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Young Children's Engagement with Objects in Science Museums: A Rapid Evidence Assessment of Research

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Abstract This rapid evidence assessment (REA) of literature was conducted to aggregate knowledge about young children's engagement with objects in science museums. The review focuses on empirical studies published between 2000 and 2020 reporting on children in the age range from birth to eight years. Scrutiny of a final sample of 48 peer-reviewed papers indicated that certain museum object characteristics may arouse children's curiosity more than others. Children's interest in museum objects is enhanced and sustained by dialogical and collaborative activity with peers and adults, by sensory, emotional and cognitive engagement with objects, and by children having choice and freedom to explore museum spaces on their own terms. The review identifies there is limited evidence pertaining to children's visits to STEM museums and a need for theoretically robust empirical research with children, museum educators, teachers and parents from diverse communities.

INTRODUCTION

Science museums are the guardians of highly diverse and culturally significant collections of material and virtual objects which trace humankind's inventiveness over millennia, often including photographic, cinematographic and televisual technologies, artworks and archival material. With growing numbers of children visiting science museums annually over recent decades (SMG, 2019),

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museum professionals have become increasingly interested in how to design exhibition spaces and plan encounters that spark children's curiosity in STEM. Many science museums have developed interactive education spaces 'where all the family are welcome and learn together through play and hands-on activity' (Association for Children's Museums, 2015: 11). However, it has been argued that interactive science spaces focus on STEM concepts rather than STEM objects (Graham, 2011), which often continue to be displayed in ways that are 'devoid of readily accessible, culturally familiar links' for children (Anderson et al., 2002: 229).

Our initial search for literature on young children's engagement with objects in STEM museums found an increase over time in academic papers on museum education, but no systematic research reviews or robust research overviews on this specific topic. This Rapid Evidence Assessment (REA) was therefore undertaken to address the gap in knowledge. The REA was used to inform a collaborative empirical research project between the London Science Museum and the Helen Hamlyn Centre for Pedagogy (0–11 years) at the Institute of Education, UCL, exploring new approaches to spark young children's curiosity in STEM museum objects. A 'rapid' review of research was chosen to meet the time constraints of the first project phase, with initial results published in an open access report for museum and education professionals (Flewitt et al., 2019).

Here, we present more detail of our systematic review procedures, a summary of the theoretical and methodological landscapes represented in the REA sample and a synthesis of key findings. We conclude by recommending future directions for museum research, practice and policy.

METHODOLOGY

Following ethical approval from (the Institute of Education, UCL), this REA was undertaken to survey the landscape of empirical studies published in English that inform the research question 'How do young children aged 0–8 years engage with museum objects related to Science, Technology, Engineering and Maths (STEM)'? The REA adopts the International Council of Museums (ICOM, 2019, para. 1) definition of museums as 'democratising, inclusive and polyphonic spaces for critical dialogue about the pasts and the futures [that] hold artefacts and specimens in trust for society, safeguard diverse memories for future generations and guarantee equal rights and equal access to heritage for all people'.

To assist the review processes, we used EPPI-Reviewer software (Thomas et al., 2010) developed at the Evidence for Policy and Practice Information and Co-ordinating Centre (EPPI-Centre) to ensure the systematicity and transparency of review processes, including article selection, quality assessment and research reporting (Tricco et al., 2015; Varker et al., 2015).

We began by developing and piloting eligibility criteria with a sample of 10 studies and subsequently revised the criteria to resolve potential discrepancies (see Table 1). We then conducted a two-stage screening process: (1) We reviewed the titles and abstracts of all studies identified through

Table 1.
Eligibility and exclusion criteria

Aspects reported	Eligibility criteria	Exclusion criteria
Focus population	Broad age range 0–8 years	1. Not about children aged 0–8 years
Topic focus	Related to children's learning and experiences in museums, and how children interact with objects in museums	2. Not on topic 3. Not about objects/artifacts 4. Not about interaction/engagement
Setting	Studies that focussed on museums, galleries or centres that display STEM, art or natural history artifacts	5. Not about museums
Types of evidence	All types of research designs, excluding papers not peer-reviewed or not supported by empirical evidence. In some cases, we included papers where supporting research evidence was published in related papers from the same research project	6. Not empirical 7. Unsuitable resource type (Not academic peer-reviewed OR Books OR Masters Theses OR Conferences proceedings that are not reliably subject to rigorous academic scrutiny)
Publication date	Published during and after 2000	8. Published before 2000

database searches and excluded those which were clearly not relevant to the review or were duplicates; (2) We retrieved the full texts for all studies judged as meeting the eligibility criteria and all studies where there was insufficient detail in the title and abstract to inform decisions about eligibility.

