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STEM Teaching and Learning in Bush Kinders

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Abstract For over 50 years, the forest school approach to nature learning has gathered momentum in the UK and across parts of Europe including Scandinavia (Knight, 2016). In other contexts such as Canada, New Zealand and Australia, nature-based early childhood education and care settings, influenced by European forest school approaches, have begun to gain popularity. Opportunities for STEM education occur in nature-based settings, such as forest schools and nature kindergartens, yet this area has only garnered limited research attention to date. One such example of a nature kindergarten which emerged in the 2010s is Australian 'bush kinder' where 4- to 5-year-old preschool children experience and learn from nature. This paper arrives at an innovative conceptualisation of STEM teaching and learning in bush kinders. Through analysing research in early years STEM education, teacher pedagogy and early childhood learning, I propose a teaching and learning process that is replicable for similar nature-based early childhood education and care settings. Drawing on vignettes from ethnographic fieldwork data, the conceptualisation of an integrated approach to STEM teaching in bush kinders is illustrated. To frame the approach to STEM teaching, this analysis builds on the notions that STEM teaching and learning can take the form of a five-phased cyclical process. It is this process that contributes to the conceptualisation of STEM teaching and learning in early childhood education.

Résumé Depuis plus de 50 ans, l'approche favorisant l'apprentissage de la nature par «l'école à la forêt» a pris de l'ampleur au R.-U. et dans d'autres régions de l'Europe, y compris en Scandinavie (Knight, 2016). Dans d'autres contextes comme au Canada, en Nouvelle-Zélande et en Australie, influencés par les approches européennes de «l'école à la forêt», les milieux éducatifs fondés sur la nature de la petite enfance et en milieu de garde ont commencé à gagner en popularité. Les milieux naturels de «l'école à la forêt» et de l'école maternelle dans la nature offrent des occasions pour enseigner les STIM, pourtant ce domaine n'a attiré l'attention que de peu de chercheurs jusqu'ici. La «maternelle dans la brousse» australienne qui a fait son apparition dans les années 2010 et qui permet à des enfants d'âge préscolaire de quatre à cinq ans de s'enrichir d'expériences dans la nature constitue un bon exem-

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ple de classe maternelle dans la nature. Cet article conceptualise de façon innovatrice l'enseignement des STIM et l'apprentissage en « maternelle dans la brousse». À travers l'étude de la recherche sur l'enseignement des STIM au stade de la petite enfance, la pédagogie mise en œuvre par les enseignants et l'apprentissage en ce qui touche la petite enfance, je propose un processus d'enseignement et d'apprentissage que l'on peut répliquer dans d'autres milieux éducatifs fondés sur la nature de la petite enfance et en milieu de garde. Puisant sur des descriptions d'éléments recueillis par travail ethnographique effectué sur le terrain, la conceptualisation d'une approche intégrée d'enseignement des STIM en « maternelle dans la brousse» est illustrée. Dans le but de définir le cadre de l'approche d'enseignement des STIM, cette analyse s'appuie sur le postulat que l'enseignement et l'apprentissage des STIM peuvent prendre la forme d'un processus cyclique en cinq étapes. C'est ce processus qui aide à conceptualiser l'enseignement et l'apprentissage des STIM dans l'éducation de la petite enfance.

Keywords Bush kinder · STEM · Early childhood education · Nature-based education

Introduction

Global growth in numbers of forest schools and nature kindergartens is providing children with greater opportunities to access the outdoors and to build perceptions of the world around them (Warden, 2015). These nature-based education contexts provide opportunities for early years' learners to develop Science, Technology, Engineering and Mathematics (STEM) understandings through child-initiated learning during play using only what nature provides. Forest schools around the world are being adapted (Knight, 2016) and in Australia there are a growing number of bush or nature kindergartens (often known as 'bush kinder') that have been adapted to suit local weather conditions and flora and fauna (Christiansen et al., 2018). While STEM learning in the early years has been a focus of numerous studies (Tao, 2019; Wan et al., 2020), STEM learning in nature-based early childhood contexts such as bush kinders remains an area for further investigation.

It has been argued that children benefit from contact with nature settings (Mawson, 2014). Past research has found that children who spend time in the environment develop strong connections with nature (Richardson et al., 2016). Children's mental well-being, development and general physical health have all found to benefit from time spent in nature (Capaldi et al., 2017). Through play-based learning in underdeveloped parklands, forests and beaches, children can build an appreciation of and care for the environment (Harvey et al., 2020).

STEM education, in its broadest sense, is defined as an integrated approach to teaching all four disciplines in equal amounts (Forbes et al., 2021). Through reviewing two examples of teaching and learning cycles, an integrated STEM model for project-based learning (Forbes et al., 2021, pp. 10–11), and an approach to children's outdoor nature learning (Wiedel-Lubinski, 2019), the contextualisation of child-led bush kinder STEM teaching and learning allowed for a model to be developed using the data collected in this research. This theorising of a model for STEM teaching and learning in the outdoors is noteworthy at a time when many early childhood education and care (ECEC) providers are attempting to incorporate STEM education due to its benefits for learners and its strategic priority for governments, including the Australian government. This is particularly relevant as a majority of twenty-first century occupations will require STEM skills and knowledge (Australian Government, 2014).

Through a novel approach to STEM teaching and learning in the developing context of bush kinders, this paper seeks to add to the scholarship that focuses on STEM learning in early childhood educational settings. The paper aims to respond to the research question of how can STEM teaching and learning in early childhood nature-based education be conceptualised? Its intent is to build deeper knowledge of what is available to foster children's enjoyment of STEM in nature. The existing literature shows that

nurturing children's love of STEM in the early years can lead to children building on those early STEM interests in later years of schooling (Campbell et al., 2018). Comprehending how young children consider and engage with the STEM apparent in nature, through the influence of educators within the setting, informs the deliberations here. This is worthwhile of consideration as through greater engagement in each of the STEM learning areas, children's skills 'such as critical and creative thinking, collaboration and communication (can) be deployed in a rich and authentic way (Victorian Curriculum and Assessment Authority [VCAA], n.d.)'.

