STEM and Digital Technologies in Play Based Environments: A New Approach

In 2018 and 2019 the Early Years STEM Australia (ELSA) program was trialled in over 100 centres Australia wide. One of the mandated components of the program was the creation of four apps for children that would inspire curiosity and engagement in STEM concepts in preschool children. This symposium will outline our novel approach regarding the use of digital technologies (DT) with young children. It will initially look at research regarding the use of DT. The second paper will discuss STEM Practices and the Experience, Represent and Apply (ERA) heuristic that embed STEM and DT whilst remaining true to the core tenets of the Early Years Learning Framework. The final paper reports on engagement data collected in the trial that supports our novel approach to STEM in the early years.

Chair/Discussant: Doug Clements

Paper 1: Kevin Larkin & Tom Lowrie *The Role and Nature of Digital Technology use in Preschool STEM*

In this paper we critique existing research on the role and nature of digital technology use in Preschools. The majority of the literature points to overwhelmingly positive outcomes for young children when digital technology is thoughtfully used in play based learning contexts. However, despite the wealth of evidence that the use of tablets can be beneficial to preschool students, early childhood teachers often report being uncomfortable in teaching STEM. We suggest that, if accompanied by suitable professional development, tablets are an important addition to early childhood contexts.

Paper 2: Tom Lowrie & Tracy Logan *The Early Learning STEM Australia (ELSA): The Policy and Practice(s) of Engagement in the Early Years*

The Early Learning STEM Australia (ELSA) pilot was a year-long investigation involving 300 educators and 4 500 four-year old children in one hundred learning centres across Australia. This paper reports on a pedagogical and design framework that was constructed to promote children’s STEM engagement across digital and non-digital learning environments. This paper describes this process in terms of a heuristic; since the educators in the study became part of the design team as they modified and adapted the activities developed by our team. The heuristic helped the educators modify and adapt the learning experiences to accommodate the diverse cultural and social needs of the students.

Paper 3: Tracy Logan & Kevin Larkin *ELPSA The ERA heuristic in action: Observations from the ELSA pilot.*

The Experience, Represent, Apply (ERA) heuristic is an innovation of the Early Learning STEM Australia (ELSA) project. It provided educators with an approach that embeds digital technologies in play-based learning in such a way that the focus of the learning remains on the child and not on the device. This paper reports on the experiences of early years educators and indicates that the ERA heuristic was instrumental in helping educators to integrate digital technologies in their everyday activities to promote engagement with STEM.

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The Role and Nature of Digital Technology use in Preschool STEM

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In this paper we critique existing research on the role and nature of digital technology use in Preschools. The majority of the literature points to overwhelmingly positive outcomes for young children when digital technology is thoughtfully used in play based learning contexts. However, despite the wealth of evidence that the use of tablets can be beneficial to preschool students, early childhood teachers often report being uncomfortable in teaching STEM. We suggest that, if accompanied by suitable professional development, tablets are an important addition to early childhood contexts.

The focus of this symposia paper is to provide a brief account of the role and nature of Digital Technologies in Early Years STEM as currently depicted in the literature. Digital Technology is a subset of technology – which can be defined as any tool that assists people to achieve goals (Lindeman & Anderson, 2015) – and in this understanding tablets and smartphones are technologies, but so are unifix cubes, books and pencil sharpeners. However, today's children are growing up in a digital age characterised by rapid changes in the types of technologies they are exposed to. As with any technology, when used wisely, digital technologies can support young children in their learning and in their relationships with adults and their peers (NAEYC, 2012). Regardless of the type of technology, its use must not "displace or replace imaginative play, outdoor play and nature, creativity, curiosity and wonder, solitary and shared experiences, or using tools for inquiry, problem solving, and exploring the world" (Donohue & Schomburg, 2017, p. 77).

The remainder of this paper will focus on tablet technology more specifically, given that research suggests that preschool-age children can handle the applications for such devices relatively easily, and that these portable devices have been described as particularly suitable for early childhood (Papadakis, Kalogiannakis & Zaranis, 2018, p. 140). It will also discuss the notion of digital play as a way of contextualising digital technology use in the early years and then conclude with a brief account of the importance of early years educators in developing appropriate scenarios for the use of digital technologies in STEM. Although there has been significant research into robotics and computational thinking with young children, in keeping with the overall thrust of this symposium, we put that research to one side and focus on tablet technology and STEM.

