or synthetic materials that may be prevalent in outdoor spaces are generally removed and not available in bush kinders for children's play (Campbell & Speldewinde, 2020). When natural, outdoor environments are understood as pedagogical spaces, opportunities abound for the enhancement of young children's play, learning and development (Moser & Martinsen, 2010).

Ethnography observing the how technology and engineering is applied

Ethnography (Delamont, 1992; Stan & Humberstone, 2011) as a research methodology, enables researchers to carefully consider how children develop their understandings of technology and technology's use in bush kinders (Speldewinde et al., 2021). Using ethnography allows the researcher to see and notice what is taking place around them by developing close and extended interactions with teachers and children over an extended period (Speldewinde et al., 2021a). Comprising different research methods, ethnography as applied here incorporated participant observations of educators and children, listening to teaching and learning dialogue between educators and children, and children and their peers, semi-structured interviews, informal discussions, and images captured using photographic and video record-

ings of play and teaching moments (Speldewinde et al., 2021a). Building trust, particularly with young children, as well as teachers, is critical to successfully establishing relationships that lead to extended interactions during fieldwork. The teachers involved in this research were all experienced and, while preschool children generally attend a bush kinder for one calendar year, teachers can work in the same bush kinder setting over many years. This ongoing connection with the bush kinder site ensures teachers observe changes and develop deep understandings of the teaching and learning opportunities that nature provides. Regular researcher attendance at a field site is important. Initial data can go out of date (Last, 2019) and, in the case of bush kinders, because the pedagogical approaches adopted by the teachers often lead to the children instigating the learning, there is an irregularity in terms of the teaching and learning taking place. This is in part due to the seasonal adaptations of the landscape of the bush kinder that change children's play focus. Ethnography can capture those processes of change over time and are illuminating for the researcher's understanding of the context (Last, 2019). As social contexts are continually shifting between young children and their teachers, ethnography provides researchers with opportunities to apply a range of data gathering methods. To further inquire into how technology was occurring, we applied what Madden (2012) describes as a consistent element of ethnography. He maintains that ethnography uses 'a particular set of methods (a toolkit)' (Madden, 2012, p. 25) and it was these tools such as interviewing and observation, that this study relied upon to gather data. By including researcher observation of teachers and children, listening to conversations between the teachers, between the children and between children and teacher, an understanding of teachers' and children's use of technology became apparent in this study. At times, the research team were drawn into conversations and into participating with applying technology in the bush kinder.

Although semi-structured interviews (Longhurst, 2003) and focus groups with teachers and parents took place, the ethnographic data in this paper is limited to observations of children documented in researcher diaries and imagery from photographs of the inclusion of technology by the children. These photographs were taken in 2015 and 2017 during the one hundred or so regular fieldwork visitations that were conducted by the research team. The visits would take place for often up to four hours per day and would involve observing, listening, note taking and interviewing. We returned to field sites in 2020 with the aim to understand developments and shifts over time and how these occurred and conducted additional semi-structured teacher interviews were conducted with nine teachers. As part of this inquiry, we were interested in gaining an updated understanding of what changes to teacher pedagogy and children's programs, if any, had been occurring in the bush kinders since 2017.

Participants and fieldwork

Four bush kinder sites were selected for fieldwork for this study. Fieldwork according to Preissle & Grant (2004) is 'the study of something in the natural environment where it occurs or that it inhabits'. The rural townships of Wicklesham, Chatlock, Sunrise and Whitesands located in the Sandy Shores Shire (all pseudonyms) of south-eastern Australia are locations that each have their own kindergarten (preschool) and nearby bush kinder site. The preschool teachers from each kindergarten were also the bush kinder teachers, except

for Chatlock where in 2015, it had its own designated bush kinder teacher. Each bush kinder was staffed by an experienced lead kindergarten teacher and two educators who were supported also by parent helpers. Three teachers jointly care for, on average, 25 children, who spend a full four-hour session, one day a week in bush kinder. The research gained university ethical approval HAE-15-016. Signed consent forms were gained for all participants, with parents approving children's involvement.

