Creative Education, 2018, 9, 11-25
http://www.scirp.org/journal/ce
ISSN Online: 2151-4771
ISSN Print: 2151-4755

STEM Practice in the Early Years

Coral Campbell[1], Chris Speldewinde[1], Christine Howitt[2], Amy MacDonald[3]

[1]Deakin University, Victoria, Australia
[2]University of Western Australia, Perth, Australia
[3]Charles Sturt University, New South Wales, Australia
Email: coral.campbell@deakin.edu.au

How to cite this paper: Campbell, C., Speldewinde, C., Howitt, C., & MacDonald, A. (2018). STEM Practice in the Early Years. *Creative Education, 9,* 11-25.
https://doi.org/10.4236/ce.2018.91002

Received: November 10, 2017
Accepted: January 16, 2018
Published: January 19, 2018

Abstract

In 2015 and 2017, we observed four pre-school centres, researching science, maths and technology pedagogy and how opportunities presented themselves for learning in outdoor settings. The purpose of this paper is to interrogate STEM practises in the early years, practices that are informed by play-based education pedagogies, to understand approaches to STEM education. The research adopted a mixed methods approach which, in addition to our observations, included a pilot survey and educator interviews. These data are brought together to examine practices of STEM education in pre-schools. We were able to view pre-school centres as places that provide varied, rich experiences for children to develop understandings of STEM. Importantly, we observed that children's STEM experiences enhance their self-belief in their ability to learn STEM, and these early years' opportunities trigger STEM appreciation and its value to everyday life. We were able to conclude from the research results that integrated STEM, particularly science and mathematics, arise through children's play and themes arising from their interests. The findings importantly highlight how different practices and pedagogies are used to support STEM learning.

Keywords

STEM Practice, Pedagogy, Early Childhood, Child-Led

1. Introduction

International interest in Science, Technology, Engineering and Mathematics (STEM) has increased significantly in recent years as a direct result of the declining interest in STEM-related occupations and the expected impact of this now and into the future. The future prosperity of many countries is dependent on life-time engagement with STEM education (Chubb, 2013). In the next 5 - 10 years, 75% of the fastest growing occupations will require STEM related skills and experience (Chubb, 2013). With a significant decline in STEM participation in schools, in higher education pathway choices and in careers, the challenge facing educators is how to meaningfully embed STEM-related content into teaching and learning in order to engage students at all levels of schooling (Marginson, Tytler, Freeman, & Roberts, 2013). In education, STEM is often taken to mean one or more of the disciplines working in concert; however, it can present itself in a more integrated manner, where all four disciplines naturally occur due to the nature of the education experience. There is therefore a need to clarify what is meant by STEM in education (Hobbs, Cripps Clark, & Plant, 2017) and how this can be transferred into curriculum and pedagogy across all stages of education, particularly in early childhood (Australian Government, 2017).

Research into the early years of childhood in the last decade has highlighted the importance of quality early childhood care for enhanced cognition (Hayes, 2007; Gordon Biddle et al., 2014: pp. 256-285). Catherwood (1999) indicates that considerable brain growth occurs during infancy and that significant learning also occurs in this time. Other studies (Perry, 2010; Laevers, 2005) have shown the importance of quality relationships in the emotional development of young children and the significance of this well-being on early learning. In particular, studies in the United States of America, *High/Scope* (Schweinhart & Weikart, 1999) and in England, *The Effective Provision of Pre-school Education Project* (*EPPE*) found that the benefits of a quality early childhood education remained with a child through into adulthood (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2010).

An important aspiration of education is the development of a supportive environment that supports life-long learning. Early childhood education is a critical time in which experiences that enable and enhance children's disposition towards lifelong learning are established (Katz, 2010). STEM at the early childhood level, if approached correctly, could offer opportunities for educators to engage young children in activities that capitalize on their interests, experiences, and prior knowledge.