Widespread Nature and Screen Time

The research literature clearly indicates the widespread nature of digital technology use by preschool children with touch screen devices being by far the most popular with this trend growing rapidly (Kyriakides, Meletiou-Mavrotheris, & Prodromou, 2016). This is perhaps due to intuitive interface of a touch-screen tablet, the ease of installing new apps, and the increased portability and autonomy of the devices. A recent US study of 350 children aged from 6 months to 4 years found that 96.6% of the children used mobile devices and in the UK, Ofcom reported that 65% of 3–4 year olds use a tablet, with one in five of this age group having their own tablet (Marsh et al. 2018). Almost 1 000 new "educational" applications are added every day and there are now more than 100 000 educational apps in Apple's and Google's online stores (Papadakis et al., 2018), many of them focusing on early literacy and numeracy skills.

Of course the elephant in the room in relation to the uptake of mobile technologies is the topic of screen time. The proliferation of digital devices with screens means that the precise meaning of "screen time" is elusive and no longer just a matter of how long a young child watches television, or playing on a device, but rather a matter of how this time is spent. In Australia, it is currently recommended that sedentary screen time should be no more than one hour per day for children two to five years of age (Australian Government, Department of Health, 2017). Other health bodies take a different approach. The American Academy of Pediatrics has relaxed their guidelines advising against screen time for young children and now acknowledge that children are growing up "in a world where 'screen time' is becoming simply 'time'" (Alade et al., 2016, p. 434) and instead are encouraging parents to use media jointly with their children. Likewise, the Royal Council of Paediatrics and Child Health in the United Kingdom found that "the contribution of screen time to wellbeing is small when considered together with the contribution of sleep, physical activity, eating and bullying as well as poverty" (RCPCH, 2019, p. 3). In addition, the report concluded that there is no evidence to suggest a definite threshold for screen time overall, suggesting instead that these thresholds become part of a family's (and we suggest educators) planning (RCPCH, 2019). This finding supports the claim of (Marsh et al., 2016) who indicate that despite children now having access to a wider range of technologies than previous generations; it appears that screen time has not increased.

Tablet Technology – Findings

A wealth of research indicates positive effects from the use of tablets and apps with the broad consensus amongst educators being that tablets can serve as an important tool to improve learning and teaching, allowing preschool children to explore advanced STEM concepts once thought to be beyond that age group (See Papadakis et al. 2018) and to improve young children's skills, school readiness, or executive-function capabilities (Hirsh-Pasek, et al., 2015). This is important given that school readiness is predictive of later school achievement. In brief, the use of tablet technologies has positive impact on emerging literacy and numeracy skills, problem solving, creativity and overall mathematics achievement. Of importance to our ERA approach to using tablets, research indicates that young children could transfer what they learned on a device to a similar scenario using non-digital objects (Schacter & Jo, 2017). These positive effects may be due to the fact that tablets present very few technical challenges (e.g. the fine motor control required to use a mouse or keyboard) and thus engagement with tablets is higher. Lyons and Tredwell (2015) also note that tablets, with their multi touch capability and their portability, encouraged cooperative and social skills rather than isolated play. In addition, when using the tablets children were collaborative, created artefacts together, and understood the difference between activities on and off the devices. In light of this research, tablets are seen as being particularly suitable for early childhood contexts (Papadakis et al., 2018).

Context For Digital Technology Use – Digital Play

Of significance in the literature, given the play based nature of preschool, is the context of tablet use. Most researchers in this space propose some version of digital play; however, we take a slightly different approach that will be outlined shortly. Marsh et al. (2016) indicate that the nature of play is changing in terms of the resources available for play and the ways in which those resources are deployed in different types of play. This includes the relationship between offline and online spaces. They argue that this leads to communication and play that moves across physical and virtual domains and integrates material and immaterial practices. In suggesting that play moves fluidly across space and time, (Marsh et al., 2016) provide a counter position against those "who seek to dichotomise digital and non-digital play, suggesting that play with digital technologies is not 'real play'" (p. 9). A related conceptualisation of play, along the lines proposed by Marsh et al. (2016), is the work of Bird and Edwards (2014) who have coined the notion of digital play as a way of contextualising contemporary play. Digital play is understood as the range of play based activities children undertake with technologies. This concept of digital play can be helpful to early childhood educators in encompassing digital technologies into existing play based learning to support STEM.