We developed the search strategy iteratively by piloting search terms in six social science and education databases (Australian Education Index; British Education Index; ERIC (EBSCO); ERIC (ProQuest); SCOPUS; and Web of Science Social Sciences Citation Index), as well as Google and Google Scholar for relevant research published in English language. We inspected the studies identified, then revised and finalized the search strategy using the following free-text terms: museum AND (objects OR collections OR artifacts OR artifacts) AND (children OR young visitors OR young people OR students OR early childhood education OR nursery OR kindergarten). Our initial search for peer-reviewed academic publications reporting empirical research was undertaken in July 2019, supplemented by a second search in June 2020.

To assess the quality of qualitative studies, we used Critical Appraisal Skills Programme (CASP) (2018) and the Mixed Methods Appraisal Tool (MMAT) (Pluye et al. 2011) to assess quantitative studies. To ensure inter-rater agreement, a 15% study sample was independently assessed for quality, the findings from this were discussed as a team and procedures for applying the MMAT criteria were agreed. This led to a final sample of 48 papers that were judged to be high and medium quality (see Appendix 1). Information extracted from the data sample included study design (methods, participants, museum type, theoretical framing), study focus and key findings.

Following an iterative process, we developed, piloted and refined descriptive codes that captured themes emerging from the findings reported in each study. The resultant inductive coding framework had eight main categories, each with sub-categories (see Table 2). The main categories

Table 2.
Analytic coding framework

Domains	Coding details
Research methods	• Quantitative • Qualitative • Mixed • Review • Not applicable
Child age	• 0–8 years
Phase of education	• Early years education/early learning/preschool/EYFS • Primary/key stage 1 • Not specified
Type of museum	• Science museum/science learning centre • Art gallery/art museum • Natural history museum • Children's museum • Social history/national/regional museum • Classroom museum (pre-school/school setting) • Virtual • Multiple • Various/does not specify
Type of objects/artifacts	• Large • Familiar to children • Moving • Authentic • New/unfamiliar • Computer/technology
Learning area	• STEM/understanding the world • Arts • Humanities
Ways of displaying	• Part of a collection • Stand-alone (not part of a collection) • Contextualized • Decontextualised • Interactive/hands-on/immersive • Fixed • Open • Closed
Nature of interaction	• Solitary (child-environment) • Child-technology • Mobile phones/guides • iPads • Computer/computer simulations/3D& VR • Other • Child-people • Guided/explanatory • Scaffolded • Facilitated • Collaboration (pair/group) • Dialogic/questioning/enquiry • Child-led

included: study methods; child age; child phase of education; type of museum; type of objects/artifacts; learning area; ways of displaying; and nature of interactions. To maximize inter-rater agreement, a 20% sample was coded by two researchers and discrepancies were discussed, prior to coding the full sample with the aid of *EPPI-Reviewer* systematic review software. A narrative synthesis of the review findings was subsequently developed.

FINDINGS

A total of 3958 references were identified from databases and hand searches, of which 441 were removed as duplicates. These initial searches were not time-bound and identified potentially relevant peer-reviewed research dating back to the early 1900s (Rathmann, 1915). However, most papers were published 2000–2020. After consulting with our collaboration partners at London Science Museum, we decided to focus on this more recent research. 3017 references were excluded based on titles and abstracts and 360 full-text articles were assessed for eligibility. 285 papers were subsequently excluded following their assessment against the eligibility criteria, and a further 27 papers were excluded during quality screening, resulting in a total of 48 studies in the final REA sample (see Figure 1). 12 of these papers were published 2000–2009, 10 between 2010–2014, and 26 between 2015–2020, suggesting incremental growth of academic interest in this field over time.

Research Locations

All 48 papers in the REA reported on empirical studies conducted in countries categorized by the International Monetary Fund (IMF, 2020) as Advanced Economies. Most were undertaken in the USA (18 studies), Australia (9) and the UK (7). Four studies were conducted in New Zealand, three in Scandinavia (Denmark, Finland and Sweden); three in the Euro-region (Austria, Italy, Portugal), and one in Hong Kong. Three papers were reviews of international research. No medium- or high-quality studies were found that reported on countries categorized as emerging markets or developing economies (IMF, 2020). We recognize that our results are skewed towards papers published in English language.

