Research linking digital technologies to young children's creativity: An interpretive framework and systematic review

Katie Fielding and Karen Murcia
Curtin University, Australia

Creativity and technology are two vital elements of 21st century learning. Increasingly, educational policies internationally are acknowledging the importance of developing children's problem solving, innovation and computational thinking skills. It is also clear that children are spending more time accessing digital technologies both at home and in educational settings. However, little research has been conducted which focuses on the intersection of young children (4 to 8 years), digital technologies, and the development of creativity. In order to identify empirical evidence of how digital technologies impact the demonstration and development of young children's creativity, a systematic review of the literature was carried out, with 19 studies meeting the review's inclusion criteria. Each of the studies was then analysed using a lens that made explicit the associated process skills and characteristics of young children's creative thinking and learning. Analysis of the identified studies through the '*A-E' of Creativity* framework (Murcia, et al., 2020) led to the conclusion that appropriately designed and used digital technologies could indeed provoke and facilitate young children's creativity. The predominance of particular devices, and emerging themes in relation to the affordances of the identified technologies, highlighted the importance of future research exploring quality learning design and digital pedagogies in early learning.

Introduction

Creativity and technology are fundamental elements of 21st century learning (Henriksen, Mishra & Fisser, 2016). Problem-solving and innovation are highly valued in an increasingly digital and globalised world, and formal education has an important role in developing these capabilities (Puccio, 2017). In March 2021, the *United Nations Convention on the Rights of the Child General Comment No. 25 (2021) on Children's rights in relation to the digital environment* (United Nations Committee on the Rights of the Child, 2021) was released, making clear that children have the right to take part meaningfully in their world, including the digital world, and that they must be given opportunities to develop the skills and understandings which allow them to do so. Digital literacy and creativity are two critical elements contributing to children's agency and positive engagement with the digitised world. The UNESCO *Transversal Competencies in Education Policy and Practice (Phase 1)* report (2015) noted that many Asia-Pacific jurisdictions had recently developed reforms or policy agendas which included "transversal competencies" (p. 5). As defined by the report, these explicitly include creativity as an example of critical and innovative thinking, and the report's findings suggest a prominent inclusion of the development of "creative and innovative thinking" in a majority of the policy and curriculum frameworks of this region (p. 13).

Despite evidence of some educator attitudes to the contrary (Bereczki & Kárpáti, 2018), creativity can and should be nurtured and developed (Craft, 2001). Conceptually framed by this literature, the study reported in this paper explored the impact of digitisation on young children's creativity. Consistent with UNESCO (2015) the study highlighted that the development of transversal competencies, including creativity and digital media and information literacy, should be regarded by governments worldwide as a core principle of all education policy and practice; including the early years of learning. Thus, there are overlapping imperatives for educators to develop young children's digital skills and their creativity.

Creativity and early childhood education

The conceptualisation of creativity has largely centred on two key approaches: the 'Four-C' model developed by Kaufman and Beghetto (2009) and the 'Four Ps' model described by Rhodes (1961). The way in which the Four-C model demonstrates a trajectory of creativity (Bereczki & Kárpáti, 2018) – from mini-c, through little-c and pro-C, to big-C – highlights that all people possess creative potential and that it is applicable in all contexts, making it particularly relevant to the consideration of creativity in early childhood. Rhodes' seminal discussion of the Four Ps of creativity (1961) is also highly relevant in understanding the creativity demonstrated and developed in young children. As Rhodes points out, there is much more to creativity than the final product: describing a child's finger-painting as a demonstration of creativity reduces it to only an observation of their feelings of freedom or disinhibition in its production (p. 306). Instead, creativity arises at the intersection of the person, the process, the press (sometimes, the 'place'), and the product.

The cross-contextual nature of creativity is particularly noteworthy in the context of education, where some studies have pointed towards an "art bias" (Runco, 2017, p. 76) wherein the assumption that creativity is the sole domain of The Arts often prevails. However, Gl□veanu's research presents an alternative view, suggesting that while many people believe that "all art is creative", the attitude that "all creativity is art" is less widespread (2014, p. 18). Irrespective of beliefs about the presence of creativity outside of The Arts, Kaufman and Beghetto's (2009) conceptualisation of creativity as being determined not by what it 'looks like' but rather the contextual value of the product is apt for this paper. In the context of creativity in early learning environments, observations of innovation and creative thinking might appear, superficially, to be different to that expected of adults; we might anticipate greater innovation or complexity in the person's thinking or approach as they mature. However, Craft's (2007) suggestion of conceptualising creativity as 'possibility thinking', or as the exploration of 'what would happen if…' allows us to see that observations of creativity in young children may be different in their products but not necessarily in their approach. Elaborating further, the products may be digital in nature or provoked and facilitated by digital technologies, but the process and characteristics of creative thinking are arguably the same.

Children and digital technologies

Marsh et al. (2019) suggested that children today live in a 'postdigital' world where the ubiquity of digital technologies means there is little purpose in differentiating between digital and non-digital. However, differences in many factors, such as care-giver attitudes and the availability of internet access mean that children do not have a universal experience of digital technologies (Early Childhood Australia, 2018). Edwards (2019) pointed to research suggesting that children from socio-economically advantaged backgrounds tend to engage more frequently in digital production whereas those from less advantaged backgrounds tend towards digital consumption. Work by researchers such as Bers et al. (2019) and Elkin et al. (2016) has demonstrated that children as young as 3 years can, in developmentally appropriate and supported settings, master skills and demonstrate problem solving abilities which allow activities such as the programming of robots.

The presence of digital technologies in the home is becoming highly normalised; international research shows that young children from diverse socio-economic and family backgrounds are engaging with them on a daily basis (Marsh et al., 2015; Kabali et al., 2015). Data collected by the Royal Children's Hospital Australian Child Health Poll (2017) reported that 17% of infants and toddlers (<3 years) and 36% of pre-schoolers (3 to <6 years) own a smartphone or tablet (p. 3). Furthermore, it found that on average, children aged up to 2 years engage in 14.2 hours per week of screen time at home, and for those aged between 2 and 6 years this was 25.9 hours per week (p. 2). The OECD (2020, p. 40) reported that in surveyed countries (England, Estonia, and the United States), an average of 83% of 5 year olds are using digital devices at least once a week; 42% are using them every day. This supports Yelland's (2011) contention that many young children arrive into early learning with a range of experiences and a keen interest in using technologies. When home-use is combined with potential use in early learning environments, it becomes clear that many young children spend significant time each day using digital technologies. Hence, developing an understanding of the way in which they can impact upon a particular aspect of children's development and learning is important.