Arnott (2016) takes a different approach, looking instead at the issue of play from an ecological standpoint. This standpoint identifies technologies as only one part of a complex ecological system supporting young children's learning. From this perspective, digital play is not reified as the goal for contemporary play, but rather it describes "how play experiences are being re-imagined in early childhood" (Arnott, 2016, p. 271). Arnott's argument raises three important points. Firstly, the use of technologies should not be considered omnipotent or deterministic as they are to be used, as children want to use them. Secondly, play with digital technologies is not to be viewed as a unique form of play but rather a component of everyday play. Thirdly, their appropriateness needs always to be considered as part of the broader ecological system.

Finally, our view on the role of digital technology and play is slightly different. We outline this view in full in Lowrie & Larkin (2019). In brief, we avoid the use of the word digital as we think it limits the opportunities for more holistic play when the focus is too heavily placed on the digital and less on the play. We tend to follow the lead of Arnott in our conception of the STEM apps we have designed being available for children to play with when they choose, much like they can choose to play with objects on the craft table or in the construction corner.

Role of Early Childhood Educators

Both in the literature, and anecdotally in our work with nearly five hundred preschool educators across Australia, it is clear that there is a need for further professional development in the use of tablets to support STEM. As with any activities involving educators, their attitudes and beliefs towards the use of technology are impacted by factors such as training and education, social economic status, and age. It is likely the case that early childhood educators received little preparation for using technology and thus may find it difficult to apply it appropriately within their pedagogical repertoire. This has flow on effects to the children in their care as "children's access to technology is ''contingent upon teachers' skills in using and integrating technology" (Vaughan & Beers, 2017, p. 322). Yelland and Gilbert (2014) suggest that these limitations can be rectified with professional development opportunities that: allow teachers to work collaboratively in designing pedagogical repertoires for the use of tablets; recognise the multimodal quality of tablets use in their centres; demonstrate the transformative nature of tablet use in modifying or redefining current practices; and promote new ways of thinking about multimodal learning to facilitate a range of STEM skills young people require in today's (and tomorrow's) society.

Conclusion

In this paper we have briefly examined existing research on the role and nature of digital technology, primarily tablets, in Preschools to support STEM learning. The majority of the literature points to overwhelmingly positive outcomes for young children when digital technologies, especially tablets and apps, are thoughtfully used in play based and intentional learning contexts to develop STEM concepts. However, despite this, many of the early childhood teachers in our pilot reported initial concerns regarding STEM, and the place of tablets in supporting children's learning in STEM. Our experience indicates that, once our pilot educators had completed workshops with us, they developed a sophisticated understanding of the role and nature of digital technologies, in play based learning.

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Early Learning STEM Australia (ELSA): The Policy and Practice(s) of Engagement in the Early Years

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The Early Learning STEM Australia (ELSA) pilot was a year-long investigation involving 300 educators and 4 500 four-year old children in one hundred learning centres across Australia. This paper reports on a pedagogical and design framework that was constructed to promote children's STEM engagement across digital and non-digital learning environments. This paper describes this process in terms of a heuristic; since the educators in the study became part of the design team as they modified and adapted the activities developed by our team. The heuristic helped the educators modify and adapt the learning experiences to accommodate the diverse cultural and social needs of the students.

The challenges of scaling and sustaining large-scale Government initiatives are profound—since most projects whither once funding ceases (Lowrie, Downes & Leonard, 2017). The ELSA pilot encountered two compelling constructs that heightened scalability and sustainability challenges in particular, namely: (1) science, technology, engineering and mathematics (STEM) needed to be defined in ways that promoted play-based engagement and enacted with such authenticity as to ensure highly diverse communities would remain engaged; and (2) learning opportunities could not rely of digital resources despite the fact the program required the development (only) of six learning apps that could be accessed through tablets.