2. Background

Research is emerging that signals the early childhood years as essential for laying the foundation for future learning in STEM with suggestions that teachers can engage children in STEM activities that take advantage of children's prior experiences, knowledge and interests (NRC). Early, meaningful experiences of science for young children, for example, have been found to enhance self-belief in their ability to learn science and to promote greater interest in science (Patrick, Mantzicopoulos, & Samarapungavan, 2009: pp. 182-183), and that such experiences trigger an appreciation for science and its value to everyday life (Fleer, March, & Gunstone, 2006). Hunting, Mousley, & Perry (2012) highlight that mathematical skills developed at an early age, such as number sense and ordinality, are strong predictors of later academic success. (Chesloff, 2013: p. 35) supports this by stating that "It is my feeling that you can't start early enough: Young children are natural-born scientists and engineers". Unfortunately, research also shows that the current time devoted to STEM in early childhood is likely to be insufficient for achieving positive educational outcomes (Sackes et al., 2011).

Eshach and Fried (2005) indicate that young children develop basic understandings of observed phenomena and processing skills, with competency increasing with age. Opportunities for interaction with STEM, supported through educator scaffolding can enable children to develop basic understanding and skills such as observing, exploring, inferring, questioning and reasoning (Eshach & Fried, 2005: pp. 332-333; Kallery, 2004). While EC educators' attitudes towards STEM subjects such as science and mathematics are relatively positive, self-efficacy and confidence to teach these areas remain low (Campbell & Jobling, 2010; Edwards & Loveridge, 2011). Educators and researchers are becoming increasingly interested in investigating contexts and practices that support children's learning in these areas, and what teaching approaches are most conducive for developing children's investigative, design and reasoning skills. This problematising of STEM in education acknowledges the diversity of approaches that are emerging, particularly within the EC setting.

This research therefore sought to focus on understanding how STEM is currently embedded in EC settings through the resources of the setting, the children and the educators' practices. An interpretive qualitative approach incorporating a small survey across three Australian states, interviews, and researchers' observations, was used to examine early childhood STEM activities and experiences to understand the ways STEM education is presented in pre-schools. The data provided critical insights into how STEM related EC opportunities align with, and can provide the foundation for, STEM education practices. The project examines how the educational outcomes associated with the holistic, integrated and play-based pedagogy common to early childhood supports STEM education.

The research questions are:

RQ 1. How does STEM present in early childhood educational settings?

RQ 2. How are EC educators engaging pre-school (four to five year-old) children in STEM?

RQ 3. How do children's interests stimulate STEM explorations?

3. Context for Researcher Observations

All settings came under one local jurisdiction and were spread across two small rural towns and one larger rural town. Three of the settings were coastal, with beaches and tourist populations during holiday times. The other location was considered a country area, with nearby farms and agricultural economies.

- Setting One—Indoor and outdoor (bush).
- Setting Two—indoor and outdoor (park).
- Setting Three—indoor, beach & bush areas.

- Setting Four—indoor and outdoor (park).

Children would spend 3 hours each week in a park, beach or bush setting and a further 12 hours each week in a normal pre-school centre with both indoor and outdoor aspects. Observations occurred in the entire range of settings.

4. Methods and Design

Over two years 2015 and 2017, we observed four and five year old children in four pre-school centres. We attended multiple sessions, generally in blocks of four weeks, attending on the same day each week. Approximately 20 children attended a session at each centre so over two years we were able to observe in excess of 150 children learning and at play. Our research centred on components of science, mathematics and technology pedagogy, and opportunities for learning in outdoor settings. Our documented evidence was drawn from observations of educator pedagogy and reflective interviews. The researchers (Campbell and Speldewinde) spent between one and three hours on site over six weeks in 2015 and then a further six weeks in 2017. While at the pre-school centre, as a STEM event occurred, either immediately after the event had taken place or at the end of the session, we would interview the educator, asking them to explain their interpretation of events and what they though had transpired. From these interviews and observations, we gained the data to discuss how STEM presents in pre-school settings. To gain further understandings, an anonymous survey was prepared and forwarded to early childhood educators in three Australian states in 2016.

Data presented in this paper were derived from the anonymous online pilot survey, educators' interviews and observations, conducted to understand the ways STEM education is embedded in pre-schools. Interviews and observations used specific observation protocols around research questions and the survey sought responses to 10 open-response questions relating to educator understandings of STEM pedagogy and practice.