The necessity of assisting children to develop digital literacy is clear. Article 11.A, paragraph 104, of the *United Nations Committee on the Rights of the Child General Comment No. 25 (2021)* (United Nations Committee on the Rights of the Child, 2021) contended that "states parties should ensure that digital literacy is taught in schools, as part of basic education curricula, from the preschool level and throughout all school years". While many guidelines for 'screen time' for young children focus on minimising daily exposure, Early Childhood Australia's *Statement on young children and digital technologies* (2018) acknowledged the many benefits of the presence of digital technologies and digital media in early learning settings, while addressing legitimate concerns and offering practical advice to educators. This approach acknowledges that digital technologies can be incorporated into early learning in thoughtful ways, and is important in addressing some of the concerns that are held by educators and parents. The perceived risks in using digital technologies should not be unduly weighted when considering them against the potential benefits and role of them in children's lives (Buchanan et al., 2019), and the biases of educators and caregivers must be reflected on when making decisions about their use (Office of the eSafety Commissioner, 2020).

Digital technologies impacting creativity

Much research has been conducted into the impact of digital technologies in various domains: how they might help to address particular problems, such as behaviour management (Cho et al., 2020; Kirkpatrick et al., 2020), the degrees to which they are useful in various learning areas (Young et al., 2018; Acker et al., 2015), and their potential application in early learning broadly (Kucirkova et al., 2014; George et al., 2020). While some key publications suggest that digital technologies can support children's creative practice (e.g., Marsh et al., 2015; Murcia et al., 2020) few studies have focused on the way that digital technologies can specifically impact the development and demonstration of creativity. Njenga and Fourie (2010) note that "educational research cannot cope with the speed at which technology is advancing" (p. 200), creating disconnection between the arrival of technology in educational settings and a clear understanding of its usefulness or appropriateness. Therefore, there is value in drawing together the findings of current research in order to build an understanding of what digital technologies may be able to offer in the early learning space.

The study

The aim of this study was to identify empirical research evidence of how digital technologies impact the demonstration and or development of young children's creativity. A rigorous systematic literature review was conducted to identify critical research in the field. This revealed limited research in this emerging area of importance to early years education. The identified research studies exploring young children's engagement with digital technologies were then subjected to detailed interrogation and analysis through a creativity framework.

Analytical tool: *The 'A-E' of creativity* framework

A thematic analysis of the research was guided by the 'process' component of Murcia et al.'s (2020) *The 'A to E' of creativity* (Figure 1). The framework provides a contemporary, empirically tested paradigm which operationalises creativity demonstrated by young children. The framework was developed by Murcia et al. (p. 1400) "to answer the question: What does children's creativity look like within an early childhood classroom?" and hence provides an apt lens through which to analyse the identified research. Some research suggests that though educators strive to provide opportunities to develop children's creativity, they often feel uncertain about what creativity 'looks like' and how to recognise it (Bereczki & Kárpáti, 2018). Murcia et al.'s framework provides a tool to assist with this. That the framework identifies behaviours that may be demonstrated by the child is important in being able to discern who is doing the creative thinking, thus differentiating between 'teaching creatively' and 'teaching for creativity'. Analysing the research using the framework provides an opportunity to identify the ways in which children may be manifesting their creativity while using a variety of digital technologies.

PROCESS: Characteristics of children's creative thinking				
AGENCY	BEING CURIOUS	CONNEC-TING	DARING	EXPERI MENTING
Displaying self-determination	Questioning	Making connections	Willing to be different	Trying out new ideas
Finding relevance and personal meaning	Wondering	Seeing patterns in ideas	Persisting when things get difficult	Playing with possibilities
Having a purpose	Imagining	Reflecting on what is and what could be	Learning from failure (resilience)	Investigating
Acting with autonomy	Exploring	Sharing with others	Tolerating uncertainty	Tinkering and adapting ideas
Demonstrating personal choice and freedom	Discovering	Combining ideas to form something new	Challenging assumptions	Using materials differently
Choosing to adjust and be agile	Engaging in "what if" thinking	Seeing different points of view	Putting ideas into action	Solving problems

Adapted from Murcia, Pepper, Joubert, Cross & Wilson (2020)

Figure 1: The 'A-E' of creativity framework: Process component

Systematic literature review

To locate the research to be analysed, a systematic literature review was conducted in March 2021. Database searches were carried out in the Educational Resources Information Centre (ERIC), PsychInfo (OVID), the Australian Education Research Theses Database, and ProQuest Dissertation and Theses Global, using the key words of *technology* ("digital technolog*" OR technolog* OR "information and communication technolog*" OR "ICT"), *creativity* (creative* OR "problem solving" OR innovat* OR "computational thinking") and *early childhood education* ("early learning" OR "early child*" OR nursery OR kinder* OR "primary school" OR child*). The researchers had access to subscriptions for the specific databases utilised which enabled advanced searches and more targeted outputs than alternatives such as Google Scholar. Issues of three key journals published between January 2010 and December 2020 (*Issues in Educational Research*, *Australasian Journal of Early Childhood*, and *Creativity Research Journal*) were also individually searched to draw out relevant research which may have been missed in database searches. Reference lists of three key pieces of research, that of Murcia et al. (2020), Behnamnia et al. (2020), and Marsh et al. (2015), and texts citing them, were consulted to source any potentially relevant studies not found through database searches.

The *Preferred items for systematic reviews and meta-analysis statement* (Moher et al., 2009), guided the screening process for articles and was carried out by one author. While it is preferable to have two people screen results, having one person do so is acceptable when methods and potential limitations are made transparent (Pham et al., 2016). While results were limited to those published in English between January 2010 and December 2020, location of research was not an exclusion criteria. Included texts were restricted to peer-reviewed journal articles and published Master and Doctoral dissertations and theses which reported on empirical research using any methodology. The content of the research was required to be focused on describing and exploring ways that digital technologies influence the development or demonstration of 4 to 8 year old children's creativity in early learning settings of any educational approach.

Using this search strategy, 2328 results were delivered. Duplicate entries (108) were removed from results and those remaining (2220) were screened by title and abstract. The full text of the remaining articles (116) was evaluated. Those containing ineligible content (56), populations (30), or language (1) were excluded, along with those where access to the text could not be gained (8) or the publication type did not fit the parameters (2). Consequently, a total of 19 studies remained for analysis.