With respect to defining STEM, our thinking was to not only improve educational practice but also provide a shift in educational purpose. Nevertheless, as English (2017) maintained, there are diverse ideas and opinions on what STEM should be and look like. Elsewhere we provide a justification for why STEM should not be limited to the four discipline areas that form the acronym (Lowrie, Leonard & Fitzgerald, 2018). As such, we see learning opportunities that focus on discipline integration, "real world" thinking and design thinking as both limiting and problematic. Rather, we focus on the *practices* (those ideas, methods and values) that manifest as STEM engagement— whether through engineering, technology, architecture or even surfboard design.

In relation to the development of digital resources, we understood the necessity of limiting children's screen time and to avoid an over reliance on the use of the digital resources. Moreover, alignment of STEM engagement to the principles and foundations of the Early Years Learning Framework (EYLF, Australian Government, 2009) was essential—consequently, digital engagement needed to be play-based and not merely associated with isolated game play or practise. To this point, the learning apps needed to be both part of an overall learning program and abreast of the spontaneous leaning environments that naturally occur in these preschool settings.

The capacity for educators to operate within a STEM Practices framework (see Lowrie et al., 2018, for details of the framework) was ambitious, however we felt that such an approach would be more productive than the hit-or-miss approach that could have eventuated in trying to find "authentic contexts" relevant or engaging to the students. After all, the hundred learning centres were distributed Australia wide across a diverse range of early learning contexts. These Practice *ideas* (e.g., problem finding, exploring and challenging), *methods* (e.g., using tools to produce artefacts, encoding and decoding information), and *values* (e.g., curiosity, creativity) needed to be promoted within a connected set of play-based and intentional-teaching experiences in both on-app and off-app engagement.

A New Pedagogical Heuristic: Experience, Represent, Apply

The STEM Practice Framework introduced new content knowledge for the educators. It was also the case that most of the educators had not considered the role and nature of STEM engagement within the EYLF. This was unsurprising given the fact that the EYLF focused on literacy and numeracy understandings—the advent of STEM in the early years being a more recent educational phenomenon.

Although most of the teachers and educators we work with understood what STEM practices are about after the delivery of workshops across Australia, the implementation of the practices within a play-based learning environment remained challenging. To operationalise the links between the STEM framework we developed the "experience, represent, apply" (ERA) heuristic, provided scope for the sequencing of play-based activities and placement of digital experiences. The heuristic was derived from a school-based pedagogical model proposed by Lowrie and Patahuddin (2015), which described a way of designing learning opportunities through a process that mirrored typical concept development. The ERA heuristic was developed to assist educators to focus on engaging students in the use of STEM practices through the enactment of practices they can perceive to be authentic.

The ERA heuristic encouraged designers (our team) and educators to create learning activities that use or enact forms of STEM practices in the context of realistic real-world situations. The three stages of the design are cyclic in nature, with each phase developing children's understandings within a framework that includes digital experiences within the learning design.

Experience. Children's lived experiences are used as the foundation for concept development through social engagement and language. Children participate in a range of play-based, off-app experiences that provide opportunities for them to use language in ways that connect personal experiences with new understandings. The experience phase encourages the use of concrete artefacts and hands-on engagement.

Represent. Children engage with activities on the apps with affordances that represent STEM concepts in different ways. These representations include creating images, interpreting pictures, visualising and using symbols. Children have opportunities to create their own representations to use within the apps via the microphone and camera tools. Importantly, the digital affordances provide opportunities that are not able to be replicated effectively without digital tools. To this point, we maintained that activities that could be developed easily off app should not be replicated digitally.

Apply. Children build on their learning from the on-app activities through a range of off-app activities, guided by their educators and their families. Engagement with the visual and symbolic representations on the app also promoted new child-centred play-based experiences.

By way of example, in the *experience* phase children might copy a pattern from a story book stimulus read by the educator that describes patterns in nature. They might then collect some objects (e.g., Lego blocks or leaves) and create a pattern which they describe to another child. They *represent* such patterns (eg., an A-A-B pattern) on the tablet by taking photos of objects, which are captured in the app. The machine leaning within the app provides opportunities for scaffolded development of pattern sequences. In the *apply* phase, children create patterns that are drawn from their own story.