Theoretical Perspectives of STEM Education in the Early Years

Differentiation between STEM education and singular, discipline-based education of the individual STEM domains (for example science education, mathematics education) has been formalised in government policies (Wan et al., 2020). Internationally, STEM education, when considered in terms of policy and curriculum, is often referred to in an integrative manner (Bybee, 2010; Wan et al., 2020). To understand the origins of STEM education, Sanders' (2009) proposal of 'purposeful design and inquiry' as a pedagogical method when dealing with problems that occur in the real world is applied here. Differing contexts provide differing approaches to STEM teaching and learning with many adopting an integrated approach and others a discipline-based approach.

STEM education in Australia remains oriented towards a disciplined-based approach and forms part of a cross-disciplinary approach to the teaching of each individual STEM discipline (ACARA, n.d.). Evidence exists of capability building in STEM through strategising at Australian national and some state levels through the adoption of pedagogical approaches such as inquiry or project-based learning (Murphy et al., 2019). Project-based learning is relevant here as it involves learning through 'real world contexts and present(s) learners with authentic problems or projects to work upon' (Murphy et al. 2019, p. 124) which can be connected to STEM. Within curriculum documentation, there is acknowledgment of the interconnectedness that exists in 'specific knowledge, understandings and skills' in each of the four STEM learning areas (VCAA, n.d.). The integration that can occur in STEM education leads to greater engagement in each of the four STEM learning areas (VCAA, n.d.).

STEM education in ECEC settings has been the subject of discussion in recent years (for example Murphy et al. (2019) and Fleer (2021)). STEM teaching in contexts such as kindergartens has highlighted educators understand the importance of STEM but often find difficulties in integrating activities relating to STEM (Tao, 2019). It has been previously identified that a reluctance by 'many early childhood educators' to intentionally teach STEM exists (Murphy et al., 2019). Early childhood educators have been found to be reluctant to teach a subject such as mathematics, for reasons including a child's readiness for mathematics learning; language and literacy being more important than mathematics; and/or children's mathematics learning only occurring when they interact with concrete objects (Lee & Ginsburg, 2009). A child's dispositions towards STEM are often influenced by educators in the early years (Murphy et al., 2019). Therefore, to understand children's STEM development, the comprehension of educators' approaches to STEM in education is worthy of consideration. The merit apparent in considering STEM education in ECEC settings is evidenced through the educational benefits that children gain through learning STEM in an integrated way (Berlin, 1989; Reynante et al., 2020). STEM in ECEC often takes the form of being play-based child-instigated learning (Wiedel-Lubinski, 2019). Play-based learning, defined here as an approach to teaching allowing for 'playful, child-directed elements', gives educators opportunities to scaffold and guide the learning objectives (Pyle & Daniels, 2017). Children's knowledge construction often evolves during inquiry activities as they attempt to understand and explain connections between experiences, information and understandings (Hedges, 2012). Fleer (2013, p. 139) highlights that young children relate to their learning environment in new and different ways when adults support their play, offering children opportunities to

develop a scientific perspective of their environment. It is a play-based approach to STEM learning that bush kinders support through the experiential opportunities children have available to them (Speldewinde et al., 2020). Through purposefully adopting a teaching approach that involves STEM in an integrated manner as the child leads their own learning, an assertion is that teaching each of the four STEM disciplines in isolation creates challenges for children in connecting those disciplines (English, 2016). Integrating STEM disciplines when they are taught enables authenticity to children's learning and connections between STEM practices begin to coalesce (Reynante, 2020). Yet, despite its benefits, an integrated STEM curriculum in ECEC is still developing in Australian contexts.

Integrating STEM Education

For children to be successful, STEM learning needs to provide opportunities to explore the interconnection of STEM disciplines that occur in real-world problems. Bybee (2010) stated that 'true STEM education should increase students' understanding of how things work'. Integrated STEM occurs when two of the four STEM disciplines are 'intentionally emphasised' in an activity (Tippett & Milford, 2017, p. 68). Similarly, Sanders' (2009, p. 21) notion of an integrated approach to STEM teaching can be described as occurring when two or more of the STEM areas are explored at the same time, for example when design technology is combined with scientific inquiry (Sanders, 2009, p. 21), mathematics concepts with engineering or for all four STEM areas to coalesce into one teaching and learning opportunity. Programs which encompass STEM teaching and learning have been found to be an 'environmental catalyst', where teachers help children to develop their STEM talents (Margot & Kettler, 2019, p. 2). STEM integration through hands-on, project-based learning is valuable to children as it can provide meaning, intention and purpose to children's understanding of how things work in the world around them (Guzey et al., 2016). Where challenges exist with integrated STEM education is in the oft heavy emphasis on science and mathematics and the lack of integration with technology and engineering (Kelley & Knowles, 2016). Therefore, as Sanders (2009) has suggested to overcome this, maths and science courses could be intentionally designed to include technology or engineering class. Building conceptual frameworks to ensure integrated STEM education (see for example Kelley & Knowles (2016) and Moore et al. (2020)) addresses this challenge, and for the purposes of this paper, I draw on one recent model of integrated STEM education.

Forbes et al. (2021, pp. 10–11) propose an integrated STEM education model to foster children's project-based learning. Adopting a five-step model for STEM teaching, their model commences with a challenge or issue, and then considers curriculum connections followed by assessment. Following these three steps are the teaching and learning processes, which are of most interest in this paper, to analyse what can occur in nature-based ECEC STEM education. The final step of the model is reflection (Forbes et al., 2021, p. 11). Embedded within the teaching and learning processes of Forbes et al. is a cycle of phases that commences with the child's asking and defining of a project's requirements, which precedes children's imagining, planning, creation and evaluation. Beneficial to contextualise child-led bush kinder STEM learning, the model provides phases which allow for examples of teaching to be interrogated and for the children's learning to be analysed. While teaching at nature-based education settings is often spontaneous and 'projects' occur because of children's discoveries of what nature provides for play, through these five phases applied to bush kinder teaching and learning, a deeper understanding of STEM in ECEC can be developed.