Results

The research located through the systematic review process was coded in a number of ways which led to the following results. It should be noted, where a study included multiple characteristics, such as including participants of various ages or being carried out in multiple locations, each of these were coded separately and account for differences between totals in each table and the total of included texts.

Location of studies

A considerably higher volume of research occurring in Australia compared to other countries and regions was evident (Table 1), as well as a higher proportion of research from primarily English-speaking countries. However, this may be due to the limitation for inclusion of studies published in the English language, as well as the choices of databases searched. While specific conclusions about the dominance of Australian research in this area are not drawn, it is worthy of future exploration. Imbalance in the location of emerging research may also present an opportunity for investigating the manner in which country-specific policies may impact on the way creativity is considered in different education systems.

Table 1: Analysis of research: Study location

Region	Country	No. studies
Australia-Pacific (9)	Australia	8
	New Zealand	1
United Kingdom and British Isles (4)	England	2
	Scotland	1
	Jersey	1
North America (3)	United States	3
Europe (4)	Denmark	1
	Greece	1
	Norway	1
	Slovakia	1
Asia (1)	Ankara	1

Type of technology

Categorisation by technology type (Table 2) was based on the aspects of the technology being tested by the research. For example, where the movement of a tangible robot was programmed on a tablet, this was coded as tangible robotics only. Despite some discussion of a specific app being used, Yelland and Gilbert's (2017) research has been categorised as focused on tablets, as the key activities undertaken by participants relate to the use of the embedded camera rather than the app being used.

Table 2: Analysis of research: Technology type included in studies

Technology type	No. studies	Technology type	No. studies
Tangible robotics/coding	8	'Smart' toys	3
Virtual coding	5	Games-based learning	1
Tablets	1	Interactive Whiteboards	1
Desktop computers	1	3D printing	1

It is evident that tangible robotics and virtual coding are favoured in the research. Bers et al. (2016, 145-6) noted that these provide young children with opportunities to engage with "powerful ideas" relating to areas such as engineering and technology, as well as being a conduit to creativity in The Arts. Robotics and coding projects provide fertile ground for developing children's computational thinking skills as they incorporate experiences with systems, symbolic representations, and debugging (Bers et al., 2016). The iterative nature of many coding platforms, where children are implicitly encouraged to tinker with the code to reach their goal, makes them apt for self-directed learning (Rose et al., 2017, p. 301). The relative ease with which robotics and coding can be incorporated into early learning contexts may also account for interest in these technologies; popular tangible robots such as *Sphero* and *Bee-Bot* provide age-appropriate and reasonably low-cost opportunities for hands-on experience with robotics. Many virtual coding apps, such as *ScratchJr*, can be downloaded onto tablet devices without cost.

The absence of smart phones in the research is noteworthy given how visible and readily available they are in children's lives. The Australian Communications and Media Authority (2020) reported that in the 12 months to June 2020, 46% of Australian children aged 6 to 13 used a mobile phone, and 47% either owned or had access to one. Rideout and Robb (2019) found that by age 11, 53% of children in the United States of America have their own smart phone. With their wide range of uses outside of making calls, and children's likely familiarity with such devices, smart phones seem to be under-represented in the research and present an avenue for future exploration.

Year of publication

Analysis of the year of publication suggests that interest in the relationship between digital technologies and young children's creativity may be rising. However, considering that the review encompassed research over a 10 year period, relatively few studies have been conducted at all. In most years between 2010 and 2020, no more than 2 studies fitting the criteria were published annually, and in some years none at all. A sharp rise in 2020 (5 studies) compared with previous years may suggest that this area of research is beginning to gain traction amongst researchers.

Educational context

The high number of studies involving children between 4 and 6 years (Table 3), and those in early learning centres and kindergartens (Table 4), is of note in light of the proposition of the OECD (2020) that children's lifelong well-being is greatly influenced by their experiences and learning in early childhood, that "starting behind means staying behind" (p. 26). While there is an overall lack of research being conducted in this space, it is heartening to observe that those studies which are being conducted are focused on this important developmental time.

Table 3: Analysis of research: Age of participants included in studies

Age (years) of participants	Number of studies
3	4
4	11
5	10
6	10
7	5
8	3

Note. The age of children in any given early learning context may not be confined to a single year, and naming conventions for early learning contexts are not consistent internationally. Hence, this table describes the frequency of specific age groups included in the identified research.

Table 4: Analysis of research: Early learning context of studies (author described)

Educational context	Number of studies
Early learning centre	5
Kindergarten	9
Preschool	1
Primary school	7
Library	1

Curriculum context

As the use of digital technologies in the included studies often takes a cross-curricular approach, it has not been separately coded according to discipline. The research collected clearly demonstrates that the creativity developing through the use of digital technologies need not be limited to particular learning areas. Examples of digital technologies being used in writing, art-making, science, and mathematics demonstrate that they are not limited in their application across the curriculum.

Research methodology

A variety of research methodology has been used in the identified studies, though qualitative methods dominate (Table 5). In studies which employed only quantitative methods (Bers et al., 2014; Kara et al., 2013; Rose et al., 2017), connections between measurable behaviours and creativity were sought. Rose et al. (2017) measured non-verbal reasoning test scores, and the number of individual moves, overall attempts, and time required for children to succeed in a virtual coding task to draw conclusions about computational thinking. Bers et al. (2014) used 6-point Likert scales to assess children's success in applying computational thinking concepts to robotics programming. With two exceptions (Brooks & Brooks, 2014, n=125; Forbes et al., 2020, n=576), qualitative studies involved small groups of children or cases (average=20), allowing for observational approaches. Quantitative studies tended to include higher numbers of participants (average=61).

Table 5: Analysis of research: Methodology

Methodology	Frequency
Quantitative	3
Qualitative	12
Mixed methods	4

Thematic analysis

The A-E characteristics of Murcia et al.'s (2020) framework which were identified in each study are indicated in Table 6. To be clear, the authors of these studies, with the exception of Murcia et al., did not themselves apply this framework to their results. In all but two studies, the researchers provided evidence which suggests that digital technologies can facilitate the development and demonstration of young children's creativity.

Brečka and Červeňanská (2016) found no statistically significant difference between the post-test measures of creativity of the control and experimental groups in their study. Therefore, they could not consider their hypothesis, that "[the intervention using interactive whiteboards]…positively influences the development of pre-school children's creative abilities as a sign of their motivation" (p. 1614), to be proven. However, they did conclude that interactive whiteboards were significant motivators for engagement. Similarly, while Kara et al. (2013) found that the 'smart' toy used in their study did have a positive impact on creativity (imaginative objects produced) their paper did not provide evidence which could be analysed using Murcia et al.'s framework.