Our focus on four pre-school centres enabled us to develop a case for each centre based on the educator, children (in each year) and the setting. We considered a case study approach as it allowed us to "investigate a contemporary phenomenon in a real-life context (Yin, 2014: p. 2)." Case study according to Yin allows multiple forms of evidence to be used to construct the case—in this case the STEM practices in each early childhood centre. The collection of data and the study itself was bounded in both time and in space (the four different sites) which identified case study as a suitable approach. As we were entering the early childhood education world and attempting to make sense of what we were seeing and hearing, we were interpreting the information from a number of stand-points. This interpretivist approach was the most appropriate in terms of allowing the meaning-making analysis of data, while acknowledging that our own interpretations would affect the data.

1) *The survey*

This was comprised of eleven open response questions related to educators' perceived understandings and practices related to STEM in early childhood. Written responses to the eleven questions were received from twenty-eight educators. The survey was administered through a link to a Qualtrics survey platform site and all responses recorded electronically. The responses were analysed using the Qualtrics text analytics tool applied to the text entry questions. Reading across each question, the software searched the text, filtering for key terms and tagging groups of words which provided themes across the survey responses.

Questions:

a) What is your understanding of STEM?

b) What teaching practices do you use for STEM learning?

c) Describe how you enable/encourage/foster children's learning in STEM areas.

d) How do you ensure that children's STEM learning is meaningful and significant in the child's world?

e) How does your strength in the STEM discipline areas promote children's learning?

f) How do you highlight a concept or process to draw children's attention to a STEM related idea in the kinder setting?

g) How do you include STEM in your programming & planning?

h) Are there particular issues you have encountered as you plan and/or implement STEM practices and how have you overcome these?

i) What is available in the kinder environment that provides opportunities for exploration related to STEM e.g. setting, materials, people?

j) What resources would you like to have to further enhance STEM learning?

k) Describe a powerful STEM learning experience that arose in one of your sessions—how did it arise, what were the learning outcomes?

2) *Educators' interviews*

There were two forms of interviews. The initial interviews were conducted prior to the observations of the kindergarten sessions (2015). Subsequent interviews (2015 & 2017) were ongoing, occurring at each session. Overall, we collected nine initial interviews of approximately 45 minutes duration, and many more small interviews across 64 visits. Semi-structured interviews were recorded and transcribed and analysed using N Vivo which searched for recurring words and themes in the responses. The interview responses were linked to the video snippets and researcher notes to increase understanding of the phenomena occurring. This provided the researchers with richer and more in-depth interpretation of the experiences observed.

The initial semi-structured interviews in 2015 were focused on understanding educators' perceptions of what science was incorporated in everyday practices or in child-instigated explorations.

- How is science learning and teaching being enacted in your settings (inside and outside)?

- What is available in the play environment that provides opportunities for children's explorations related to science?
- How do you highlight a concept or process to draw children's attention to science related ideas in the physical environment?
- What learning do you think is happening in the outside setting?

Ongoing interviews occurred during the sessions, supported by researcher observations. Across each of the two years, we visited the 4 pre-school centres each week for 12 weeks collecting anecdotes which were used for teacher input.

Prompts for the educator,

- Can you tell me what is happening here (indicating the video snippet)?
- What are the children doing here (indicating the video snippet)?
- What was the purpose of your involvement here?

3) *Researcher Observations*

The observations occurred in 2015 and again in 2017 and focused on science, mathematics and technology learning. For the STEM observations, we documented instances of play that demonstrated and enabled science/maths/technology knowledge development as well as STEM skills, using those identified by Milford & Tippett (2015): observing, describing, categorising, predicting, and communicating. Across each of the two years, we visited the four pre-school centres each week for a total of 12 weeks and collected over two hundred instances (researcher observations) of STEM learning through play, most of which were supported with teacher reflection notes (teachers' comments collected at the time of the observation). These observations were sorted into the categories of: integrated, science, mathematics, technology and STEM skills, which enabled the researchers to fully examine what type of activity was occurring and how frequently they were occurring.