Active engagement with the app is restricted to the *represent* component of the learning design. The "experience' activities are intended to establish understanding, as well as encourage play-based curiosity to use the apps. The "apply" component of STEM Practices are similarly important, since the children are likely to disengage with the digital resources at any time, of their own choosing.

Complementary Methodologies: Iterative Pedagogies and Agile Digital Approaches in Practice

The STEM Practices Framework and the ERA heuristic have now been used extensively in both app design and piloting during the first year of the nation-wide ELSA project. The design phase for the ELSA program included our team (as pedagogical and content experts) and digital game developers and coders. The iterative methodology employed by the pedagogical team and the agile approach of the digital team provided opportunities for numerous mini-trials in learning centres as activities within the three elements of the heuristic were developed. As off-app and on-app activities moved from Alpha to Gold implementation, a second iteration of the design process occurred—with educators from the pilot sites being engaged as co-designers of the *experience* and *apply* activities that "bookended" the *represent* activities that were contained within the apps. In this sense, professional learning was ongoing, with educators challenged to modify and adapt "E" and "A" elements of the heuristic to produce learning activities that both (1) satisfied the tenants of the STEM Practices framework and (2) were abreast of the contextual and cultural nuances of their respective centres.

An analysis of the products of these educator "second waves" of iteration highlighted the functionality of the model since it afforded sufficient conceptual and pedagogic structure for educators to design complex and effective learning activities despite the content demands of understanding STEM concepts. To this point, the heuristic has provided us with an alternative to teaching content first—an approach that would simply not work at scale. Instead, the project has progressed through design discussions around the two parts of the model. The second ELSA app, for example, is associated with the spatial concepts of location and arrangement. Spatial concepts have a strong association with STEM engagement (Uttal, et. al., 2013) and can be developed rapidly within well-designed intervention programs (Lowrie, Logan, Harris & Hegarty, 2018). The ERA heuristic has provided a vehicle for educators to understand how to discuss the concepts associated with location and arrangement with educators as agents. These practices include the positional language, orientation and perspective taking.

One of the *experience* activities we designed for the development of location and arrangement understandings involved immersion with a book stimulus (see Figure 1a) written by members of our team (Simoncini, Logan & Kawka, 2018). The book promoted spatial language with a STEM Practice lens that involved children developing ideas (designing and building), methods (decoding and encoding information) and values (creativity, teamwork) through the lens of a STEM Practitioner (in this case, an architect). The *represent* activities included on-app experiences requiring children to solve perspective taking challenges (see Figure 1b). One educator was able to use the STEM Practices Framework and ERA heuristic to generate an authentic and contextually-rich application activity that captured the children's engagement with these STEM understandings. The educator's *apply* phase included the design and construction of a story book that featured all the spatial language and representations they had encountered throughout the term. Noteworthy, the story book had a strong STEM Practices theme associated with the challenges of understanding where a possum was hiding within the confines of the learning centre (see Figure 1c).

a b c

Figure 1. A Book Stimulus (a), App Activity (b) and Student Generated Book (c) Representing the Heuristic Nature of the ERA Process

Conclusions

The ERA heuristic provided educators with a sense of agency as they developed their understanding of STEM. Many of the educators were able to adapt and modify the experience and application activities we had developed in order to heighten authenticity and contextual appropriateness. At the same time, the heuristic was critical to the implementation success of the program since it provided the pedagogical team and the digital team with an approach to align the iterative nature of the pedagogic design to the agile digital development required for app production.

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The ERA heuristic in action: Observations from the ELSA pilot.

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The Experience, Represent, Apply (ERA) heuristic is an innovation of the Early Learning STEM Australia (ELSA) project. It provided educators with an approach that embeds digital technologies in play-based learning in such a way that the focus of the learning remains on the child and not on the device. This paper reports on the experiences of early years educators and indicates that the ERA heuristic was instrumental in helping educators to integrate digital technologies in their everyday activities to promote engagement with STEM.