To minimise the disruptions to preschool children's play and learning, we observed and interacted with the children, but we did not interview them. Even though the pre-school children (who were four -five years old) who attended the bush kinder programs participated in the study, their involvement and any interruptions to their play and learning were kept to a minimum. The fieldwork observations were of children playing, and children playing amongst themselves. As researchers, we listened, talked, watched and at times, participated in the bush kinder sessions, undertaking participant observation (Madden, 2012). We attempted to observe from a distance, without participating in the play. However, at times, the children would draw us and the other adults into the play situation. So, we were both non-participant observers, but also participant observers. Some photographs and video recordings of children at play occurred, however were they deleted from any device prior to leaving the bush kinder site for the day. The purpose of the video recordings was as stimuli for reflective interviews with teachers and for our researcher notes which were written while at the bush kinder and elaborated upon as soon after as possible. Teachers were asked to describe what was happening during a particular event or the technology and engineering they were observing. Videos and photos while part of the collection of data were something that we could refer back to, rather than just relying on memory. In terms of data, we conducted:

- Structured interviews with teachers at the commencement of the project in relation to their views of bush kinder learning.
- Unstructured interviews with teachers as the play evolved.
- Unstructured interviews with teachers who viewed the videos of play.

The data has been collected for this research over six years, from 2015 to 2020, increasing the depth of information presented but the study is somewhat limited by its small number of field sites, which were four. The low number of sites was due to the relative newness of the bush kinder approach at the time of initially undertaking of the research in 2015. For example, the bush kinders we visited were in their second year of operation. A pilot bush kinder, based at Chatlock began in 2014 for one term which was extended to five bush kinders in 2015. This meant that the bush kinders were still in a development phase when we commenced our research.

Findings: technology and engineering play in bush kinders

This paper presents one finding where bush kinders provide the context for children to develop understanding of technology and engineering concepts with only what nature provides. Often simple items like a stick can have a myriad of purposes ranging from writing implements to tools for use in engineering to erect dwellings. The following vignettes

Fig. 1 Sand drawing

demonstrate technology and engineering learning and skills in early years children's nature-based education. By participating in bush kinder, children can investigate and solve problems as part of their play. For these vignettes, we have elected to focus on fallen tree debris, sticks and larger limbs which were available on the ground for children to pick up and apply in a range of ways.

Small sticks: nature's writing implements for creating sand patterns

Relocating children from the indoor kindergarten and placing them in nature settings does not reduce their ability to draw and document their experiences. At beach kinder, three children wanted to make patterns in the sand, they began by deciding to use a technological tool, rather than their hands. Yet, problems arose as the children found difficulties that need solutions to allow them to continue their play.

> Sam had been playing in the sand at beach kinder. While Sam appeared to enjoy his play, he found that, while wanting to make impressions in the soft, loose sand, that he could not effectively do so with his small fingers. He observed that there was a small stick of wood nearby that had washed ashore and found, upon picking up the stick, that it fit comfortably in his hand. Sam did not modify the stick in any way and began to make marks in the sand. Dissatisfied with what he had accomplished he moved to another part of the beach where there was flat, unbroken sand and he began to use the stick to draw a circle. He then added to the circle with lines (Fig. 1). Satisfied with this drawing and having admired his work, he moved onto drawing a wavy line. As the minutes past the wavy line grew longer and longer, all the while, the stick proved useful as a technological implement to allow Sam to draw in the sand (Fig. 2, 3).

What became apparent using the small stick was Sam's determination to think and problem solve to find a technological approach to allow him to continue with his sand drawing. As his drawing progressed, his enthusiasm for the task allowed him to confirm the appropriateness of this technology to achieve his task and continue his play. The product of

Fig. 2 Sand drawing

Sam's determination was his drawing as he returned to the task over numerous occasions, the end point being reached when his drawing concluded. Sticks were often present at each bush kinder and their size varied. Larger sticks which we classified as being of a medium size could be utilised for other purposes and used to collect sap specimens from trees as is demonstrated in Vignette 2.

Medium sticks: levers to extract sap

This vignette provides an account of how nature provides resources for use in technological developments through which children can develop STEM understandings. It demonstrates how children can be creative and how the simple task of moving a lightweight object can take on complexity if children wish not to handle that object themselves. The repurposing of sticks to move objects provides the opportunity for technology to be taught. Abbey and Kayla had begun their play and the girls needed a technological solution to allow them to continue their play.