5. Data

1) *Survey findings*

In line with the question intent, several key themes arose: child-instigated learning; discipline specific knowledge; discipline specific planning practices; general pedagogical principles and integrated learning

2) Educators' comments

- Child-instigated learning.
  - *Listen to the children's interests, explore these with them and learn with them.*
  - *Setting up experiences based on children's interests, community events and intentional teaching.*
  - *I always try to follow the children's interests for example adding pvc pipes to the sandpit when the children were experimenting in how the water flows and making lakes.*

- Discipline specific knowledge.
  - *…believe science is in everyday practices.*
  - *My background is science so I'm passionate about extending the children's learning in this higher order thinking. At school I was not good a maths or engineering, building is not my strength, but I understand the value - exposure to these areas will impact on the children learning later in life, hoping they will find if joyful and provoke fond memories to inspire.*
  - *As children talk about something they are familiar with, converse further, questioning understanding and pose other questions to further knowledge. Use conceptual words they know already, break down the words…*
  - *…some parents only see it as playing at kinder not understanding that building with blocks develops many skills in maths and engineering.*
- Discipline specific planning practices.
  - *We ensure that we offer the children a variety of activities in these areas in our fortnightly program. We offer discussion, demonstration and then the children experiment in the area of science with adult supervision. Maths is offered indirectly through play using Lego, Duplo, beads, puzzles, games, counters and during group times with games and songs.*
  - *We make sure there is always an investigation table. Science experiences are offered each fortnight-chemical reactions, air, heat, wind, absorption etc… Construction and making tables are always available to encourage creation and following step by step instruction.*
  - *I always try to have a science activity and maths activity. In my past kindergartens I've always implemented a technology program during term* 3.
- General pedagogical principles.
  - *I should probably be more purposeful in my documented planning, but I identify interest areas, needs, strengths of the group, and incorporate experiences.*
  - *Cycle of planning is focused on children's interests, children's observations and discussions. Set group goals.*
  - *Some experiments are done as a group, maybe teacher-led experiences and then set ups where the children can experience their own opportunity to see how things work or don't work. Children are encouraged to play and participate and educators listen to the needs and interest and question to explore what knowledge is already there and where to take this.*
- Integrated learning.
  - *Try to provide a variety of activities to introduce/reinforce STEM concepts. Integrated within the whole of planning—ensuring the terminology is supportive/correct. Seek out materials, experiences, opportunities to explore.*
  - *I have an integrated programme where one activity can cover many of the areas. We have lots of outside play and hands on opportunities for the children to learn as they play and lots of verbal interactions throughout the day.*
  - *Through an integrated theme based approach.*

Some of these were expected. For example, it was common for educators to indicate that much of children's learning in STEM was related to "explorations" they initiated themselves or through child-instigated activities. However what was unexpected was the strong delineation arising through educators' answers around what constituted STEM practice. When providing examples of STEM activities, educators tended to represent children's themed explorations that led from one discipline to another. Comments indicated that the educator recognised the discipline content in the activities and also how an activity could move from one discipline to another. Less was noted about integration of understanding across discipline areas. Another unusual finding of the survey was that educators tended to plan in disciplines, mentioning science and mathematics planned activities. Planning generally did not incorporate STEM or even an integrated approach. Integration tended to occur through the child-instigated themed activities.

In reporting on pedagogies used to support children's STEM learning, educators' comments related to general pedagogies and principles such as scaffolding, discussions, extending activities etc. There were no reported STEM specific pedagogies mentioned, although educators did acknowledge that they used an inquiry approach for science.

3) *Educators' Interviews*

Educators' interviews provided some strong themes in terms of their expectations. Evidence presented indicated that inside environments were more typical of discipline learning in kindergartens with many resources (e.g. magnifying lenses) provided to enhance science or technological play. In addition, all educators indicated that they expected that science learning could occur in outdoor spaces through children's own explorations. There was an expectations that the outdoor settings would be productive spaces for learning about the environment – biological, ecological concepts and an ethos of caring.

- How is science learning and teaching being enacted in your settings (inside and outside)?

We did a science experiment yesterday inside the classroom (*JJ*, *Aug* 2015).

Children to become…to become observers of their environment and to see what's actually happening rather than just assuming and telling. I find with the physical hands-on with a lot of things as well, it's more of holistic way for children to learn and it seems to really sink a lot more rather than just talking about it and saying I know about it, actually experiencing it (*BB*, *Aug* 2015).