Agency

Many of the studies analysed provide evidence that digital technologies give children the chance to demonstrate agency. Ellison and Drew's (2020) research using *Minecraft* showed how digital game-based learning can enable children to *find personal meaning and relevance* in a task they might otherwise find tedious and meaningless, and to find a space to make their ideas concrete (albeit in a virtual environment). Opportunities to make personal connections and find relevance are often described when children are engaged in inquiry-driven activities being facilitated or enhanced with digital technologies (Berson et al., 2019; Murcia et al., 2020).

Table 6: Overview of analysis using The 'A-E' of creativity in early childhood framework

Study	No. participants	Age (yrs)	Study focus	*Children demonstrate…* A	B	C	D	E
			A: Agency; B: Being curious; C: Connecting; D: Daring; E: Experimenting					
Bers et al. (2014)	53	4-6	Examines the feasibility of a tangible robotics program. Describes how the implementation impacted upon children's computational thinking abilities.	✓		✓		✓
Berson et al. (2019)	2 cases	3-4	Describes how tangible robotics used in two preschools facilitated collaboration, problem solving, and multidisciplinary engagement.	✓	✓	✓	✓	✓
Blakemore (2017)	722	6-7	Examines the implications of developing a computer programming initiative on enhancing children's problem solving and computational thinking abilities.			✓		
Brečka & Červeňaská (2016)	44	4-6	Investigates the impact of interactive whiteboards on children's technical skills acquisition and the influence on their creative skills (as a sign of their motivation). Creative skills were measured using a pre- and post-test protocol, using 'Urban's figural test of creative thinking (TSD-Z)'.					
Brooks & Brooks (2014)	125	3-5	Analyses children's interaction with KidSmart furniture focusing on affordances for digital creativity potentials and play values.			✓		
Burleson et al. (2018)	9	6	Investigates the affordances offered by a tangible vs. virtual programming space, particularly in terms of 'just in time' programming.		✓	✓		✓
Ellison & Drew (2020)	12	7-8	Reports on an intervention aimed at exploring the how 'sandbox' style games may aid boys' development of creativity in writing.	✓		✓		
Falloon (2016)	32	5-6	Investigates the types of thinking young children employ when undertaking computational tasks using *ScratchJr*.		✓	✓		✓
Fessakis et al. (2013)	10	5-6	Investigates children's problem solving while using two programming environments.		✓		✓	✓
Forbes et al. (2020)	576	5-8	Explores the nature of students' learning and processes in technology-enhanced makerspaces, focusing on 3D design and printing.	✓		✓	✓	✓
Kara et al. (2013)	90	4-6	Investigates how playing with a 'smart' toy impacts children's creativity.					

Study	No. participants	Age (yrs)	Study focus	*Children demonstrate…*				
				A	B	C	D	E
			A: Agency; B: Being curious; C: Connecting; D: Daring; E: Experimenting					
Kewalramani et al. (2020a)	40	4-5	Presents findings about how 'Internet of Toys' can influence children's interactions.		✓			✓
Kewalramani et al. (2020b)	17	4-5	Presents findings from a small case study considering how tangible robotics can develop children's cognitive capacities, including creative thinking.			✓	✓	✓
Murcia et al. (2020)	8	3-4	Investigates how children's creativity can be impacted by digital coding, and how that creativity can be effectively observed.	✓	✓	✓	✓	
Murcia & Tang (2019)	8	3-4	Documents the way that computational thinking is impacted by the use of tangible robotics.	✓	✓	✓		✓
Newhouse et al. (2017)	50	4-6	Reports on an exploratory study investigating how young children interact with tangible robots in a free-play setting.		✓		✓	
Portelance (2015)	42	7-8	Explores how ScratchJr provides opportunities for computational thinking in early childhood classrooms.	✓		✓		
Rose et al. (2017)	40	6-7	Investigates the impact of using two different virtual programming interfaces on computational thinking.					✓
Yelland & Gilbert (2018)	49	4	Explores the potential for iPads to encourage exploration and reflection, investigating, and creating.	✓	✓			

In Yelland and Gilbert's (2017) study, the *iPad*'s inbuilt camera gave children the ability to *demonstrate personal choice and freedom* by allowing them to decide on the modality of image they would use in texts they were creating, as well as to personalise their photos by digitally drawing on them. The authors point out that without the tablets, the children would not have had such options. Other studies similarly noted that the affordances of digital technologies allowed children to make their own choices (Murcia et al., 2020; Murcia & Tang, 2019; Portelance, 2015). Berson et al.'s (2019) study engaged with the youngest participants but even they *acted with autonomy* when they were given the freedom to learn how to use their *Cubetto* robot without explicit teacher guidance. Children in Murcia et al.'s (2020) and Murcia and Tang's (2019) case studies were also able act with autonomy when they chose to create stories with their robots.

Bers et al. (2014) noted that children did not always solve problems or complete tasks in the intended manner. Some children *chose to adjust and be agile*, finding different paths to solutions or even changing goals to achieve success. While young children clearly need assistance in many instances – they sometimes lack the dexterity, reading skills, or foundational knowledge required to manage some devices (Burleson et al., 2018) – the studies demonstrate that we should not assume their age makes them incapable of completing tasks or that they need ongoing explicit teaching to engage meaningfully. In providing opportunities for young children to develop their creativity, there is a challenge in balancing appropriate and necessary scaffolding with allowing for agency and self-direction. Kewalramani, Palaiologou, Arnott and Dardanou (2020a, p. 205) highlighted the importance of responsive rather than instructive guidance from "competent others" such as peers or educators in enabling children to participate in creative opportunities. Newhouse et al. (2017) observed that children in their study were more motivated and engaged with the technology after a session of explicit scaffolding. Murcia and Tang (2019) saw that children were encouraged to use higher order cognition when educators were actively involved in facilitating inquiry and providing relevant scaffolds. The evidence from these studies suggests that with appropriate support, digital technologies can provide young children with opportunities for being autonomous, agile, and purposeful creators.

Being curious

Digital technologies can provide opportunities for young children to develop their creativity by providing a fertile environment for curiosity. Children in Falloon's (2016) study were *engaging in "what if" thinking* when they made predictions about what their *ScratchJr* code would do when activated. However, while this is an important step to be encouraged, Falloon suggested that a fixation on prediction seemed to slow down children's overall progress and recommended that it should be balanced with encouragement to take risks.