Outdoor Nature-Based Learning

Internationally, outdoor learning spaces such as forest schools and nature kindergartens challenge educators to react to events as they occur in time (Knight, 2016). Rather than spending time in preparing, often there is a need for educators to adopt a place-based approach to their teaching (Mannion et al., 2013; Card & Burke, 2021) that responds to the immediacy of children's discovery-led learning in bush

kinders (Speldewinde et al., 2020). Nature occurs as the 'central organising concept, which other learning builds upon' through curriculum and children's experience and activity in nature-based learning (Wiedel-Lubinski, 2019, p. 182). STEM teaching in nature-based education contexts exposes children to the real world, particularly when children have available only what nature provides for learning.

Wiedel-Lubinski (2019, pp. 194–196) devised a five-step cyclical model to demonstrate how children's learning in nature occurs. Commencing when children observe and explore nature, the child's discoveries, experimentation, predicting and sharing of learning outcomes all form part of this model which has a place when considering how children learn through their nature experience. This cycle provides opportunities for children to inquire about the world around and lead their own projects to facilitate their STEM learning.

Nature-Based STEM Learning Contexts

Educators, while often led by children's discoveries in nature, can adopt a project-based pedagogical approach to nature-based teaching as has been observed in Canadian contexts (Harwood et al., 2020). This pedagogical approach can provide children the opportunity to focus on STEM-related tasks that integrate, for example, investigations of the science of floating and sinking, while documenting their thoughts with applying technology such as sticks to draw in the sand or earth (Campbell & Jobling, 2010). The educators can support learning of engineering by building rudimentary structures and identifying patterns and counting as part of the children's projects. A relationship exists between children's outdoor play and teaching practice (Mawson, 2014). Opportunities to support children's nature learning occur through seasonal changes, natural phenomena, chance meetings with wildlife or domestic animals and other physical elements of the territory. Outdoor spaces such as forest schools and bush kinders can challenge educators 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 all form part of the resources available for understanding technology and can lead to children's experimentation with engineering (Nicholson, 1971). Often, artificial or synthetic materials that may be prevalent in outdoor spaces are removed from children's play and not available in bush kinders (Speldewinde et al., 2021). When natural, outdoor environments are understood as pedagogical spaces, opportunities abound for the enhancement of younger children's play, learning and development (Moser & Martinsen, 2010) and have been found to improve children's emotional well-being and association with nature (Tiplady & Menter, 2020).

Research Design

Context: Bush Kinders as a Place for STEM Teaching and Learning

Influenced by the forest school approach to ECEC nature-based education, bush kinder programs often occur in Australian urban, peri-urban and regional settings. These settings can range from open paddocks (fields) and 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 (Speldewinde et al., 2021). Differing from the European iterations of ECEC outdoor nature-based education, bush kinders are still in a developmental phase as they only began to appear in the early 2010s. They do not have the same curriculum and regulatory constraints of, for example, UK forest schools and are grounded in Australian cultural traditions of outdoor learning.

Bush kinders provide physical outdoor learning spaces as well as the affordances and opportunities that are available for teaching and learning (Christiansen et al., 2018). Previous bush kinder research

(Speldewinde et al., 2020) highlights the range of pedagogical approaches that guides educators' practice. The growing field of nature pedagogy or nature-based learning provides 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). Bush kinder educators often adopt a pedagogical approach that is reliant on the child's discovery in nature to create teaching opportunities (Speldewinde et al., 2020). Contextually, bush kinders are an approach to nature education with Australian conditions in mind (Cumming & Nash, 2015). As a place for STEM learning, bush kinders generally provide an abundance of flora, fauna and natural materials for teachers to apply their preferred pedagogical approach to teaching in nature across the STEM disciplines. These pedagogical approaches can range from teacher-led, teacher-guided and child discovery–led approaches (Speldewinde et al., 2020). Bush kinders generally involve the removal of artificial and synthetic implements that are often found in regular kindergarten situations.

While in bush kinder, young children have been found to have the capacity to notice and play with what nature provides (Harvey et al., 2020). Important when considering how children can apply the STEM skills available to them, children's noticing in nature develops over the duration of their bush kinder 'year' to the extent that children tend to demonstrate growth in their understanding of STEM in nature (Speldewinde et al., 2021). Educators build confidence in applying STEM pedagogically to their bush kinder teaching. This compliments previous thinking that pedagogy is determined by the educator's prior teaching experience and how they approach teaching in the traditional kindergarten setting (Aldemir & Kermani, 2017, p. 1704). The accessibility of nature spaces provides opportunities for play through which children can reconnect with nature in urban settings (Kaplan et al., 1989). Play is crucial to child development as it is a primary source of children's learning and often 'self-directed, imaginative, challenging, self-directed and meaningful' (Hesterman & Hunter 2021, p. 138). Allowing children to play in nature therefore often provides opportunities to build STEM understandings and apply what they learn in nature to a myriad of other contexts such as kitchen gardens (Forbes et al., 2021), indoor classroom STEM activities and around the home (Howitt & Campbell, 2021).