Science learning explored in the outside environment is often brought into the inside environment and vice versa (*CJJ*, *Aug*, 2015).

- What is available in the play environment that provides opportunities for children's explorations related to science?

…with changes with the weather for example, the children now can get a bit of a prediction. They are watching the clouds, they are seeing the changes, they are feeling the wind, it's a whole sensory, visual, knowledge based way of learn-

ing for them (*BB*, *Aug*, 2015).

I do a lot of science and maths with the children…. I like to introduce them to things they wouldn't normally experience… (*W*, *Aug*, 2015)

- How do you highlight a concept or process to draw children's attention to science related ideas in the physical environment?

…but now the information that I can give them is more direct and more specific. Then it makes it even easier for me to extend the understanding. Because I know they have discovered this concept. How can we extend that concept? (*CJJ*, 21 *Aug*, 2015).

…so asked her why they are swooping? … and then we went back into the kinder and we then looked up what the nests look like because we couldn't find a nest. What the nest looked like and the different sorts of birds and different sorts of eggs. So a lot of the time, this can be the basis of a lesson you take back (*JJ*, *Aug*, 2015).

I'm comfortable to have a little bit of structure like this now and then, just to give myself and all the staff confidence and to have that knowledge base for the children to just work off afterwards because a lot of these learning experiences, you do them in the classrooms but to me, it makes more sense if we're out in this environment to incorporate it in this environment as well (*BB*, *Aug*, 2015).

- What learning do you think is happening in the outside setting?

I felt there was a lot of creativity happening with their descriptions. The literacy of what they were actually seeing and comparisons. There was a lot of maths in there with sizes and shapes like fairy rings and things like that. Just the different layers of it… (*BB*, *Aug*, 2015)

The kids here are learning about gravity. When they are building shelters, sometimes things fall down. …there's lots of weather when the sun comes out and the rain. Rainbows… I suppose there's lots of physics involved. It's all to do with leverage, in nature, we're just discovering where they find things. Like, where does that hole lead, where's the bird for that nest. They are just discovering where things are. Because we've got a lot of branches, and we've got a lot of leftover tree trunks and stuff, they're actually also discovering sizes. In fact, a few weeks they actually doing, the little stumps that they found, from small to large and using them as steps to go on (*JJ*, *Aug*, 2015).

Many educators mentioned children as observers of their environment and also how they experience the environment when outside "it's more of holistic way for children to learn". Another educator indicated "I believe that what we're doing here is a partnership with the sciences, they go hand in hand" (*RJJ*, 5 *Aug*, 2015).

Often educators highlighted a biological concept or process to draw children's attention to science related ideas in the physical environment where the natural phenomenon was the catalyst for a child's play.

Example of chemistry—"…when you add water to dirt to create a muddy puddle or the clay had been dried out on this log here and then putting it in the puddle and how it was manipulated. Links to Solids and liquids. Even putting sticks in the clay and digging using a tool or your hands manipulate things into shapes" (*RJJ*, 5 *Aug*, 2015).

4) *Researcher Observations*

Across the time of the observations, we saw many different instances of specific discipline experiences but also examples of integrated activities (**Table 1**). These were documented using an observation protocol, which recorded the specific experiences, but also researcher notes which complimented the observations. The researcher notes commented on other elements such as the educator involvement, duration of play or a note on other factors which could be considered relevant to the play experience.

Teachers' planning for the disciplines often involved the introduction of a

Table 1. Selected examples of children's STEM activities.

Integrated	Science	Technology	Mathematics	Skills& processes
Children building "cubby houses" using sticks and branches.	Forces related to which branches were strong enough to hold others	Investigate materials, design, construct and evaluate cubby (fit for purpose, aesthetics)	Measuring the branches and sticks to fit the space available. Choosing the best size.	Problem-solving (analysing & creative thinking), estimation and approximation
Weather watch	Observing clouds, their shapes. Discussion on what causes rain & rainbows	Children creating clouds, rainbows and rain as a room exhibit.	Measuring rainfall	Observation (of clouds), measurement, recognising scales—difference in size, shape
Doctor & medicine (whole centre themed)	Bone collections, skeletons, human body model,	Adapting a wooden stick as a tool to lever sap out of a tree.	Measuring bones and aligning them to a template. Measuring body parts.	Establishing and justifying sorting criteria of a set of bones
Balancing on a log—children placed items on a log, counting how many and how long they stayed on the log before falling off.		Adaptation of a pair of wooden sticks to form pick-up tongs	Children using beads to create a pattern	Creativity, recognising patterns
Learning about animals	Finding small animals and their "homes"	Constructing an environment to house them—small container adapted to the purpose	Measuring the sizes of the container to fit the small animal	Animal enclosure—Fit-for-purpose (normative knowledge). Describing key attributes of small animals.