> Abbey and Kayla had been seated together, playing for twenty minutes in an open, grassed area of the bush kinder. They decided that they wanted to move to a different area of the bush kinder, closer to a fallen log, away from where their play was currently being interrupted by other children's play. Their imaginary play involved fairies and being part of a fairy colony. The girls proceeded to move to another part of the bush kinder and within a few meters of their new play space, they observed a tree with sap running down the tree. 'Fairy drops' proclaimed Abbey loudly. Both girls wanted to extract the fairy drops (sap) away from the tree so it could be part of their play. Both were reluctant to use their hands yet were determined to obtain some of the valuable fairy drops. Abbey suggested to Lucie that they use sticks as they could not reach high enough to collect the sap. Initially, one short stick of about 50 centimetres was found and the girls tried to extract the sap without success. Abbey and Kayla continued attempting to use longer sticks, up to a meter long, still without success. By now an assortment of sticks had been gathered, of varying length, along with some long pieces of native grasses. A teacher, Alice, joined in the play and asked if girls,

> ‘can you come up with a way to get the sticks to come together so you can reach the fairy drops? The teacher moved away to support another group. Kayla suggested they wrap the grass around two sticks to make them longer. The girls tied the grass together making long ribbons of grass. Time was spent securing the sticks together to make a longer implement to collect the fairy drops. Finally, after thirty minutes two sticks were connected, and fairy drops were gathered and the girls moved away.

Abbey and Kayla’s play allowed them to discover tree sap. To be able to reach the sap and use it for their purpose, the creating of a technological tool was the outcome applied to collect the sap which would allow them to continue their play. The medium sized sticks available to Abbey and Kayla were useful during imaginary play and in facilitating understandings of technology. To understand engineering though, larger sticks were required as is discussed in Vignette 3.

Big sticks: perfect for erecting a dwelling

Being in wooded areas, the bush kinders that formed part of this study were spaces where children often had large fallen branches available for play. The children who came to bush kinder experience playhouses at their regular kindergarten as part of the outdoor landscape. The playhouse or cubby house would become a gathering point or a bush kinder activity. The children would play in their cubby houses for long periods of their four-hour bush kinder session. Often, children would roam around the bush kinder looking for natural resources including fallen limbs and branches that would suit for construction and development of their cubby houses. In the example below, we see the application of naturally occurring resources as well as fence palings, a resource constructed for a specific purpose).

> On this day, a group of children who had been playing under a tree determined they wanted to construct their own cubby house as several large tree branches had fallen on the ground. The children began by dragging the tree branches, and with some support from their teacher, were able to lean the branches against the tree. A process of trial and error, testing and application occurred over time as different branches were stacked against each other. The structure was somewhat sound (Fig. 4) but the children desired a structure that provided more shelter. A discussion between the children and teacher ensued as to why this first cubby house did not meet the children’s needs and what could be done to improve the dwelling. As it was not fit for purpose, a suggestion was made to add more branches, but the cubby house engineers had set their sights on a nearby boundary of the bush kinder. The bush kinder site was bordered by a fence line, the fence line was permanent and provided more protection and stability for a cubby house. Tree branches were dragged and used as a framework and then more and more fallen branches added to make a roof on the cubby house. Some fence palings were also on the ground and were repurposed as a cubby house wall. This building took place for almost two hours until the dwelling was built (Fig. 3). It provided the necessary protection from the wind and became the focal point of the children’s play as imaginary games and role playing took place.

Fig. 3 The initial cubby house

Fig. 4 The subsequent cubby house

Bush kinders: facilitating while learning about technology and engineering

We examined how the children applied technology and engineering in a number of situations were influenced by Baynes (1984) categories of configuration, situation and story. Baynes' work, although not strong empirically and described by Baynes (1984, p. 12) as 'informal', was influential in providing categories to consider how play with technology and engineering occur. Baynes' categories of 'Configuration, Situation and Story' support the conceptualisation of designerly play in bush kinders. Configuration is regarded as how 'props' such as pieces of wood are used and arranged and where 'the essence of the play is to make the arrangement as much as to do anything with it.' The configuration becomes 'essence' of the child's play and creates order in a place like a bush kinder. Often children in bush kinders play imaginary games creating the 'situation'. Baynes describes how children develop role playing 'situations' from what they observe in an 'adult world.' The story provides the basis of the play, is often worked out in advance, then enacted. It allowed us to further think on the planning that the children in bush kinders would undertake.