Despite an increasing body of research on the use of digital technologies in early childhood education (see Alade, Alexis, Beaudoin-Ryan, & Wartella, 2016; Edwards, 2016; Fleer, 2017; Lowrie & Larkin (2019 in review), Marsh, Plowman, Yamada-Rice, Bishop, & Scott, 2016), there is still uncertainty for educators surrounding the best way to implement these technologies in centres and preschools (Nuttall, Edwards, Mantilla, Grieshaber, & Woods, 2015). During the development of the Early Learning STEM Australia (ELSA) Pilot program, there was an identifiable need to assist early years educators as they incorporate digital technologies in a play-based environment to engage children in STEM activities. As such, the Experience, Represent and Apply (ERA) heuristic was developed. With the first-year pilot of the ELSA program complete, it is an ideal time to reflect on how the ERA heuristic was enacted within the project and how early years educators received it.

ERA Engagement with Two STEM Apps

The structure of the ELSA pilot delivered one children's app approximately every eight weeks, starting in mid-March 2018 with the first children's app and the educator app. The first children's app, Patterns and Relationships, included learning activities involving ordering, sorting, patterning and representing patterns in dance. The second children's app, Location and Arrangement, focused on position, location, arrangement and orientation. Along with the children's apps, educators in the pilot were provided with an educator app that included a range of activities, question prompts, and STEM Practices. The educator app was designed according to the ERA heuristic and structured in such a way as to support the STEM concepts developed within the children's apps. The Experience activities introduced children to the relevant STEM concept before they used the tablets. The Representation activities occurred on the device, with support for educators including question prompts to ask as children engaged with the digital learning activities. The Application activities were designed to build on the knowledge gained by the Experience and Represent activities, allowing children to further explore the concepts after they have played the app. At the beginning of the pilot it was unknown how the educators would react to the ERA heuristic, as the project team had not previously used the heuristic with early years educators. The following sections describe some of the student engagement data and educator feedback associated with the Patterns and Relationship app and the Location and Arrangement app. Engagement data was collected and uploaded to our database as the children used the device. Only children whose parents had provided permission for their data to be used were included. Educator feedback was collected through workshops, surveys and the community of practice (CoP) site.

ERA Through Children's Engagement Data

As per the ERA heuristic, the educators were encouraged to engage children in off-app *experience* activities before using the tablets. This engagement could be encouraged via a range of activities provided in the educator app or could come about through their own play-based provocations. Next, children played the digital apps, allowing them to *represent* their understanding of the various concepts introduced earlier. Finally, the educators prompted the children to complete further off-app activities (supplied or generated by the educators) to extend and *apply* the children's understanding. Figure 1 provides a chart of the children's engagement with apps 1 and 2 over a 28-week period. For both apps, the graph indicates a peak in the middle of the respective time periods, suggesting that the educators were not exposing children to the digital learning activities until a range of *experience* activities or provocations had been offered. The downward slope towards the end of each time period indicates that educators were bringing children off the apps to engage in *apply* activities in the centres. The data also indicates that app 1 remained in use even after the introduction of app 2. Figure 1 reinforces that the ERA heuristic was generally being followed by the pilot educators and that they were able to interpret and apply the ERA heuristic successfully.