Museum Types

Twelve papers reported on studies conducted in children's museums, 12 on studies across different museum types with STEM-related exhibits, six in national museums, six in natural history museums, five in art galleries/museums, four in interactive science centres, two in classroom museums created by children and one paper reported on a virtual museum. These diverse museum sites reflect the presence of STEM artifacts and exhibits in national and children's museums, and the diversity of authentic, facsimile, material and virtual artifacts that make up STEM collections, including works of art and artifacts from the natural sciences.

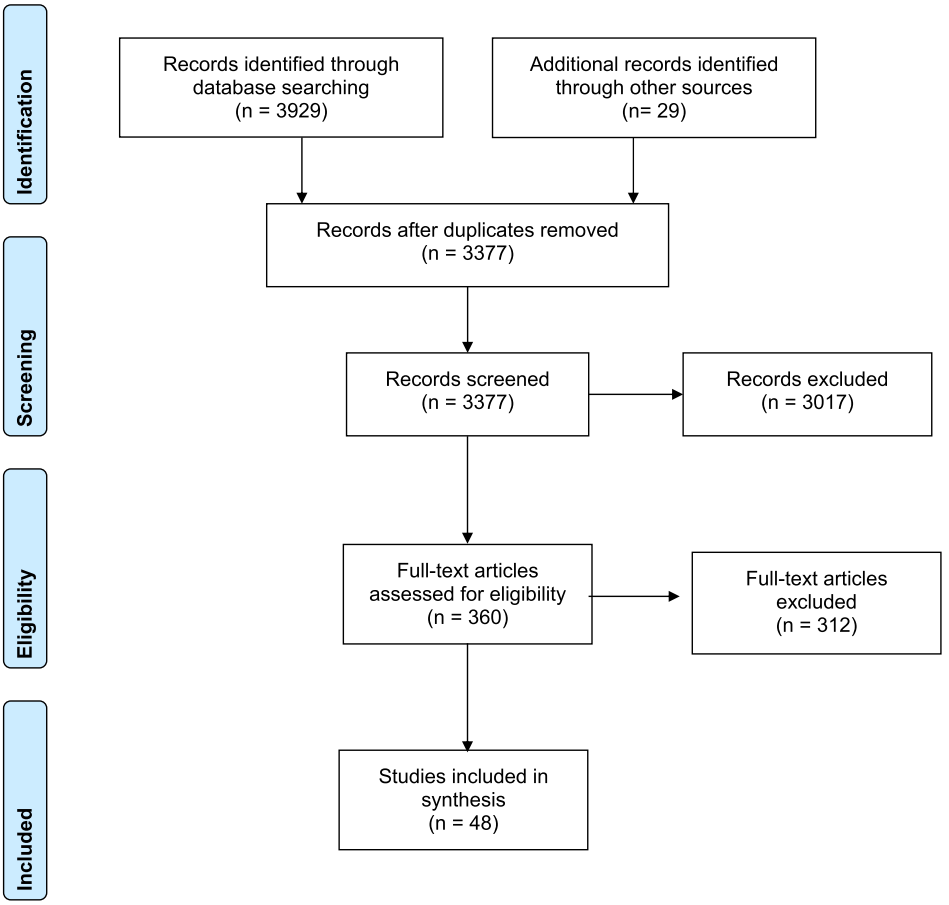

Figure 1. Flow of studies through the review.

Research Participants

We define research participants as all children and adults whose behaviors and views contributed to the evidence informing the REA papers. All the papers in our final sample reported on studies pertaining to children aged eight years or younger, their parents, school/nursery or museum educators. Most studies indicated child mean age or the age distribution of child participants, so it was often not possible to ascertain the precise age of participants within a sample. Some studies included older children as well as children from birth to age eight and relatively few studies reported more precise child participant ages.

Most studies in the REA sample ($n = 28$) focussed on family groups or parent–child dyads visiting museum spaces, and/or children visiting museums with their teachers ($n = 10$), sometimes also accompanied by parents whose views were reported. One study included children and college students, two studies presented primarily the views of museum educators and seven studies reported

young children's perspectives. Very few studies reported ethnic diversity in participant samples or included detail of the ethnic and social diversity of participant groups.