Similarly in developing a more complete understanding and analysis, we considered elements from Fleer's (2021) model of designerly play. In our research, applying fallen branches, sticks, and twigs for learning have their place in developing young children's

understandings of technology and engineering. We observed children's inclusion through play of these re-purposed materials to engineer structures, make technological advancements and develop systems within the constraints of what the environment provided for play. The analysis of children's technology and engineering and learning at bush kinder, was influenced by Fleer's (2021) notion of designerly play, where design is a critical element of technology and engineering. Fleer's model was selected for application here due to its cyclical, dynamic nature. With play at its centre, grounding the stages of learning that occur, Fleer's work allows us to conceptualise what we were witnessing in the bush kinder. In addition to Fleer's (2021) work, Baynes' (1984) earlier notions of designerly play, were influential when considering elements of Fleer's model of 'designerly play' which were observable in bush kinder programmes as teachers were combining play-based pedagogy while children's technology and engineering play was occurring through role playing. Fleer's (2021, p.19) designerly play model has at its centre, play where 'play acting (is) the source of design development.' 'Designerly play' is according to Fleer (2021), a dynamic model in which a problem to be solved arises which then leads to problem solving, solution generation, design, further research and prototyping then finally returning to another social problem to be solved. Baynes and Fleer's work led us to examine how the children were learning and playing in the bush kinder and their inclusion of technology and engineering to problem solve and develop solutions. Baynes' work provided three categories to allow for the analysis of the data. Using Fleer's model allowed for a more complete understanding and analysis of the children's approach to technology and engineering explorations in bush kinders.

The technological play in the natural setting provided children with a range of features that are unavailable or different in a conventional kindergarten. In bush kinder, children had more space, allowing them to 'go bigger' and to tackle larger projects such as building cubby houses for multiple children. The generally natural materials facilitated the opportunity for creative thinking about what these materials could become, as opposed to prescribed or gendered materials and tools. Children's group dynamics altered in bush kinders (Speldewinde et al.,2021) enabling a greater variety of 'voices' to contribute ideas, potentially leading to more creative outcomes. These are obvious similarities in that the process used is approximately the same regardless of setting, but the context presents many opportunities for more complex thinking based on the factors indicated above. Overall, technological projects undertaken in bush kinders leads to more creative outcomes (Campbell & Speldewinde, 2022, 2021).

Yet, despite these similarities, differences abound between conventional kindergarten natural environments that can support designerly play in nature. The space and time that occurs through bush kinder sessions are almost exclusively play focussed with little or no prescribed activities. Few natural materials were readily available in conventional kindergarten contexts unless brought in by the educator. The tools and gendered items that can influence children's play are not present in bush kinder (Speldewinde & Campbell, 2021). Group dynamics in the bush kinder are not constrained by expectations and enable designerly play and creativity (Campbell & Speldewinde, 2020). It is these similarities and differences that are the value of the natural environment in comparison with other environments. We capture in Fig. 5 the children's process of applying technology and engineering, influenced by Fleer's model of designerly play.