Data Collection: Researching the Field by Participating in and Observing Children's STEM Learning

The findings reported in this paper form part of a longitudinal project titled 'Bush kinders: Locating the Science'. It became apparent during the research that science was not being taught exclusively. STEM was prevalent in and influencing the teaching and learning. The project applied an ethnographic design (Delamont, 1992; Madden, 2012) to examine how educators' pedagogical positioning of science occurs in bush kinders. Ethnography allows researchers to see and notice what is taking place around them by developing close and extended interactions with educators and children over an extended period (Speldewinde, 2022). Building trust, particularly with young children, as well as educators, is critical to successfully establishing relationships that lead to extended interactions during fieldwork. The educators involved in this research were all experienced and, while preschool children generally attend a bush kinder for 1 calendar year, educators can work in the same bush kinder setting over many years. This ongoing connection with the bush kinder site ensures educators observe changes, develop deep understandings of the teaching and learning opportunities that nature provides and develop their own practices over time as they understand the opportunities nature provides for children's STEM learning.

Regular researcher attendance at a field site is valuable as initial data becomes dated (Last 2019). In the context of bush kinders, because the pedagogical approach adopted by the educators often involved child-led learning, there can be an irregularity in terms of the teaching and learning taking place due to the seasonal adaptations of the landscape of the bush kinder (Campbell & Speldewinde, 2018). Ethnography can capture developments, in this instance in STEM teaching and learning, over time and can illuminate the researcher's contextual understanding (Last, 2019). As social contexts continually develop

and alter between young children and their educators, ethnography allows researchers the opportunities for applying varied data gathering methods. To further inquire into how STEM teaching and learning occurred, I applied what Madden (2012, p. 25) describes as 'a particular set of methods (a toolkit)'.

The data applied in this ethnographic study was collected through journal notes taken in the field and reflexive note taking upon returning from the field as part of participant observation (Madden, 2012). Semi-structured interviews (Longhurst, 2003) were conducted that were recorded on iPads and handheld voice recorders, and image capture using photographs and video. By including participant observation of educators and children, listening to conversations between educators, between children and between children and educator, an understanding of educators' and children's STEM teaching and learning became apparent. As a researcher, being drawn into conversations and into participating with the STEM teaching and learning in the bush kinder allowed for insights other research methods may not have facilitated.

Although semi-structured interviews (Longhurst, 2003) and focus groups with educators and parents took place, the ethnographic data applied and analysed in this paper is limited to fieldwork participation and observations, researcher notes documented during and immediately following the fieldwork and imagery from photographs of the educator's STEM teaching. Photographs were taken in 2015 and 2017 during the one hundred and twenty regular bush kinder visitations. Each of the four bush kinders was visited for between 3 and 4 h each week for 10 to 12 weeks in both 2015 and 2017 and approximately 200 children were observed as eight separate groups.

Participants

Four bush kinder sites were selected for fieldwork for the broader study associated with this research. Prior to commencement of this research, ethics approval was gained from Deakin University's human research committee (Approval number HAE-15–016). Participation in the research was voluntary and signed written consent gained from the relevant organisational authorities, kindergarten organisation, educators and parents. Visits to the four sites took place regularly over the duration of the year to capture children's learning influenced by seasonal and weather changes. Bush kinder sessions would almost always proceed unless there were the most extreme of weather conditions that could endanger the children's health (for example excessive heat, thunderstorms). The rural townships of Wicklesham, Chatlock, Sunrise and Whitesands each have their own kindergarten (preschool) and nearby bush kinder site, located in the Sandy Shores Shire (all pseudonyms) of south-eastern Australia. The preschool educators from each 'regular' kindergarten were also the bush kinder educator except for Chatlock which in 2015 had its own designated bush kinder educator. Each bush kinder was staffed by an experienced lead kindergarten teacher and two educators who were supported also by parent helpers. Yet, although all were very experienced early childhood teachers and educators, their experience in bush kinder teaching was limited when they started a bush kinder program in 2015 and their pedagogy was still in a developmental phase with each primarily adopting similar pedagogical approaches to bush kinder as regular kindergarten (Speldewinde et al., 2020).

Even though the preschool children (aged 4 to 5 years) 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, educator interaction with the children and children playing amongst themselves. There was a cognisance of minimising the disruptions to preschoolers' play and learning. Some interactions between researcher and the children occurred as part of the play and often children wanted to draw me into their play to show me their discoveries, but the children were not interviewed as their learning time in the bush kinder was valued. Subsequently, building the children's perspective regarding their STEM development in nature programs remains an

opportunity for future exploration. Listening, talking, watching and, at times, participation in the bush kinder sessions provided rich research data.

This paper applies data that draws on the participation of six educators and approximately 80 children who were involved in over sixty sessions that were observed during the research fieldwork. The data were collected for this research over a number of years, increasing the depth of information presented, but the study is somewhat limited by its small number of field sites. 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 visited were in their second year of operation. A pilot bush kinder based at Chatlock began in 2013 for one term which was extended to five bush kinders in 2014. This meant that the bush kinders were still in a development phase when this research commenced.

Data Analysis: STEM Learning and Teaching in Bush Kinder Vignettes

This paper presents the finding that the experiential context of bush kinders offers opportunities for educators to develop teaching and learning approaches that foster children's STEM learning. At the four bush kinders visited, many STEM teaching and learning events were observed. For the purposes of this paper, one of the bush kinder sites, Sunrise Bush Kinder, is focussed on. The educators at Sunrise Bush Kinder had previously attended professional development sessions which focussed upon bush kinder teaching as well as STEM teaching. They were experienced educators with sound understandings of STEM and who were reliant on web-based and textual resources to support their STEM teaching. What became apparent at Sunrise Bush kinder was that the educators were applying an emergent curriculum, an approach to learning that is a child-centred, and through which learning develops during imaginative or creative play (Card & Burke, 2021, p. 129). Educator planning was often limited and generally involved scaffolding learning during the children's play. Thus, a child-centred pedagogical approach was adopted by the educators at Sunrise Bush Kinder and the children would spend their bush kinder time discovering what nature would provide for play in the bush kinder; then, the educators would support the children's learning through scaffolding. Minimal planning went into the educator's routines, rather they would apply their prior knowledge of STEM and occasionally undertake some research to support the children's learning. Also, on occasions, the children's learning would be taken from bush kinder into the indoor kindergarten program.