science idea or phenomena, which may then have been left on the exploration table or may have been more formally introduced to the children. An example of this was that children were introduced to hydrophilic beads which are small transparent capsules which absorb water. The children were asked to describe the beads and offer a hypothesis on what they thought might happen when the beads were placed in water. Responses included that the beads might change colour, dissolve or get softer. These responses indicated that children were drawing on their prior knowledge to make reasonable suggestions.

The educators observed at each of the four sites demonstrated different pedagogical approaches.

Setting One—Indoor and outdoor. The lead educator at Setting One took a structured approach organising a "focus" for each week. The children's experiences were augmented as much as possible and there was a purpose to the questions asked that related to play activities. The educator would intervene, proactively moving towards play when she saw an opportunity for inquiry questions.

Setting Two—Indoor and outdoor. Three educators were present at Setting Two. All adopted the same approach to children's interactions, child directed learning with educator scaffolding. There was no "focus" for each week, children would arrive and immediately begin outdoor play. As more children arrived, small groups would form and the children allowed to roam and explore. The educators would roam for the duration of the session and the children's learning would be augmented on a needs basis—child directed learning with scaffolding by the educator. Learning experiences in the outdoor spaces were often extended into the indoor space and *vice versa*.

Setting Three—indoor, *beach & bush areas*. Three educators were involved in this setting. The lead educator planned activities with science and mathematics focuses, although technology (construction) usually arose through children's own interests. When in the outside environments of the beach or the bush, planned activities related specifically with engaging with the natural environment, e.g. undertaking a rock scramble or a bush walk along an unknown path. STEM learning was incidental to what the environment presented—aspects like weather or seasonal changes in trees or foliage was noted and explored through children's interests. All educators moved in and out of children's play when invited by the children.

Setting Four—indoor and outdoor park area. There were two educators at Setting Four. The lead educator had a strong science and mathematics focus in specific activities introduced to children in the indoor setting. Often this learning was taken into the outside environment. She would take a small amount of additional material outside for children to use such as magnifying lenses, containers, and drawing implements. She was actively involved alongside the children in discovering "things". The second educator scaffolded children's learning when asked by the children to help, but tended to stay on the side otherwise. She was initially more timid in the more open outside setting. New to this teaching space, her own pedagogy began to adapt as she became accustomed to notions of fewer constraints on children's behaviour.

6. Discussion

In considering the data, we return to the aim of the research which was to understand how STEM is currently presented in EC settings, through the resources of the setting, the children and the educators' practices. Responding to the research questions will address this aim.

RQ 1. How does STEM present in early childhood educational settings?

We found that STEM presented in a wide range of forms in EC settings. The settings we observed included inside pre-schools, outside preschools—formal and informal (parks, beaches and bush). In the inside environments, children's learning was developed through the way the setting was arranged, through specific activities presented by the educator and through children free play. Children's interests tended to be confined or restricted by the materials and resources available. STEM materials were things like building blocks or joining materials, counting or measuring tools, cooking, magnifying glasses, exploratory table, magnets, and kits.

Activities that focused on STEM were presented mainly as science or mathematics. One such activity was where children were provided with multiple plastic pre-historic animals and asked to arrange them from smallest to largest. The educator provided children with the correct biological names of the animals. Another activity was to provide children with coloured beads to create patterns. However, one pre-school educator set the entire space up around the theme of the 'doctor and medicine' and allowed it to run for six weeks until children's interests decreased, while another created a "space" corner based on children's continuing interests—this ran for about three weeks.