Research Designs and Disciplinary Approaches

Twenty-nine of the 48 papers reported on qualitative study designs: 20 employed ethnographic approaches, including case studies; seven adopted participatory research with children; and two involved action research with teachers or museum educators. Six further papers presented findings from qualitative studies supplemented by quantitative analysis. 10 papers reported on studies with quantitative research designs, using quasi-experimental or experimental research designs, with interventions that enabled comparisons to be made between different participant groups, before or after interventions or with control groups, or between different intervention strategies with the same participant groups. Three further papers presented reviews of research.

Whilst many studies in the REA drew on diverse disciplinary fields to inform their findings, we identified three dominant paradigms through which child engagement and learning in museums have been conceptualized in the literature: (1) cognitive and developmental psychology; (2) education and museum studies framed by sociocultural theorisation; and (3) an emerging field of research informed by posthuman theorisation that engages with the assemblages and entanglements between bodies, spaces and materiality (Ingold, 2004; Macrae et al., 2018). See Table 3 for a synopsis of the disciplinary and methodological orientations of the review papers.

We categorized fourteen papers in our database as informed primarily by cognitive and developmental psychology. Studies in this category focused on intrinsic characteristics of museum objects and demonstrable signs of children's engagement with objects as manifested through child talk, actions and/or length of time spent with exhibits. Ten papers employed quantitative research designs to focus on: children's perceptions of object authenticity (Frazier & Gelman, 2009; Bunce, 2016a, 2016b, 2019); parent–child joint attention on objects displayed in dioramas (Povis & Crowley, 2015); family/parent–child talk about objects in museum exhibits about dinosaur bones (Callanan et al., 2017), gear mechanisms (Willard et al., 2019), family talk and children's learning about STEM during a construction activity (Haden et al., 2014); object manipulation and parent–child talk (Jant et al., 2014); and children's problem-solving during different types of engineering instruction (Marcus et al., 2018). Three papers reported on mixed methods research designs to study: child-artifact and child-adult interaction (Braswell, 2012); shared scientific thinking as evidenced through talk about STEM exhibits (Crowley et al., 2001) and how museum signage about exhibits mediates family learning in museums (Kim et al., 2009). One paper in this category (Fletcher Tina et al., 2018) reported a qualitative study exploring the efficacy of sensory guides for young children with autism and sensory processing disorders.

Reflecting the turn towards 'new museology', where emphasis is placed on the purposes of museums, how museums are perceived by visitors, and on 'the meaning of museum objects as situated and

Table 3.
Disciplinary and methodological orientation of review sample

		Methodology					
					Qualitative		
Disciplinary and theoretical orientation	**Total no. of papers**	**Research review**	**Quantitative/ experimental/ quasi-experimental**	**Mixed qualitative and quantitative**	**Case study and/or ethnography**	**Action research**	**Participatory research**
Review of research across disciplines	**3**	3					
Cognitive and developmental psychology	**14**		10	3	1		
Education and museum studies informed by sociocultural theory and 'New Museology'	**26**			3	15	2	6
Education and environment studies underpinned by post-human theorisation of body, space and material assemblages	**5**				4		1
Total	**48**	**3**	**10**	**6**	**20**	**2**	**7**

contextual rather than inherent' (Macdonald, 2007: 2), papers from the fields of education and museum studies were informed primarily by sociocultural models of learning. These constituted more than half the studies in the REA sample ($n = 26$). Three papers reported studies with mixed methods investigating: observable learning in museum spaces (Puchner et al., 2001); how tinkering and conversational reflection can enhance young children's STEM learning (Pagano et al., 2019); and how online activities spark children's engagement with virtual and physical objects (Prosser & Eddisford, 2004). 23 further papers presented qualitative studies investigating how children and adults/peers construct learning together. Of these, 15 papers reported ethnographies and/or case studies of individual children or museum spaces (Anderson et al., 2002; Anderson et al., 2008; Carr et al., 2012; Carter, 2018; Degotardi et al., 2019; Della Croce et al., 2019; Dooley & Welch, 2014; Eckhoff, 2008; Faria et al., 2015; Letourneau et al., 2020; Lifschitz-Grant, 2018; McInnes & Elpidoforou, 2018; Piscitelli & Penfold, 2015; Rönkkö et al., 2016; Watson et al., 2002). Two papers reported action research with teachers and museum educators (Clarkin-Phillips et al., 2014, 2018). Six papers presented participatory research exploring young children's perspectives on museum visits (Dockett et al., 2011; Dunn & Wyver, 2019; Hope, 2018; Kelly et al., 2006; Piscitelli & Anderson, 2001; Wong & Piscitelli, 2019). The findings from many of the studies in this category focussed on talk-as-evidence of child learning, the nature of adult-child interaction, and adults'

role in child talk. That is, they prioritized cognition over affective and sensory dimensions of children's museum experiences.