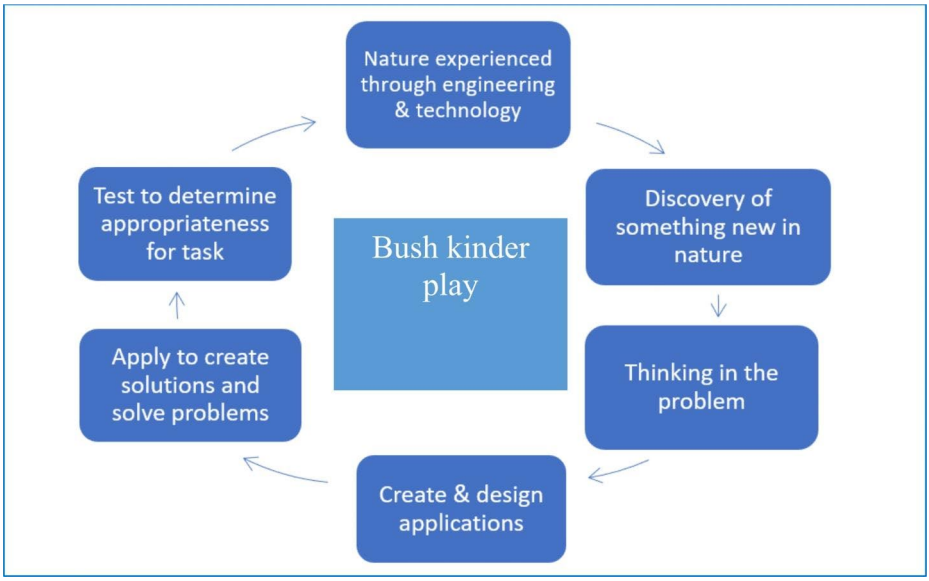

Fig. 5 Our model of bush kinder technology and engineering learning

What became apparent as we came to consider these three vignettes was that, regardless of the size of the stick, and its inclusion in technological or engineering outcomes, each example demonstrated that the children were following the technology and engineering model for bush kinder play outlined in Fig. 5 that was occurring during the children's STEM-related nature play. While the play was iterative, where children were moving back and forth across the phases, we haven't depicted this in the model as we wanting to keep the key aspects more prominent. Multiple lines of iteration would become confusing in the diagram. What is evident in each vignette, is that the children are playing and experiencing nature that then leads to a discovery. Upon their discovery, the children would use thought processes to make decisions, apply judgements and determine actions to solve problems – what we have termed 'thinking in the problem'. Having thought through the problem, the children would undertake a creative process of design, then apply that design. Once the design is applied, testing of the technology or the engineering occurs through play.

Each of the vignettes exhibit steps in the model of bush kinder technology and engineering learning (Fig. 5). Using key moments in the vignettes as indicated in Table 1, we can tabulate those to correspond with the steps in the model.

In the three examples, following discovering of what nature provides for play, the children's thinking occurred. Abbey and Kayla's (Vignette 2) discovery of tree sap prompted thinking regarding how to apply this to fit the story they were enacting in the situation of the bush kinder. Sam (Vignette 1) had a need, to be able to draw, and required a technological tool to extend his capacity to draw. Having found an inadequacy with his hand as that tool, through thinking he determined that re-purposing a stick would be a suitable technological implement. Similarly, the group of cubby house builders (Vignette 3), having previously been playing under a tree, discovered that the environment provided the resources to engineer a dwelling.

Table 1 Bush kinder technology and engineering play

Technology/ Engineering process	Sam	Abbey and Kayla	Cubby builders
Nature play	Sam is playing in the sand	Abbey and Kayla are playing fairies.	Children are playing under a tree. The tree is an imaginary cubby house.
Discovery	Sand is available for Sam's writing and pattern drawing	Abbey and Kayla discover small globules of tree sap but it is out of reach.	Children discover large branches on the ground around the bush kinder.
Thinking	Sam determines that his hand will not allow him to effectively write in the sand.	Abbey and Kayla wish to play with the sap but need to find a way to collect it.	Children consider constructing their own dwelling.
Design	Sam decides he needs an alternative writing implement that is hard and has a pointy end, if he wishes to draw in the sand	Abbey and Kayla decide sticks will suit their purpose but need to extend the sticks they have.	Children are influenced by the shelter provided underneath the tree to design their cubby house.
Apply and Problem Solve	Sam solves his problem when he finds the stick to allow him to write	Abbey and Kayla link the sticks together using grass which they had tied together.	Children construct the cubby house through a process of trial and error. The builders determined what would be fit for purpose.
Test	Sam applies the stick as a writing implement	Abbey and Kayla successfully collect the sap. Abbey and Kayla redesign and display perseverance.	Children move in and out of the structure, determining its effectiveness.
Nature play continues	Sam can now play through drawing patterns	Abbey and Kayla now have fairy drops to include in their play.	The focus of the group of children shifts from constructing the cubby to imaginary play in the cubby.