In the outside environment, children's play changed. If the external environment of the pre-school is small or contains well-developed prescribed play areas, then that is what encourages or discourages the type of play that children engage with. Sand pits offer opportunities for STEM play as it is a versatile material which can be re-fashioned to represent what the child desires. With loose parts, children can construct bridges, roads, rivers and in fact whole cities, developing and integrating understanding across a range of STEM disciplines. Other simple activities, such as creating water flows in the sandpit, or rolling cars down a garden path presented opportunities for experiencing STEM.

In broader outside environments, such as parks, beach or bush, children's imaginations are not restricted by previously determined ideas presented in "toys". Tree branches can become horses, or trains or measuring devices. Ideas are integrated due to the nature of what children want to do. Climbing a tree can present ideas around balance, friction, weight, branch strength, branch size. These ideas can then change if a child moves to a different tree or under different weather conditions, where wet surfaces require adjustments in the thinking of the various aspects previously considered.

Children, when engaged in play, often tackled mini-learning projects that involved an integration of several STEM areas, for example—building cubbies.

RQ 2. How are EC educators engaging pre-school (four to five year old) children in STEM?

Early childhood educators engage with STEM, however, what they do relates to their own understandings of what STEM actually means and their level of comfort in developing this further. Generally, STEM was interpreted to mean each of the disciplines and in most cases, educators planned in that way. The integrated STEM tended to arise from children interests and while some educators felt comfortable offering support for that, many indicated that they felt that there was a gap in their understanding about how best to integrate. While the survey results presented a strong picture of science, mathematics and technologies within the preschool through planning, the observations tended to indicate fewer instances in inside settings. However, some educators do provide a themed approach, either through their own planning or arising through children's interests.

RQ 3. How do children's interests stimulate STEM explorations?

Children's play followed their interests which could be generated by things that they had seen or heard at home or from the stimulus of the environment. When children presented strong interests, educators adapted to meet these interests. With the inside environments of the pre-school, children's play tended to be around the materials provided, which was often in the form of sets of blocks, art materials, books, other toys. The loose materials (pipes, branches, containers) which educators provided could offer children opportunities to use the materials and their other resources in different ways and sometimes this led to a STEM exploration (e.g. bridge-building in the sand-pit). Educators observed that creative play was less developed in the inside environment. However, in the outside environment, educators commented on how enhanced creative play involved children in more explorations of their environments. Children would spend longer periods of time undertaking their own investigations to find answers to their own questions.

7. Conclusion

Our research provides evidence that STEM, particularly science and mathematics, is occurring in pre-schools, including regular planning supported by activities. The environment of the pre-school is rich in opportunities for children to be involved in STEM and, particularly in the freedom of the outdoors, where resources are less defined by adults, children are able to explore around their own interests. Sciences are naturally integrated with mathematics and/or technologies as defined by the question or activity of the child. Indoors, STEM learning occurs mainly through planned educator activities.

In pre-schools, the pedagogy supporting STEM learning is presented in different ways. Educators plan for specific disciplines and incorporate a range of defined activities, but offer fewer opportunities for an integrated approach to STEM. Most acknowledge that this is an area where they could improve. Where integration does occur, it is generally through a themed approach where each discipline is specifically targeted. Educators acknowledge that they use approaches such as inquiry, concept development, appropriate language development, child-instigated and are able to define what these mean. However, STEM as a language or concept or approach is still ill-defined. This is not surprising, as definitions for STEM across the world vary, depending on the context. This is the challenge for early childhood education—to define STEM pedagogy such that meaningful learning in STEM is effectively achieved.

References

Australian Government (2017). Department of Education and Training Restoring Focus on STEM in Schools Initiative. https://www.education.gov.au/support-science-technology-engineering-and-mathematics

Campbell. C., & Jobling, W. (2010). A Snapshot of Science Education in Kindergarten Settings*. International Research in Early Childhood Education Journal, 1,* 3.

Catherwood, D. (1999). New Views on the Young Brain: Offerings from Development Psychology to Early Childhood Education. *Contemporary Issues in Early Childhood, 1,* 23-35. https://doi.org/10.2304/ciec.2000.1.1.4

Chesloff, J. D. (2013). STEM Education Must Start in Early Childhood. *Education Week, 32,* 32-27. https://www.edweek.org/ew/articles/2013/03/06/23chesloff.h32.html

Chubb, I. (2013). *Science Technology, Engineering and Mathematics in the National Interest: A Strategic Approach*. Canberra: Office of the Chief Scientist, Australian Government.