Data were analysed thematically whereby I sought to understand patterns occurring in the data collected (Braun & Clarke, 2006). By interrogating the events observed at Sunrise Bush Kinder in 2015 and 2017, I was able to draw understandings of how STEM was integrated into the children's play and how the educators were responding to the teaching opportunities presented. Here, the theme captured events 'in relation to the research question' (Braun & Clarke, 2006, p. 82) where I observed and documented in my journal any of the four STEM disciplines occurring in the play. I then interrogated examples to uncover if the other three STEM disciplines were also evident during the children's play activity.

To understand what was transpiring in the vignettes and to analyse the forms of STEM teaching and learning occurring in nature, with my themes now clear, two five-phase processes from Forbes et al. (2021) and Wiedel-Lubinski (2019) were applied to the data. These five-phase processes were valuable as one considers STEM teaching and learning and the other how science learning in nature can occur for early years' learners. The value in both processes was that they could be contextualised with what was apparent in the data. What became apparent was that, by combining the two processes, a model of STEM teaching in ECEC nature settings such as bush kinders could be developed.

Table 1 was constructed by combining Forbes et al.'s (2021) model of Ask, Imagine, Plan, Create and Improve and Wiedel-Lubinski's (2019) Wonder and Ask questions; Tinker, investigate and experiment; Modify predictions; Consider and/or share outcomes; and Observe and explore outdoors. Once combined, the STEM teaching undertaken by the bush kinder educator could be considered against the

Table 1 Bush kinder teaching and learning 'phases'

STEM teaching and learning processes (Forbes et al. 2021, p. 11)	**ASK:** Teacher defines and understands the task requirements.	**IMAGINE:** Teacher investigates and researches the teaching and learning to take place.	**PLAN:** Teacher designs and plans the teaching and learning.	**CREATE:** A preferred teaching and learning solutions are produced.	**IMPROVE:** Solutions developed to support teaching and learning are evaluated.
Children's outdoor learning (Wiedel-Lubinski 2019, p. 219)	**OBSERVE AND EXPLORE OUTDOORS:** Children observe and explore in nature.	**WONDER AND ASK QUESTIONS:** Children ask questions and wonder about nature.	**TINKER, INVESTIGATE AND EXPERIMENT:** Children tinker and experiment in nature.	**MODIFY PREDICTIONS:** Children predict outcomes and modify their thinking about nature.	**CONSIDER AND/OR SHARE OUTCOMES:** Children reflect and share outcomes of their nature interactions.
Bush kinder teaching and learning phases: Building on the work of Forbes et al and Weidel-Lubinski to understand how the Bush Kinder STEM teaching was evident in this research.	**Phase one: Identifying and understanding** • Teacher identifies what opportunities exist for bush kinder STEM teaching to occur. • Some development of teacher STEM understandings in bush kinder may be required. • Children observe and discover what nature provides for bush kinder STEM play.	**Phase two: Examine and research** • Teachers undertake research and apply their own knowledge to respond to child-led STEM discoveries at Bush Kinder. • Children's interests are piqued by their observations and interactions with STEM in bush kinder.	**Phase three: Plan and Design** • Nature learning in bush kinder is often child-led, so teacher STEM program planning and design may be limited. • Teachers respond to the children's STEM experimenting in bush kinder. • The children can balance, apply technology, build and view patterns and develop counting. They become adept at STEM in an integrated manner.	**Phase four: Creation** • The teacher considers the STEM outcomes that can occur in bush kinder. • Teacher supports children to develop solutions to STEM-based problems that arise in nature. • Children's STEM creativity occurs through play in bush kinder.	**Phase five: Assessment and evaluation** • Teacher evaluates what type of STEM learning has taken place in bush kinder. • Children evaluate what type of STEM learning has occurred in bush kinder.

model. This consideration is illustrated here by applying the processes associated with children's STEM learning in nature-based settings through a description of three of many examples observed during this research where STEM integration was incorporated into teacher scaffolding.

The vignettes described here occurred at different times of the year and the data described elicits how several of the STEM phenomena experienced by young children coalesce into teaching events. The vignettes focus on how the educator addresses what the children were experiencing whilst at play and illustrate insights into the three children's activity that led to their developing understanding of STEM. Each of these vignettes is written from the perspective of this paper's author, as a first-person narrative, to describe what occurred during each STEM teaching 'event'. Vignette 1 provides an example of a group of boys being transported into space through their imaginary play. A large fallen log on which the boys were sitting, at other times, allowed children to observe small animals and repurpose leaves as a tool to inspect those animals. As the educator became involved with the boys, a discussion took place that integrated STEM as science in the form of weather, gravity and balance; this was combined with maths through counting. The vignette supports Tippett and Milford's notion (2017) of how STEM-integrated learning occurs through two of the STEM disciplines being evident during children's play. The real STEM situations that astronauts must consider became a part of the teaching and learning.

Vignette 1: Flying to Outer Space (Fig. 1)

It was an Autumn (Fall) morning in April. Arriving at Sunrise Bush Kinder at 8:45am, about a quarter of an hour prior to the session commencing, three early childhood educators were preparing for the session by setting up a portable toilet, mats on the ground for children to sit on and a small shelter. Several children had arrived and commenced their play. A large limb of a Gum tree had fallen on the ground. Miriam, one educator, informed me that it had fallen several weeks prior, that the Shire Council had trimmed it and left it for the children's play. The limb was a gathering point and suited several purposes. There were 'lots of opportunities for STEM play' according to Miriam who viewed STEM play as 'the focus of Bush Kinder' and 'it was where children could take science, technology, engineering and maths and play'.