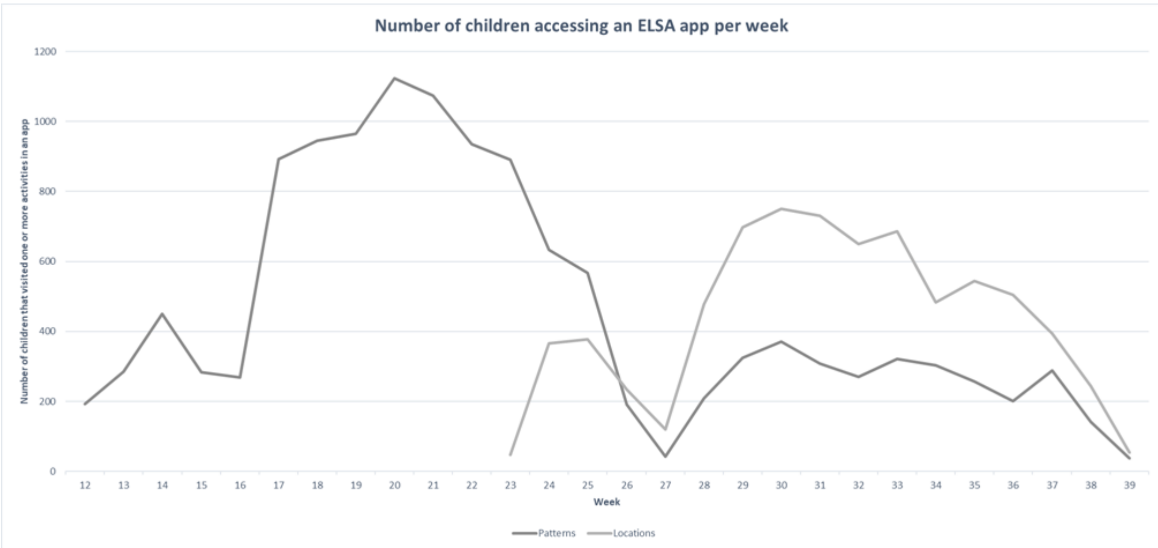

Figure 2. App 1 and app 2 child engagement data.

ERA Educator feedback and activities

Throughout the pilot, the ELSA team were interested in how the educators were implementing the ERA heuristic and the different sorts of activities and provocations they were using in their centres. Table 1 provides some of the themes that emerged from the feedback in relation to the ERA heuristic. An interesting finding for the ELSA team was the change in teaching practices that emerged as a consequence of educators following the ERA heuristic, particularly with regards to language use. Accompanying their feedback, educators often provided photos of activities the children had been engaged with, mostly the *experience* and *apply* activities. Figures 2a, 2b and 2c represent an example of the ERA activities respectively from app 1. It can be seen that children engaged with various patterning activities both off app and on app.

Table 1.
ERA themes from educator feedback and example quotes

Theme	Quotes from Educators
Connection to the ERA heuristic	iPad apps not the main focus Parents expressed concerns around their children spending lots of time on the iPads and apps, had to explain that the apps are only a bridge Love the apps, some more than others and we are working on developing the E and A support experiences as well as around the capacity of what the apps can do Extending from app is easy
Off-app activities	Off app concepts and ideas are supportive of what we are doing in the program I like the off-app suggestions - I work with three year old group so we use the off-app ELSA ideas Good introduction to off-app experiences
Changing in teaching	Gives structure/direction to teaching ELSA pilot has inspired a focus on explicit teaching - use of 'language' related to concepts Improve language (technical) We have been able to have more detailed discussions with the children during non-app experiences Fabulous shift in thinking, not a shift in doing Using the apps makes you think and recognise and focus more on the hands on STEM activities that you are participating in/planning for the children

Figure 2a. An E patterning activity with natural materials showing an AB pattern.

Figure 2b. Children playing the patterning game (R).

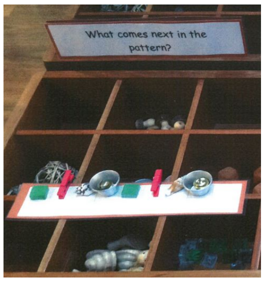

Figure 2c. An A patterning activity with an ABC pattern.

Figures 3a and 3b illustrate an "E" and "A" activity respectively for app 2, where children engaged with different types of maps and considered scale and direction.

Figure 3a. Children read a book and drew a map as part of an E activity.

Figure 3b. A 3D model of the zoo from the app as an A experience.

Conclusions

The ERA heuristic was a critical factor in the implementation of the ELSA project. The ELSA team was cognisant of the possible hesitation of the profession to include digital devices into their STEM play and learning (Palaiologou, 2016) and therefore our program design made explicit the link between digital engagement and more traditional play-based activities. As such, the ELSA apps were not designed to be stand-alone activities, played by individual children with no support. Rather they were part of a package that incorporated the ERA heuristic, where the on app activities built on previous off app experiences and led to further off app activities. The data presented here highlights that the ERA heuristic was well understood and appreciated by the pilot educators, especially as they reflected on their own teaching practice. Further studies could investigate the heuristic with other digital programs.

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