Using digital technologies as a prompt for discovering emerged in a number of the reviewed studies (Berson et al., 2019; Murcia et al. 2020; Murcia & Tang, 2019; Yelland & Gilbert, 2018). In using the technologies, children were engaged with diverse topics and were motivated to take steps to find out more such as by accessing websites for information, or searching *YouTube* to find time-lapse videos. While the digital technology being employed was not always itself used for investigation, it sparked enthusiasm and desire to know more.

Children in Yelland and Gilbert's (2018) study were *exploring* by recording a variety of sounds onto *iPads*. The use of the digital technology led them to search their environment for interesting noises they could find and make which could be recorded into their device. In Burleson et al.'s study, children were observed playing with coding commands "just to see what they do" (2018, p. 103). It is noteworthy that similar behaviours across studies have been interpreted differently depending on how the researchers have implicitly understood the idea of exploration. Observations of button-pressing in Newhouse et al.'s (2017) study of children engaging with *Bee-Bots* and *Spheros* were dismissed as being purposeless and random.

A variety of studies highlighted the way that young children are *imagining* when they use digital technologies. Some of the children in Newhouse et al.'s (2017, p. 8) groups had their *Bee-Bots* become loading trucks or tried to ride on them like a horse. In Kewalramani, Palaiologou, Arnott and Dardanou's (2020a) study, where 'smart' toys were used, some children imagined scenarios for their characters where the virtual and physical worlds converged. The children in Berson et al.'s (2019) study imagined stories and adventures that their *Cubetto* robot might have.

Connecting

Recurring across the research are examples of children *making connections* and *sharing with others,* particularly in peer-to-peer collaborations. Children in many studies (Brooks & Brooks, 2014; Burleson et al., 2016; Falloon, 2016; Fessakis et al., 2013; Forbes et al., 2020; Kewalramani, Palaiologou, Arnott & Dardanou, 2020a; Kewalramani, Palaiologou & Dardanou, 2020b; Murcia et al., 2020) collaborated with each other for decision making, ideas generation and troubleshooting. Even when not explicitly discussed, it was often implied that the use of the digital technologies led to this. Brooks and Brooks (2015) noted that the physical properties of the 'KidSmart' furniture they worked with (an IBM computer housed within 'Little Tykes' children's furniture), provided opportunities for collaboration. Sitting together on bench seating with a shared screen made it easy for them to offer suggestions and assist each other without educator intervention. The authors described more technologically proficient children acting as guides and supporters for those less able. The single mouse set-up led to self-monitored social 'rules' being implemented for turn-taking and sharing with minimal conflict.

Children were *seeing different points of view* when they manipulated their bodies (Murcia et al., 2020; Murcia & Tang, 2016) or used their imaginations (Blakemore, 2017) to understand concepts such as direction and measurement. By putting themselves in the position of a robot or sprite, children are seeing the world from someone (or something) else's perspective. The children in Portelance's (2015) study considered the perspectives of others when describing how users might interact with games and stories created with *ScratchJr*. Other children were *seeing patterns* by understanding sequencing to create programs incorporating conditionals and looping instructions, or when they succeeded in making code more efficient (Bers et al., 2014; Berson et al., 2019; Blakemore, 2017; Rose et al., 2017). Forbes et al. (2020) highlighted a child *reflecting on what is and what could be* when they linked their design and 3D printing of a hermit crab's home to how the technology could be used in future to address world housing problems.

Daring

Fessakis et al. (2013) and Kewalramani, Palaiologou and Dardanou (2020b) provided examples of children *willing to be different.* They persisted with suggesting their own solution to a problem even when others disagreed. However, the strongest themes of 'daring' arising was that using digital technologies gave children opportunities to develop their resilience by *learning from failure,* and *persisting when things get difficult*. Newhouse et al., (2017, p. 10) described observing a child persist for more than 15 minutes to achieve a particular self-imposed goal for their *Sphero*. Several studies describe children having to make multiple attempts to reach a solution or to complete an activity (Berson et al., 2019; Falloon, 2016; Kewalramani, Palaiologou & Dardanou, 2020b) even when they struggled with the task (Murcia et al., 2020). Forbes et al. (2020) described observations of developing resilience: children actively looked for errors when in the past they had been reluctant to expose such vulnerabilities. With the exception of Brooks and Brooks (2014) who implied that some children were not able to engage with the activity due to the large size of the mouse supplied, and Newhouse et al. (p. 6) noting that in one session some children lost interest in the activity and "only the more proficient children persisted", the studies did not explicitly describe children completely giving up when they were finding the task difficult.

Experimenting

Studies focusing on tangible robotics and virtual coding commonly note the presence of *tinkering* (Bers et al., 2014; Burleson et al., 2018; Falloon, 2016; Fessakis et al., 2013; Kewalramani, Palaiologou & Dardanou, 2020b; Rose et al., 2017), suggesting that these particular digital technologies lend themselves to such experimentation. Rose et al. (2017) suggested that the affordances of some digital technologies can lead to inapt problem solving strategies. In their study, *Scratch* and *ScratchJr* seemed to encourage children to take both bottom-up (designing components in isolation before linking them together) and top-down (beginning with the 'whole' and decomposing into individual components) programming approaches "to the extreme" (p. 302) by using excessive and redundant coding blocks to create their programs. While this solution may be sub-optimal, the results of experimentation should not be expected to always be 'right' or 'the best way'. A number of studies (Bers et al., 2014; Burleson et al., 2018; Falloon, 2016; Kewalramani, Palaiologou & Dardanou, 2020b) demonstrate that digital technologies allow for trial-and-error and debugging in order to *solve problems*.

Forbes et al. (2020) also mentioned that some children were finding and solving problems proactively rather than waiting for educator input. However, Rose et al.'s (2017) research does offer insight into the importance of examining the affordances of digital technologies for how they might provide opportunities for children to grow their creative thinking through purposeful experimentation. Falloon (2016, p. 589) observed that children in their study appeared to be engaging in surprisingly sophisticated thinking to solve problems. However, when the recorded audio was analysed, they concluded that this apparent willingness to experiment was actually caused by a lack of inclination to risk being wrong. While our analysis of the studies tends to take a positive view of behaviours (e.g., trial-and-error approaches are a legitimate, if not efficient, approach to problem solving), it is possible that these may be random attempts resulting from frustration or uncertainty (Fessakis et al., 2013). This highlights the importance for future research to include children in discussion of their processes to allow insight into their behaviour.