Often design is attributed to writing and drawing (Anning, 1997; Fleer, 2021) although at other times, design can involve clay and plasticene and be unplanned, spontaneous and involve trial and error (Milne, 2013). In the bush kinder setting pencils and paper are often not present so children's design is left to their imagination, which supports Fleer's (2000)

and Webster et al.'s (2006) notion of children's capacity to visualise their technology learning. Children can occasionally extend their design to drawing on the bare ground. Sam (Vignette 1) applied design by being able to draw in the sand and Abbey and Kayla (Vignette 2) were able to design with sticks and grass in hand as they constructed a tool to collect tree sap. Then, having successfully created and developed technological and engineering applications, problem solving occurs and the children apply and solve, such as Abbey and Kayla who needed to lengthen their stick to collect the sap, thus allowing for further nature play to continue.

Often the play has an intent that requires a need to be addressed, or a problem to be solved. Each of the three vignettes supports the notion of bush kinder children's developing understandings of technology and engineering knowledge and skill. As Kayla and Abbey's extendable stick was applied and the problem of how to collect tree sap solved, they were able to test their tool. Similarly, as the cubby house (Vignette 3) was constructed, the sticks occasionally fell to the ground and the problem of finding the appropriate sticks to act as the cubby house roof became a process of calculated and deliberate testing of a range of fallen sticks to eventually determine which would remain in place. The testing of the successful engineering of the cubby house would be in its ability to remain standing and allow the children to continue to play. Likewise, Sam (Vignette 1) and Abbey and Kayla (Vignette 2) continued their play, Sam with his technology, a re-purposed drawing stick and Abbey and Kayla, who proceeded to play around the bush kinder in a fairy wonderland.

Throughout the process of children's play in settings such as bush kinders, the nature play itself acts as a pivotal point for the development of understandings of technology and engineering. Much like Fleer's (2021) model of designerly play, children in bush kinder come to a point in their play where a discovery occurs of what is available in nature. Through their designerly play, children's capacity to apply technology and engineering became more attuned to the environment despite them not having a range of artificial and synthetic resources and equipment, such as toys, dolls and balls. What transpires supports Baynes' (1984) three components of designerly play. The arrangement of props (configuration), in the form of differing sizes of pieces of wood, allows for children's story telling through imagination and creativity to unfold in the situation of the bush kinder. Small, medium and large sized sticks facilitate the designerly technology and engineering play of pattern drawing, of cubby house building, and of tool design to collect sap. Nature provision in the form of a stick provided the opportunity for early years learners to develop understandings of technology and engineering.

Conclusions

Bush kinders and other types of nature-based places of early childhood education continue to proliferate and remain places where further research is required. Greater emphasis on environmental awareness and sustainability is becoming apparent in education. The opportunities of learning in and with nature become increasingly important. The three vignettes discussed in this paper are but a small snapshot of the myriad of other occurrences that foster deep understandings of technology and engineering events occurring in early childhood bush kinder education. Bush kinders are suited to intensifying our understanding of how natural materials can be applied to ensure children move forward towards more complex

understandings of technology and engineering. Through an ethnographic approach, close observation of teachers, educators and children's interactions with nature in the bush kinder space, allowed for these engineering events to be uncovered.

Going forward, an opportunity exists for further research into technology and engineering education and the influence bush kinders, forest schools and nature kindergartens are having on children's later levels of education. Bush kinders' value lie in their features, which differ from conventional kindergarten settings, and their capacity to provide children with opportunities for different forms of play. With greater space in which to roam, children's designerly play allows for greater scope to plan and implement larger projects such as building cubby houses. Educators in countries without access to these types of early childhood education contexts could consider drawing upon Loose Parts Theory (Nicholson 1971) and applying items such as sticks, leaves, flowers, rocks and stones that nature provides in classroom settings to support technology and engineering education. Consideration could also be given to instigating approaches to teaching and learning technology and engineering in underdeveloped, natural spaces in the outdoors as this is growing movement that has been consolidated in many European and UK countries. The role of the children's interactions with each other, where sticks as technology are repurposed and used in a variety of ways, presents itself as an opportunity for further research exploration. It allows for lines of future enquiry that include developing understandings of children's collaboration and collaborative processes while learning in nature as well as building understandings of cognition and how cognitive exchanges of ideas can occur to facilitate what children determine as the 'best' idea for applying technology and engineering. Further insights into pedagogical approaches towards technology and engineering in nature education and children's learning about these concepts are needed.