Edwards, K., & Loveridge, J. (2011). The Inside Story: Looking into Early Childhood Teachers' Support of Children's Scientific Learning. *Australasian Journal of Early Childhood, 36,* 28-35.

Eshach, H., & Fried, M. (2005). Should Science Be Taught in Early Childhood? *Journal of Science Education and Technology, 14,* 315-336. https://doi.org/10.1007/s10956-005-7198-9

Fleer, M., March, S., & Gunstone, D. (2006). *Investigations into the Engagement of Preschool and Primary Aged Children in Science, Engineering and Technology.* Melbourne: Department of Science and Training, Monash University.

Gordon Biddle, K. A., Garcia-Nevarez, A., Roundtree Henderson, W. J., & Valero-Kerrick, A. (2014). *Early Childhood Education: Becoming a Professional*. Thousand Oaks, CA: SAGE.

Hayes, N. (2007). *Perspectives on the Relationship between Education and Care in Early Childhood: A Research Paper.* Dublin: National Council for Curriculum and Assessment (NCCA).

Hobbs, L., Cripps Clark, J., & Plant, B. (2017). Successful Students STEM Program: Teacher Learning through a Multifacted Vision for STEM Education. In R. Jorgensen, & K. Larkin (Eds.), *STEM Education in the Junior Secondary* (pp. 133-168). Singapore: Springer.

Hunting, R., Mousley, J., & Perry, B. (2012). A Study of Rural Preschool Practitioners' Views on Young Children's Mathematical Thinking. *Mathematics Education Research Journal, 24,* 39-57. https://doi.org/10.1007/s13394-011-0030-3

Kallery, M. (2004). Early Years Teachers' Late Concerns and Perceived Needs in Science: An Exploratory Study. *European Journal of Teacher Education, 27,* 147-165. https://doi.org/10.1080/026197604200023024

Katz, L. (2010). *STEM in the Early Years*. Chicago, IL: Early Childhood and Parenting Collaborative (ECRP), University of Illinois.

Laevers, F. (2005). The Curriculum as Means to Raise the Quality of ECE. Implications for Policy. *European Early Childhood Education Research Journal, 13,* 17-30. https://doi.org/10.1080/13502930585209531

Marginson, S., Tytler, R., Freeman, B., & Roberts, K. (2013). *STEM: Country Comparisons*. Melbourne: The Australian Council of Learned Academies. http://www.acola.org.au

Milford, T., & Tippett, C. (2015). The Design and Validation of an Early Childhood STEM Classroom Observational Protocol. *International Research in Early Childhood Education, 6,* 24-37.

Patrick, H., Mantzicopoulos, P., & Samarapungavan, A. (2009). Motivation for Learning Science in Kindergarten: Is There a Gender Gap and Does Integrated Inquiry and Literacy Instruction Make a Difference. *Journal of Research in Science Teaching, 46,* 166-191. https://doi.org/10.1002/tea.20276

Perry, R. (2010). Mathematical Thinking of Preschool Children in Rural and Regional Australia: Looking to the Future. *Journal for Australian Research in Early Childhood Education, 16,* 99-109.

Sackes, M., Trundle, K., Bell, R., & Connell, A. (2011). The Influence of Early Science Experience in Kindergarten on Children's Immediate and Later Science Achievement: Evidence from the Early Childhood Longitudinal Study. *Journal of Research in Science Teaching, 48,* 217-235. https://doi.org/10.1002/tea.20395

Schweinhart, L., & Weikart, D. P. (1999). The Advantages of High/Scope: Helping Children Lead Successful Lives. *Educational Leadership, 57,* 76-78.

Sylva, K., Melhuish, E., Sammons, P., Siraj-Blatchford, I., & Taggart, B. (2010). *Early Childhood Matters: Evidence from the Effective Provision of Preschool and Primary Education (EPPE) Project*. Abingdon-on-Thames: Routledge.

Yin, R. (2014). *Case Study Research: Design and Methods* (5th ed.). Thousand Oaks, CA: Sage Publications, Inc.