Limitations of the analysis

The analysis of the research has been informed by Murcia et al.'s (2020) *The 'A-E' of Creativity* framework which provides a structure for identifying young children's creative thinking and behaviour. However, this framework is being imposed on the data; that is, we are only able to interpret the evidence which has been provided in the published material. It is likely that analysis of primary data (e.g., viewing video and audio recordings; involvement with in-person observations) would enable richer analysis of children's demonstration and development of creativity. For example, Rose et al.'s (2017) research lends itself to providing evidence only in the 'experimenting' domain but this is likely due to the researchers' focus on comparing two virtual coding platforms rather than on observing creative thinking behaviours more broadly.

The analysis conducted for this paper has focused specifically on the 'process' component of creativity. Other aspects of creativity (i.e., the person, product and place) have not been explicitly considered. To an extent, the necessity of the creative product being 'fit for purpose' and 'original' have largely been assumed, and consideration of whose creative thinking is foregrounded (i.e., the child's or the educator's) has not been part of the paper's scope. However, across these studies is a recurring presence of the educator as facilitator and supporter, highlighting potential for research into their role in promoting children's creativity through digital technologies. Likewise, some studies (Brooks & Brooks, 2015; Rose et al., 2017) highlight the importance of evaluating the affordances of the tools being used to ensure that they provide opportunities for creativity to flourish.

The characteristics of children's creative thinking and doing which do appear in the evidence presented have been identified and analysed. Murcia et al.'s (2020) framework is not designed as a checklist to determine whether or not a specific example meets each of the Four-Ps criteria of creativity. It is instead a framework to assist in identifying the thinking and behaviours which characterise and provide opportunities for young children's creativity. In the research underpinning the development of the framework, the 'learning journey' used to inform Murcia et al.'s work demonstrated that creativity can be anywhere on a continuum from spontaneous to carefully planned, educator-led or child-led, collaborative or individual. Future research which may build on this analysis, and which would focus on primary evidence, could consider demonstrations and development of creativity related to place, person and product alongside process.

Discussion

Analysis of the research identified by the systematic review suggests there is evidence that digital technologies can facilitate the demonstration and development of young children's creativity. However, the evidence provided by these papers also points to a number of issues which need to be considered in order to ensure that the use of the technologies is conducive to such creativity. Firstly, the way educators understand creativity and how it will be demonstrated by young children is important. If children are expected to achieve a specific outcome, in a specific way, then examples of creativity may be overlooked. For example, trial-and-error approaches are often inefficient and may be assumed by observers to be random or purposeless (Newhouse et al., 2017). Conversely, assumptions may be made that a child's frequent attempts are as a result of being daring or experimentation when they may instead be due to a fear of being wrong or a sense of perfectionism (Falloon, 2016).This paradox highlights the value of consciously planning for and including children's perspectives in research seeking to understand their behaviour.

Secondly, the affordances of digital technologies should be considered. The ability for some technologies to function as several different tools (e.g., for a tablet to be a camera, an audio recorder, and a digital canvas) presents possibilities for educators to include them in a variety of ways and across the curriculum. Where cost may be an issue, digital technologies which can be utilised flexibly could be a consideration. Technologies which present opportunities for collaboration may be particularly apt in early learning settings and may alleviate some concerns about them interfering with children's social engagement. The bench seating described in Brooks and Brooks' (2015) research allowed children to work together on tasks and to establish social codes. However, the same technology was poorly suited to young children's hands due to the size of the mouse. Technologies such as *Cubetto* robots use large, colourful blocks to manually program the device. Such affordances may be better suited to young children than those which require virtual coding due to their developing dexterity, reading skills, and abilities to use unfamiliar programs or apps (Burleson et al., 2018). Hence, exploration of the physical characteristics of digital technologies, as well as their potential for varied uses, should be considered in order to provide the best opportunity for meaningful integration in children's creativity development.

Finally, digital technologies as conduits to creativity need to be thoughtfully and meaningfully integrated into early learning settings. While the inclusion of digital technologies may provide some inherent motivation and engagement, several studies analysed in this paper (Kewalramani, Palaiologou Arnott & Dardanou, 2020a; Murcia & Tang, 2019; Newhouse et al., 2017) noted that children get the most out of the opportunity when they are guided in intentional ways. Simply providing digital technologies with minimal scaffolding is unlikely to lead to scenarios where children are able to develop and demonstrate their creative potential.

Conclusion

The analysis of the research suggests that when accompanied by appropriate scaffolding and support, the inclusion of digital technologies in early learning settings provides opportunities for children to develop and demonstrate their emerging creativity. Given that the scope and context of each study analysed differed, it is not possible to make judgments as to whether any particular aspect of creativity is privileged or overlooked in the research, irrespective of what has been identified here. It is possible that aspects of creativity not identified through the analysis of the published results were in fact present but not reported on by the authors as they were not relevant to their research. It is also not possible (nor the purpose of this paper) to judge which digital technologies might be particularly useful in this context, though it is clear that the majority of research being undertaken focuses on tangible robotics and virtual coding.

To the extent to which it is possible to extrapolate, the studies analysed suggest there is evidence that digital technologies provide potential for children to demonstrate and develop their creativity. However, in the time period under consideration, little research has been conducted in this space and many opportunities exist to contribute further to what is known about quality digital pedagogies and how digital technologies may be harnessed to provide children with rich opportunities for creativity.

References

Acker, A., Nyland, B., & Niland, A. (2015). The relationship between children's learning through music and the use of technology. *Australian Journal of Music Education*, (1), 64-74. https://www.academia.edu/30427235/The_relationship_between_childrens_learning_through_music_and_the_use_of_technology.pdf

Australian Communications and Media Authority (2020). Kids and mobiles: How Australian children are using mobile phones. ACMA. https://www.acma.gov.au/publications/2020-12/report/kids-and-mobiles-how-australian-children-are-using-mobile-phones

Bereczki, E. O. & Kárpáti, A. (2018). Teachers' beliefs about creativity and its nurture: A systematic review of the recent literature. *Educational Research Review*, 23(February), 25-56. https://doi.org/10.1016/j.edurev.2017.10.003

Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. *Computers & Education*, 72(March), 145-157. https://doi.org/10.1016/j.compedu.2013.10.020

Bers, M. U., Gonzalez-Gonzalez, C. & Armas-Torres, M. B. (2019). Coding as a playground: Promoting positive learning experiences in childhood classrooms. *Computers & Education*, 138(September), 130-145. https://doi.org/10.1016/j.compedu.2019.04.013

Berson, I. R., Murcia, K., Berson, M. J., Damjanovic, V. & McSporran, V. (2019). Tangible digital play in Australian and U.S. preschools. *Kappa Delta Pi Record*, 55(2), 78-84. https://doi.org/10.1080/00228958.2019.1580986