By contrast, five papers turned to spatial theories and/or post-human ontology to conceptualize children's museum visits as sensory and embodied experiences (Carr et al., 2018; Hackett et al., 2018; Kelton et al., 2018; Larsen & Svabo, 2014; Wöhrer & Harrasser, 2011). Questioning what Latour (2004) refers to as the Great Divides that are assumed in humanist research, such as between humans and artifacts, this literature points to new ways of conceptualizing and designing museum spaces as social, material, embodied and sensory assemblages rather than as places of gazing (Larsen & Svabo, 2014) and to new ways of researching and theorizing children's museum visits, where 'the world is experienced through sensory entanglements, indivisible from the places that bodies inhabit' (Hackett et al., 2018, p. 489).

Findings from Reviews of Research

Our final sample of papers included three relevant reviews of research. The most recent review (Andre et al., 2017) interrogated 44 theoretical and empirical, cross-disciplinary papers published 1999–2012 and identified three salient museum interactivity types that support children's learning: child–adults/peers; child–technology and child–environment, a framework which they suggest offers a map for future research and for the design of educational museum programs and exhibitions.

Focusing on learning outcomes for children aged eight and under in museums, Munley (2012) reported on papers published 2000–2012 and concluded that learning in museums is not given the same attention as learning in preschools, so early childhood, policy and academic professionals should work together to develop shared goals for children's museum learning. Similar conclusions are reached by Griffin (2004), whose review homes in on a decade of research (early 1990s – early 2000s) reporting school group visits to museums and children's views about these visits.

Together, the findings of these reviews suggest that museums need to transform themselves from 'being about something to being for somebody' (Weil, 1999, p. 229) and that greater collaboration is needed between museum and school educators to enable children to have greater autonomy, more opportunities for sociality and fewer constraints placed on them as they explore museum spaces and artifacts.

Findings from Empirical Studies

Analytic synthesis of the 45 papers reporting empirical studies identified five salient factors that influence young children's engagement with STEM objects: (1) characteristics of museum objects; (2) connecting museum objects with children's lives, knowledge and interests; (3) sparking children's

curiosity in objects through interaction; (4) designing museum exhibits in ways that promote play and multisensory experiences; and (5) child agency during museum visits. These factors are now examined in turn.

Characteristics of museum objects

Findings from the REA papers suggest that although there is wide variation in individual children's 'favorite' objects (Clarkin-Phillips et al., 2014), certain object characteristics spark many children's curiosity and recall. These include objects that are: unusually large (Piscitelli & Anderson, 2001); small and displayed in object collections (Dockett et al., 2011; Kelly et al., 2006); authentic (Bunce, 2016a, 2016b); can be handled (Dockett et al., 2011; Lifschitz-Grant, 2018); and objects that are unfamiliar or familiar but displayed in unfamiliar contexts (Callanan et al., 2017). Young children are likely to perceive museums as places where they can see 'special things' (Piscitelli & Anderson, 2001: 278) and to revisit objects they are interested in each time they return to a museum, so the unfamiliar becomes familiar (Hackett et al., 2018). Participatory research with children draws attention to the significance of how museum objects and displays make children feel (Wong & Piscitelli, 2019) and how children enjoy and remember humorous objects and displays (Dockett et al., 2011).

Combinations of these object characteristics (e.g., large and unfamiliar; small and authentic; scary but amusing) are likely to prompt children's interest and recall, particularly if children have opportunity to interact with objects.