Acknowledgements We would like to thank the study's participants, the teachers, educators and preschool children for participating in the research.

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

References

Albion, P. Campbell, C & Jobling, W. (2018). *Technologies education for the primary years.* Cengage.

Anning, A. (1997). Drawing Out Ideas: Graphicacy and Young Children. *International Journal of Technology and Design Education*, *7*, 219–239

Australian Curriculum and Reporting Authority (ACARA) (2021). *Technologies*. https://www.australiancurriculum.edu.au/f-10-curriculum/technologies/

Bagiati, A., & Evaneglou, D. (2016). Practicing engineering while building with blocks: identifying engineering thinking. *European Early Childhood Education Research Journal*, *24*(1), 67–85

Baynes, K. (1984). *Designerly play*. Loughborough University. Online resource. https://hdl.handle.net/2134/1690

Campbell, C. (2010). The technological knowledge of early childhood pre-service educators, in Middleton, Howard and Pavlova, Margarita (eds), *TERC 2010: Proceedings of the 6th Biennial International Conference on Technology Education Research: Knowledge in Technology Education*, pp. 83-91, The International Technology Education Association, Surfers Paradise, Qld.

Campbell, C & Jobling, W (2014). Design, Creativity and Technology in Victorian primary schools: a process "missing in action"? *TERC 2012 : Proceedings of the 8th Biennial International Conference on Technology Education Research*. Griffith Institute for Educational Research, Sydney NSW.

Campbell, C., & Speldewinde, C. (2018). Bush kinder in Australia: A new learning 'place' and its effect on local policy. *Policy Futures in Education, 17*(4), 541-559.

Campbell, C., & Speldewinde, C. (2020). Affordances for Science learning in "Bush kinders." *International Journal of Innovation in Science and Mathematics Education, 28*(3), 1-13.

Campbell, C. & Speldewinde, C. (2022). Bush Kinders in Australia: A Creative Place for Outdoor STEM Learning. In (Eds.) Murcia, K.J., Campbell, C., Joubert, M.M. & Wilson, S.. *Children's creative inquiry in STEM.* Springer. pp. 185-206

Cumming, F., & Nash, M. (2015). An Australian perspective of a forest school: shaping a sense of place to support learning. *Journal of Adventure Education & Outdoor Learning*, *15*(4), 296–309

Christiansen, A., Hannan, S., Anderson, K., Coxon, L., & Fargher, D. (2018). Place-based nature kindergarten in Victoria, Australia: No tools, no toys, no art supplies. *Journal of Outdoor and Environmental Education*, *21*(1), 61–75

Department of Education and Early Childhood Development (DEECD). (2009). *Victorian Early Years Learning and Development Framework For all Children from Birth to Eight Years*. Early Childhood Strategy Division. Department of Education and Early Childhood Development and Victorian Curriculum and Assessment Authority

Department of Education, Employment and Workplace Relations (DEEWR). (2009). *Belonging, Being and Becoming: The Early Years Learning Framework for Australia*. Australian Government Department of Education, Employment and Workplace Relations for the Council of Australian Governments, Commonwealth of Australia

Delamont, S. (1992). *Fieldwork in educational settings*. The Falmer Press

Edwards, R. C., & Larson, B. M. H. (2020). When screens replace backyards: strategies to connect digital-media-oriented young people to nature. *Environmental Education Research*, *26*(7), 950–968

English, L., & Moore, T. (2018). *Early Engineering Learning*. Springer

Fleer, M. (2000). Working Technologically: Investigations into How Young Children Design and Make During Technology Education. *International Journal of Technology and Design Education*, *10*, 43–59

Fleer, M. (2021). The genesis of design: learning about design, learning through design to learning design in play. *International Journal of Technology and Design Education*. https://doi.org/10.1007/s10798-021-09670-w

Fox-Turnbull, W. (2019). Enhancing the learning of technology in early childhood settings. *Australasian Journal of Early Childhood*, *44*(1), 76–90