Fig. 1 Balancing while flying to space

At times, the children would balance and walk along the log, counting their steps as they progressed and noticing the small animals crawling along and burrowing into the wood. At times they would gently prod the animals with a leaf to understand how the animal moved. Miriam had spent some time recently during kindergarten talking to the children about safe play and how best to balance on the play equipment. She asked the children if they knew what gravity was? On this day, several boys had focussed their play on the limb, gesticulating to other children to join in their play. 'Come and see what we're doing' one yelled to me. Miriam and I approached the boys and Miriam asked 'What are you doing?' One boy replied, 'we are about to leave for the Moon, and this is our spaceship'. Miriam enquired as to the suitability of the log for going into space. A discussion continued for three minutes regarding what the young astronauts would require departing Earth and what the children hoped to find in space. The young astronauts had found a house brick which was repurposed to become the astronauts control panel, the instruments to make the spaceship fly. The children looked to the heavens and one boy mentioned to Miriam that the sky was clear, a good day to take off to which Miriam asked, what is it about today's weather which makes this a good day? The discussion continued that there was not much wind, little cloud cover, and the sun was shining. It became obvious that little effort was needed to remain seated on the imaginary spaceship, but Miriam asked if the children needed to ensure they were well balanced and seated for lift off. Miriam also asked the boys to guess how many students can be on the log to balance their weight so the "rocket" does not capsize. One boy said five and another boy replied, yes, and now we are ready to take off. It was decided that a countdown was needed. The educator asked where they would start to which one astronaut shouted, let's start at ten. It was agreed upon and the countdown began. Ten, nine, eight…two, one, lift-off. The boys' excitement was audible as they spoke about what they would see and experience. All the while, Miriam was asking about the journey. How much food they would need for the journey? Had they considered if too much food would make the rocket too heavy to fly? Did they know what gravity was? What could they see in space? The spaceship journey continued for fifteen minutes after which time, the astronauts returned safely to Earth and departed the vessel having experienced the wonders of space.

In Vignette 2, STEM integration takes place through science, with native animals and the application of force in digging combined with technological implements, tools available in nature that were repurposed to find a scorpion. Lyndal, the educator, used her knowledge of the small animals and weather and changes to the terrain brought about by rain to scaffold the learning.

Vignette 2: A Scorpion Hunt (Fig. 2)

I ventured to a Sunrise Bush kinder session in mid-June. It was a cold winter's morning and overnight rain had made the ground wet. The lead educator, Lyndal, and I were talking about recent rain and the

Fig. 2 **a**, **b** Scorpion hunt

teaching opportunities afforded by the weather. The children had been discussing weather during their regular indoor kindergarten sessions and Lyndal mentioned that she had been looking at various websites to develop her understandings of weather knowledge. She said that 'STEM was everywhere at bush kinder' and she needed to 'work out ways to help scaffold the children's learning while they were playing'.

I noticed a group of children on the other side of the park. They were digging a hole with sticks and pieces of bark. I could hear excitement and children shouting. 'Chris, Lyndal come quickly and see what we had found'. Lyndal mentioned the children were digging where a scorpion had been found. Being aware through some research that the scorpions were generally only present in warmer months, the scorpion nest had been a place where Lyndal taught the children about animal habitats and how to use limited force in their digging so as not to create damage. As we moved nearer, it was evident that the children had found a scorpion so Lyndal began to question the children about what they had learned. What did they notice about the hole and the scorpion's home? Explain what we mean by the word habitat? What did they think the scorpion needed to survive? What was it about the ground that made this suitable for the scorpion? How had they used the sticks to dig and what force had they applied to shift the ground so as not to damage the habitat? Lyndal, conscious to protect the scorpion, left briefly returning with a small hand shovel which was used to safely display the scorpion (Fig. 2). The shovel was used to return the scorpion to the hole and then used by the children to scrape the loose earth back into the scorpion's habitat. Lyndal and I recommenced walking around the bush kinder and Lyndal used her phone to show me an app that placed native animals on an Australian map, alluding to where scorpions were found in Australia. She discussed how science and technology came together to allow the children to think about implements in nature can be repurposed for digging.

As apparent in Vignette 2, the Australian bush kinder is often a place where children can observe a range of flora and fauna. The march of a colony of ants between two points is the focus of Vignette 3. The ants themselves became less of the focus as mathematics and engineering came to the forefront. The integration of these STEM disciplines (Tippett & Milford, 2017) and the use of a resource in the form of a stick used as a pointer became evident as animals, patterns through the lines of the ant procession, the ants carrying materials to engineer a new colony and ant counting were all apparent.

Vignette 3: An Ant Procession (Fig. 3)

By late October, the mornings at Sunrise bush kinder remained cold but days would become sunny and warm. The season had been dry but, on this day, there was wet weather approaching. The

Fig. 3 Searching for ants

impending rain had set many of the insects to moving and this was particularly so with a colony of ants. Wandering around the site with Alice, one of the children and Miriam, the bush kinder educator, Miriam pointed to a bird's nest in one tree. Miriam remarked that the same birds nested in the tree annually and that she had come to know when the birds would return to nest. Miriam showed me a book that was devoted to Australian native fauna. Miriam indicated that she had researched and developed her own understandings of what animals were going to appear in the bush kinder setting.

Alice had collected a magnifying glass and was looking at some fungi at the base of a tree when she noticed an ant trail. With magnifying glass in one hand and a small stick to move grass blades, Alice gently uncovered the ant trail. Alice sat counting the ants as they moved around the tree, ninety-seven, ninety-eight, ninety-nine then stopped. Alice looked quizzically at us, unsure what to say next. Miriam asked, what comes next Alice? Alice shook her head, not knowing what to say. Miriam explained that one hundred was next. Miriam and Alice continued their counting of ants for another minute. Alice became restless and decided to follow the direction the ants were travelling. Alice noticed the ants were moving in a line and they were 'carrying things'. As Miriam and Alice followed the ants and their trail through the grass, they talked about how strong ants must be, where the ants must be travelling and how many ants Alice thought there must be. Alice said to Miriam, 'there must be one hundred and one hundred!' Miriam smiled and said to Alice, 'One Hundred and One…One Hundred and Two Alice'.