Blakemore, L. (2017). Does teaching computer programming within Key Stage 1 of the primary curriculum enhance children's problem solving skills? EdD thesis, University of Sheffield, UK. https://etheses.whiterose.ac.uk/18410/ https://etheses.whiterose.ac.uk/18410/

Brečka, P. & Červeňanská, M. (2016). Research of technical knowledge and creativity development of children in pre-primary education through interactive whiteboard. *Education and Information Technologies*, 21(6), 1611-1637. https://doi.org/10.1007/s10639-015-9405-5

Brooks, E. P. & Brooks, A. L. (2014). Digital creativity: Children's playful mastery of technology. *Arts and Technology, Fourth International Conference, ArtsIT 2014*, Istanbul, Turkey, November 10-12 (pp. 116-127). https://doi.org/10.1007/978-3-319-18836-2

Buchanan, R., Southgate, E. & Smith, S. P. (2019). 'The whole world's watching really': Parental and educator perspectives on managing children's digital lives. *Global Studies of Childhood*, 9(2), 167-180. https://doi.org/10.1177/2043610619846351

Burleson, W. S., Harlow, D. B., Nilsen, K. J., Perlin, K., Freed, N., Jensen, C. N., Lahey, B., Lu, P. & Muldner, K. (2018). Active learning environments with robotic tangibles: Children's physical and virtual spatial programming experiences. *IEEE Transactions on Learning Technologies*, 11(1), 96-106. https://doi.org/10.1109/TLT.2017.2724031

Cho, V., Cumings Mansfield, K. & Claughton, J. (2020). The past and future technology in classroom management and school discipline: A systematic review. *Teaching and Teacher Education*, 90, article 103037. https://doi.org/10.1016/j.tate.2020.103037

Craft, A. (2001). Little c creativity. In A. Craft, B. Jeffrey & M. Leibling (Eds.), *Creativity in education* (pp. 45-61). Bloomsbury Publishing.

Department of Education, Employment and Workplace Relations (2009). *Belonging, being and becoming: The early years learning framework for Australia*. https://www.acecqa.gov.au/sites/default/files/2018-02/belonging_being_and_becoming_the_early_years_learning_framework_for_australia.pdf

Early Childhood Australia (2018). *Statement on young children and digital technologies*. Early Childhood Australia. https://doi.org/10.23965/ECA.001

Edwards, S. (2019). Digital play. In C. Donohue (Ed.), *Exploring key issues in early childhood technology: Evolving perspectives and innovative approaches* (pp. 55-62). Routledge. https://doi.org/10.4324/9780429457425

Elkin, M., Sullivan, A. & Bers, M. U. (2016). Programming with the KIBO robotics kit in preschool classrooms. *Interdisciplinary Journal of Practice, Theory, and Applied Research*, 33(3), 169-186. https://doi.org/10.1080/07380569.2016.1216251

Ellison, M. & Drew, C. (2020). Using digital sandbox gaming to improve creativity within boys' writing. *Journal of Research in Childhood Education*, 34(2), 277-287. https://doi.org/10.1080/02568543.2019.1675823

Falloon, G. (2016). An analysis of young students' thinking when completing basic coding tasks using Scratch Jnr. on the iPad. *Journal of Computer Assisted Learning*, 32(6), 576-593. https://doi.org/10.1111/jcal.12155

Fessakis, G., Gouli, E. & Mavroudi, E. (2013). Problem solving by 5-6 years old kindergarten children in a computer programming environment: A case study. *Computers & Education*, 63, 87-97. https://doi.org/10.1016/j.compedu.2012.11.016

Forbes, A., Falloon, G., Stevenson, M., Hatzigianni, M. & Bower, M. (2020). An analysis of the nature of young students' STEM learning in 3D technology-enhanced Makerspaces. *Early Education and Development*, 32(1), 172-187. https://doi.org/10.1080/10409289.2020.1781325

George, R., Howitt, C. & Oakley, G. (2020). Young children's use of an augmented reality sandbox to enhance spatial thinking. *Children's Geographies*, 18(2), 209-221. https://doi.org/10.1080/14733285.2019.1614533

Glăveanu, V. P. (2014). Revisiting the "art bias" in lay conceptions of creativity. *Creativity Research Journal*, 26(1), 11-20. https://doi.org/10.1080/10400419.2014.873656

Henriksen, D., Mishra, P. & Fisser, P. (2016). Infusing creativity and technology in 21st century education: A systemic view for change. *Journal of Educational Technology & Society*, 19(3), 27-37. http://www.jstor.org/stable/jeductechsoci.19.3.27

Kabali, H. K., Irigoyen, M. M., Nunez-Davis, R., Budacki, J. G., Mohanty, S. H., Leister, K. P. & Bonner, R. L. (2015). Exposure and use of mobile media devices by young children. *Pediatrics*, 136(6), 1044-1050. https://doi.org/10.1542/peds.2015-2151

Kara, N., Aydin, C. C. & Cagiltay, K. (2013). Investigating the activities of children toward a smart storytelling toy. *Educational Technology & Society*, 16(1), 28-43. https://www.jstor.org/stable/jeductechsoci.16.1.28

Kaufman, J. C. & Beghetto, R. A. (2009). Beyond big and little: The Four C model of creativity. *Review of General Psychology*, 13(1), 1-12. https://doi.org/10.1037/a0013688

Kewalramani, S., Palaiologou, I., Arnott, L. & Dardanou, M. (2020a). The integration of the Internet of toys in early childhood education: A platform for multi-layered interactions. *European Early Childhood Education Research Journal*, 28(2), 197-213. https://doi.org/10.1080/1350293X.2020.1735738

Kewalramani, S., Palaiologou, I. & Dardanou, M. (2020b). Children's engineering design thinking processes: The magic of the ROBOTS and the power of BLOCKS (Electronics). *EURASIA Journal of Mathematics, Science and Technology Education*, 16(3), 1-14. https://doi.org/10.29333/ejmste/113247

Kirkpatrick, M., Rivera, G. & Akers, J. (2020). Systematic review of behavioral interventions using digital technology to reduce problem behavior in the classroom. *Journal of Behavioral Education*, 1-25. https://doi.org/10.1007/s10864-020-09406-1

Kucirkova, N., Messer, D., Sheehy, K., & Fernández Panadero, C. (2014). Children's engagement with educational iPad apps: Insights from a Spanish classroom. *Computers & Education*, 71(February), 175-184. https://doi.org/10.1016/j.compedu.2013.10.003