Harvey, C., Hallam, J., Richardson, M., & Wells, R. (2020). The good things children notice in nature: An extended framework for reconnecting children with nature. *Urban Forestry and Urban Greening, 49*, (2020)126573, 1–8

Kaplan, R., Kaplan, S., & Ryan, R. (1989). *With People in Mind: Design And Management Of Everyday Nature*. Island Press

Knight, S. (2016). *Forest School in Practice*. Sage Publications Ltd

Last, M. (2019). Medical Ethnography over Time Penetrating "the fog of health" in a Nigerian community, 1970–2017. *Anthropology in Action*, *26*(1), 52–60

Longhurst, R. (2003). Semi-structured interviews and focus groups. In N. Clifford, M. Cope, T. Gillespie, & S. French (Eds.), *Key Methods in Geography (third edition)* (pp. 143–156). Sage Publications Ltd.

Madden, R. (2012). *Being ethnographic: A guide to the theory and the practice of ethnography*. Sage Publications Ltd.

Mawson, W. B. (2014). Experiencing the 'wild woods': The impact of pedagogy on children's experience of the natural environment. *European Early Childhood Education Research Journal*, *22*(4), 513–524

McGarvey, L., Luo, L., & Hawes, Z. (2018). Spatial Skills Framework for Young Engineers. In L. English, & T. Moore (Eds.), *Early Engineering Learning* (pp. 53–81). Springer

Milne, L. (2013). Nurturing the designerly thinking and design capabilities of five-year-olds: technology in the new entrant classroom. *International Journal of Technology and Design Education*, *23*, 349–360

Moser, T., & Martinsen, M. T. (2010). The outdoor environment in Norwegian kindergartens as pedagogical space for toddlers' play, learning and development. *European Early Childhood Education Research Journal*, *18*(4), 457–471

Nicholson, S. (1971). "How not to Cheat Children: Theory of Loose Parts". *Landscape Architecture* 62, 30–34

Pantoya, M. L., Aguirre-Munoz, Z., & Hunt, E. M. (2015). Developing An Engineering Identity In Early Childhood. *American Journal of Engineering Education*, *6*(2), 61–68

Preissle, J., & Grant, L. (2004). Fieldwork traditions: Ethnography and participant observation. In K. DeMarrais, & S. D. Lapan (Eds.), *Foundations for research. Methods of inquiry in education and the social sciences* (pp. 161–180). Mahwah, NJ: Lawrence Erlbaum Associates

Speldewinde, C. & Campbell, C. (2021). Bush kinders: enabling girls' STEM identities in early childhood. *Journal of Adventure Education & Outdoor Learning*. https://doi.org/10.1080/14729679.2021.2011337

Speldewinde, C., Kilderry, A., & Campbell, C. (2020). Beyond the preschool gate: Teacher pedagogy in the Australian 'bush kinder.' *International Journal of Early Years Education, 28*(3), 1-13.

Speldewinde, C., Kilderry, A., & Campbell, C. (2021). Ethnography and Bush Kinder Research: A Review of the Literature. *Australasian Journal of Early Childhood.* https://doi.org/10.1177/18369391211011264

Speldewinde, C., Kilderry, A.& Campbell, C. (2021a). 'All the things children can see': understanding children's noticing in bush kinders. *Journal of Outdoor and Environmental Education, 24*(2), 151-167. https://doi.org/10.1007/s42322-021-00080-z

Stan, I., & Humberstone, B. (2011). An ethnography of the outdoor classroom – how teachers manage risk in the outdoors. *Ethnography and Education*, *6*(2), 213–228

Turja, L., Endepohls-Ulpe, M., & Chatoney, M. (2009). A conceptual framework for developing the curriculum and delivery of technology education in early childhood. *International Journal of Technology and Design Education*, *19*(4), 353–365

Victorian Curriculum and Assessment Authority [VCAA] (2016). *Design and Technologies*, https://victoriancurriculum.vcaa.vic.edu.au/technologies/design-and-technologies/introduction/rationale-and-aims

Warden, C. (2015). *Learning with nature: embedding outdoor practice*. Sage Publications Ltd.

Webster, A., Campbell, C., & Jane, B. (2006). Creativity in Primary Technology Education, International Journal of Technology and Design Education, 16(3), 221-235