Discussion

The vignettes provided here confirm Tippett and Milford's (2017) suggestion that integrated STEM learning occurs when at least two of the domains are evident. Each of the five phases (Fig. 4), when considered alongside the events described in the three vignettes, allows for STEM teaching and learning to be analysed and contextualised. How these vignettes can be applied to the five-phase model is demonstrated in Table 2, through applying Vignette 1 as an example.

To deepen the understanding of STEM and its contextualisation in bush kinder teaching, each component of the five-phase model is now discussed.

Phase 1: Identifying and Understanding Phase

Identifying and understanding the STEM in nature plays an important role are establishing the educator and children's grounding to proceed through the remaining four phases of bush kinder STEM teaching and learning. The vignettes demonstrate that Miriam and Lyndal (kindergarten educators) adopted an

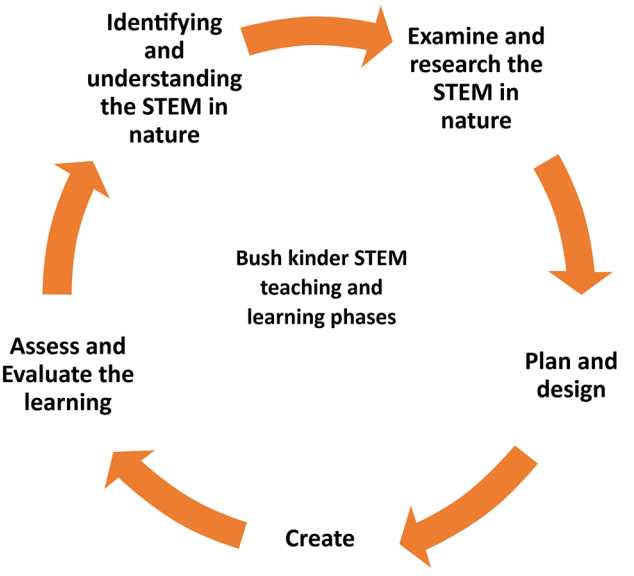

Fig. 4 Bush kinder STEM teaching and learning phase

emergent curriculum (Card & Burke, 2021) with an integrated STEM focus (Tippett & Milford, 2017), yet educators can identify the STEM teaching and learning opportunities from their pre-existing knowledge of what is available in the bush kinder. Miriam and Lyndal both understood the STEM learning that was apparent in the bush kinder setting and had clear understandings of what characterises STEM and how it existed in the bush kinder context. Through STEM awareness, Lyndal (Vignette 1) realised

Table 2 Applying the five-phase model to the data

Phase	Example taken from Vignette 1
Identifying and understanding the STEM in nature	Miriam identified that the log the children were playing on in bush kinder was appropriate to teach them about balancing. She understood that the weather could form part of the children's learning
Examine and research the STEM in nature	Miriam had undertaken prior research into what the weather would be on the day allowing her to know what would occur at bush kinder. She examined the weather conditions on the day to support her own local knowledge of weather to support the children's learning
Plan and design	Miriam had devoted time during regular kindergarten talking to the children about safe play and how best to balance on the play equipment. Through this planning, Miriam was able to reinforce this at bush kinder. This was spontaneous planning and design, a reaction to the play on the log that was occurring
Create	Miriam took up the opportunity, while the children were being creative, to support the children's learning and problem solving to develop science conceptual knowledge such as gravity and space while also incorporating number sense as the children counted down from ten
Assess and evaluate the learning	Miriam was able to assess and evaluate the children's number sense through their counting and came away from the bush kinder session with a deeper understanding of the children's knowledge through her questioning which included their understanding of gravity and what could they see in space

that 'STEM was everywhere' and Miriam (Vignette 2) that STEM was present in the children's play and 'the focus of bush kinder'. Miriam (Vignette 2) noted that bush kinder 'was where children could take science, technology, engineering and maths and play'. Both educators were able to define how their teaching of STEM was occurring. By understanding what STEM means to them, Miriam and Lyndal could then undertake research and investigations of STEM to support what was occurring in the bush kinder. The children, through their play, also can discover what is apparent in nature to develop their understandings of STEM. Identifying the appropriate log on which to balance and how to determine the existence of a scorpion's nest or to identify an ants' trail all are important commencement points in children building a sense of the STEM in nature.

Examine and Research Phase

Armed with an understanding of how STEM can be defined in the context of bush kinder, educators can commence developing that understanding further through research and by critically examining the bush kinder surrounds. Defining STEM is a valuable step for educators' research into the STEM teaching opportunities that can arise in the bush kinder. Often, a child-centred approach (Speldewinde et al., 2020) would lead to unanticipated events and activities and educators can be prepared to support children's learning with relevant research. If educators know of the existence of small animals in the bush kinder, they can be prepared to initiate a teaching 'moment' with the children. If weather is known to be cloudy or raining during a bush kinder session, the educator can use the weather being observed to talk to children about their bush kinder experience. In Vignette 1, Miriam understood the approaching weather pattern when the children were attending bush kinder. Similarly, in Vignette 2 Lyndal researched animal habitats and how to best observe these habitats without causing a detrimental effect to the animal. In Vignette 3, Miriam's awareness of the children's desire to balance and the children application of balancing skills observed by Miriam on the play apparatus at kindergarten (swings and parallel bars) allowed her to discuss the children's balancing and gravity and force while the children were playing at the bush kinder.

Plan and Design Phase

At Sunrise Bush Kinder, very little formal planning and design went into the STEM teaching due to the adoption of an emergent curriculum (Card & Burke, 2021). As the teaching is determined by the play and what children discover, educators are adaptable to teach to situations as they arise. Yet, educators can plan for seasonality and knowing that birds return in Spring to nests constructed years prior (Vignette 3), scorpions (Vignette 2) and ants (Vignette 3) may be active at times of the day or of the year. An educator's understandings of the external events that may trigger the child's interest in, for example, flight or space can provide planning opportunities. All three vignettes confirm that the educators' knowledge and preparation support teaching at the point of need and the applicability of 'identifying and understanding' and 'examine and research' phases. As the nature learning in bush kinder is often child-led, educator lesson planning and design may be limited, yet educators respond to the children's application of design in their STEM learning.