Marsh, J., Plowman, L., Yamada-Rice, D., Bishop, J. C., Lahmer, J., Scott, F., Davenport, A., Davis, S., French, K., Piras, M., Thornhill, S., Robinson, P. & Winter, P. (2015). *Exploring play and creativity in pre-schoolers' use of apps: Final project report.* Technology and Play. https://researchonline.rca.ac.uk/4279/1/Component%201%20TAP_Final_Report.pdf

Marsh, J., Wood, E., Chesworth, L., Nisha, B., Nutbrown, B. & Olney, B. (2019). Makerspaces in early childhood education: Principles of pedagogy and practice. *Mind, Culture, and Activity*, 26(3), 221-233. https://doi.org/10.1080/10749039.2019.1655651

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G. The PRISMA Group (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med,* 6(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Murcia, K., Pepper, C., Joubert, M., Cross, E. & Wilson, S. (2020). A framework for identifying and developing children's creative thinking while coding with digital technologies. *Issues in Educational Research*, 20(4), 1395-1417. http://iier.org.au/iier30/murcia2.pdf

Murcia, K. & Tang, K.-S. (2019). Exploring the multimodality of young children's coding. *Australian Educational Computing*, 34(1), 1-15. http://journal.acce.edu.au/index.php/AEC/article/view/208/163

Newhouse, C. P., Cooper, M. & Cordery, Z. (2017). Programmable toys and free play in early childhood classrooms. *Australian Educational Computing*, 32(1), 1-14. https://ro.ecu.edu.au/ecuworkspost2013/3494

Njenga, J. K., & Fourie, L. C. H. (2010). The myths about e-learning in higher education. *British Journal of Educational Technology*, 41(2), 199-212. https://doi.org/10.1111/j.1467-8535.2008.00910.x

OECD (2020). *Early learning and child well-being: A study of five-year-olds in England, Estonia, and the United States.* OECD Publishing. https://doi.org/10.1787/3990407f-en

Office of the eSafety Commissioner (2020). Best practice framework for online safety education reports. Australian Government, Office of the eSafety Commissioner. https://www.esafety.gov.au/about-us/research/best-practice-framework-for-online-safety-education

Pham, M. T., Waddell, L., Rajić, A., Sargeant, J. M., Papadopoulos, A., & McEwen, S. A. (2016). Implications of applying methodological shortcuts to expedite systematic reviews: Three case studies using systematic reviews from agri-food public health. *Research Synthesis Methods*, 7(4), 433-446. https://doi.org/10.1002/jrsm.1215

Portelance, D. J. (2015). *Code and tell: An exploration of peer interviews and computational thinking with ScratchJr in the early childhood classroom*. MA thesis Tufts University, USA. https://sites.tufts.edu/devtech/files/2018/04/DPortelance_2015.pdf

Puccio, G. J. (2017). From the dawn of humanity to the 21st century: Creativity as an enduring survival skill. *Journal of Creative Behavior*, 51(4), 330-334. https://doi.org/10.1002/jocb.203

Rhodes, M. (1961). An analysis of creativity. *The Phi Delta Kappan*, 42(7), 305-310. https://www.jstor.org/stable/20342603

Rideout, V. & Robb, M. B. (2019). *The common sense census: Media use by tweens and teens, 2019*. Common Sense Media. https://www.commonsensemedia.org/sites/default/files/uploads/research/2019-census-8-to-18-full-report-updated.pdf

Rose, S. P., Habgood, M. P. J. & Jay, T. (2017). An exploration of the role of visual programming tools in the development of young children's computational thinking. *Electronic Journal of e-Learning*, 15(4), 297-309. https://files.eric.ed.gov/fulltext/EJ1154629.pdf

Royal Children's Hospital Australian Child Health Poll (2017). *Screen time and kids: What's happening in our homes?* Royal Children's Hospital Melbourne. http://www.rchpoll.org.au/wp-content/uploads/2017/06/ACHP-Poll7_Detailed-Report-June21.pdf

Runco, M. A. (2017). Creative interpretations of educational contradictions. In R. A. Beghetto & B. Sriraman (Eds.), *Creative contradictions in education* (pp.75-87). Springer International Publishing. https://doi.org/10.1007/978-3-319-21924-0_5

United Nations Committee on the Rights of the Child (2021). *General comment No. 25 (2021) on children's rights in relation to the digital environment.* https://tbinternet.ohchr.org/_layouts/15/treatybodyexternal/Download.aspx?symbolno=CRC/C/GC/25&Lang=en

UNESCO (United Nations Educational, Scientific and Cultural Organization) (2015). Transversal competencies in educational policy & practice. UNESCO. http://unesdoc.unesco.org/images/0023/002319/231907E.pdf

Yelland, N. (2011). Reconceptualising play and learning in the lives of young children. *Australasian Journal of Early Childhood*, 36(2), 4-12. https://doi.org/10.1177/183693911103600202

Yelland, N. & Gilbert, C. (2018). Transformative technologies and play in the early years: Using tablets for new learning. *Global Studies of Childhood*, 8(2), 152-161. https://doi.org/10.1177/2043610617734985

Young, J., Gorumek, F. & Hamilton, C. (2018). Technology effectiveness in the mathematics classroom: A systematic review of meta-analytic research. *Journal of Computers in Education*, 5(2), 133-148. https://doi.org/10.1007/s40692-018-0104-2

Katie Fielding *BA MEd* is a sessional academic in the Humanities Faculty, Curtin University, Western Australia. Her research focuses on how digital technologies are used by and with young children, particularly in the area of creativity development. She is a member of the Australian National Centre of Excellence for the Digital Child (https://www.digitalchild.org.au).
ORCID: https://orcid.org/0000-0002-6427-7856
Email: katie.fielding@curtin.edu.au

Karen Murcia *MEd PhD* is an Associate Professor in the School of Education, Curtin University, Western Australia. Her research interests include scientific literacy for citizenship, creativity and digital technologies, and STEM education leadership. She is a Chief Investigator with the Australian National Centre of Excellence for the Digital Child (https://www.digitalchild.org.au).
ORCID: https://orcid.org/0000-0002-1900-2781
Email: karen.murcia@curtin.edu.au

Please cite as: Fielding, K. & Murcia, K. (2022). Research linking digital technologies to young children's creativity: An interpretive framework and systematic review. *Issues in Educational Research*, 32(1), 105-125. http://www.iier.org.au/iier32/fielding.pdf