Creation Phase

Bush kinder provides a myriad of opportunities for the creation of STEM-related activities as children's creativity and imagination take hold (Campbell & Speldewinde, 2022). Educators gain an ability to consider the STEM learning outcomes that can occur in bush kinder and what solutions to STEM-based problems that arise in nature the children may apply. Children create their own understanding and

interpretations of what nature provides for play that applies STEM. The integration of STEM becomes apparent in each of the vignettes as a fallen log creates opportunities to learn science concepts of force through balance, gravity and space while also incorporating the mathematics of counting (Vignette 1). The application of a stick as a technological tool to investigate the habitat of a small animal (Vignette 2) and for Alice (Vignette 3) to recognise the patterns in an ant procession allowed for STEM integration to occur. Bush kinder allows children to modify and develop their thinking of nature and for educators to produce a solution for teaching these integrated STEM concepts.

Assessment and Evaluation Phase

Evaluation can take place in a number of ways as evidenced in the three vignettes, yet it remains ad hoc. The vignettes provided here demonstrate that the children's evaluation is somewhat limited, although Vignette 2 points towards children developing an understanding of how to appropriately care of an animal's habitat, the assessment of which would be how the animal survives following its interaction with the children. The benefits of children's noticing of nature because of their bush kinder interactions has been documented elsewhere (Speldewinde et al., 2021), yet the three vignettes point to further development of this phase, through the educators' approaches. For example, Vignette 1 demonstrates Miriam's deeper understanding of the children's ability to count, in Vignette 2 Lyndal's discussion regarding science and technology integration allows her to assess how the children think of technological applications in nature, and in Vignette 3 Miriam gained the opportunity to individually assess Alice's skills of counting and pattern recognition.

Future Implications

There is potential for further development of approaches to nature-based teaching in ECEC as bush kinder programs grow. The problem solving and project-based learning that bush kinders provide compliment Margot and Kettler's (2019, p. 2) notion that the authenticity of experiences associated with STEM education requires that teachers have skilled understandings of how best to teach STEM. As growth continues and other contexts become aware of the benefits of taking children into nature-based settings for ECEC, greater awareness of the environment and sustainability will become more prevalent in education. This awareness lends itself to STEM teaching and learning and for educators to apply the steps outlined in five phases articulated in the bush kinder STEM teaching and learning cycle (Fig. 4).

It is important to acknowledge the limitations that can occur with this type of nature-based teaching and learning. In other contexts, nature may not provide suitable materials. While the Australian climate is extremely varied, instances exist in other contexts where the climate may be prohibitive for such activities during the school year. Continuing to theorise how the teaching and learning processes are applicable in nature-based ECEC contexts will become increasingly important as these sites flourish. By examining further how nature-based teaching and learning contexts develop, children's affinity for STEM in nature may become apparent and understanding the influence of children's uptake of STEM into later years of schooling will be worthy of consideration. The three examples provided in this paper are only a small sample of the myriad of STEM experiences that were observed, yet they illustrate opportunities where STEM learning and teaching was embedded into play-based teaching and learning in an integrated manner.

The examples analysed in this paper confirm that STEM teaching and learning is highly suited to a nature-based teaching environment and support Wiedel-Lubinski's (2019) notion that opportunities exist for children to learn through interacting with nature. What is evident is the educators' capacity to take real-life STEM situations such as the challenges an astronaut may encounter or caring for

animal habitats and apply them in children's bush kinder teaching and learning. An opportunity exists for further research in this area to consider, in the context of STEM education, the children's learning through interacting with nature. Taking an approach to STEM teaching and learning that is aimed at indoor classroom learning (Forbes et al., 2021) and applying it to the bush kinder context demonstrate that STEM teaching and learning is as appropriate indoors as it is in nature. The teaching and learning phases theorised in Fig. 4 provide a way to think further about the processes under consideration here. Additional investigations in different contexts are also required. For example, to assess and evaluate the (children's) learning phase in the process of bush kinder STEM teaching and learning presents an opportunity for further investigation. Educators can develop opportunities to devise methods to collect concrete evidence to base assessment and evaluation of children bush kinder learning as opposed to anecdotal evidence apparent in the vignettes here. This may also be an acknowledgement that the planning and design phase also requires educator attention to ensure that children learn a wide range of STEM concepts and skills.

If nature is a central experience to building children's learning, as indicated by Wiedel-Lubinski (2019, p. 182), then an ethnographic approach (Madden, 2012; Stan & Humberstone, 2011) that facilitates observation of educators' interactions with children and nature will be valuable to gain rich understandings of how STEM teaching and learning occurs in these contexts. Elsewhere, as the result of this research (Speldewinde et al., 2021), it has been documented that children's STEM noticing and confidence when being 'in' bush kinder develop over time and girls' STEM identity grows as a result of bush kinder interactions (Speldewinde & Campbell, 2021). As young children's affinity with nature or their desire to relate with other life forms is integral to their development as individuals (Mawson, 2014), I argue that STEM teaching and learning is integral to building this affinity. There is the potential for this to be further explored and for the direct and indirect outcomes for young children of STEM teaching and learning to be examined. Additionally, there is the potential for other discipline-based learning domains such as Art, Literacy or Humanities, and their connection to bush kinder STEM teaching and learning, to be explored in future.

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Declarations

Ethics Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Ethics approval was granted for the study, HAE-15–016 Bush kinders – locating the science through Deakin University Faculty of Arts and Education Human Ethics Advisory Group (HEAG) on May 5, 2015.

Conflict of Interest The author declares no competing interests.

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