Connecting museum objects with children's lives

Children are often motivated to find out about objects that relate to their own knowledge, experience and interests (Anderson et al., 2008; Carter, 2018; Faria et al., 2015; Hope, 2018). Making connections between museum objects and children's lives helps bridge the gap between new and existing knowledge (Della Croce et al., 2019; Dockett et al., 2011), and children often remember familiar objects after museum visits, such as rainbows or robots (Carter, 2018). Familiar objects can help children to grasp unfamiliar concepts, for example, using popular videos and storybooks to help children understand number and data science concepts (Letourneau et al., 2020) and to learn about the concept of taxidermy in STEM museums (Bunce, 2016a). Pre- and post-visit activities, such as speculation about objects using replicas and images, can help to familiarize children with museum objects and enhance their curiosity (Jant et al., 2014), as does displaying objects in the context of larger narratives, such as dioramas (Carr et al., 2018; Piscitelli & Anderson, 2001).

Parents' unique knowledge about their children is particularly effective in prompting children's interest in museum exhibits as parents often relate objects to children's past experiences (Callanan et al., 2017; Dockett et al., 2011). Shared reminiscing prompts cognitive and language development, enriching children's familiarity with narrative and prompting autobiographical memory (Degotardi et al., 2019). Several studies report how stories, as familiar and enjoyable aspects of children's everyday culture, can be particularly effective in enhancing children's engagement, learning, and recall (Anderson et al., 2002; Hope, 2018), particularly if stories appeal to children's imagination and are

emotionally and physically engaging. Live, theater-based learning experiences prompt children's recall and description of the objects they encounter in museums (Andre et al., 2017), and children often make sense of unfamiliar museum artifacts by using their imagination to make up stories about them (Anderson et al., 2002; Dockett et al., 2011; Hope, 2018; Lifschitz-Grant, 2018).

Sparking children's curiosity in objects through interaction

Almost all the studies in our review drew attention to the importance of adult-child and peer interaction during museum visits, with analysis of interaction frequently focusing on talk and how adults scaffold child learning through conversation. Some studies adopted a broader view of interaction as guided participation (Rogoff, 1990) and emphasized the value of shared adult-child activity and co-enquiry. However, with very few exceptions (Carr et al., 2018), we found very little extant research investigating and valuing cultural diversity in modes of parenting and ways of interacting.

From the review literature, we identified the following ways in which adult-child talk supports children's learning in museums: to encourage young visitors to follow their own interests (Anderson et al., 2008; Della Croce et al., 2019); to model and explain new and technical vocabulary related to exhibits (Degotardi et al., 2019); to teach complex data science concepts and statistical learning through scaffolding, particularly when children gather data about museum objects of their choice (Letourneau et al., 2020) and when adults and children are actively engaged in co-enquiry (Marcus et al., 2018; Pagano et al., 2019); to scaffold child learning during hands-on activities, especially about 'simple cause-and-effect' relationships, concepts and processes and when it is clear to adult visitors what they can do to support children's learning (Puchner et al., 2001: 254).

In this respect, museum educators can successfully model how accompanying adults might support children's learning, for example through modeling praise (Lifschitz-Grant, 2018) and the language of evaluation and explanation (Crowley et al., 2001). Adult-child dialogue is reported as most effective when children have time to respond and contribute their own ideas (Callanan et al., 2017; Carr et al., 2018), when there is genuine reciprocity in the exchanges and when children are valued as experts in their own knowledge and interests (Clarkin-Phillips et al., 2018). As well as enjoying interacting with educators, peers and family members (Faria et al., 2015), young children enjoy learning from experts during museum trips, such as artists pointing out technical features in paintings (Dooley & Welch, 2014). Well-designed digital and virtual learning resources can also scaffold children's conceptual understanding of museum objects (Prosser & Eddisford, 2004).

Yet not all collaborations with adults are equally beneficial. Puchner et al. (2001) found that adult scaffolding led most frequently to low-complexity rather than higher-order child learning. Overly didactic adult explanations risk alienating children's interest (Callanan et al., 2017) and parents may need guidance on when to step back during co-enquiry (Willard et al., 2019). Conversely, when play is encouraged, some parents step back because they do not associate play with learning or are reluctant to play in public spaces (Degotardi et al., 2019).

Designing for play and multi-sensory experiences

Our analysis of empirical research found museum spaces must be welcoming for children, with accessible displays (Pagano et al., 2019; Piscitelli & Penfold, 2015) where children can handle objects through playful, kinaesthetic and multisensory experiences - by touching, hearing, seeing, smelling, and tasting (Anderson et al., 2002; Hope, 2018; Kelly et al., 2006; Rönkkö et al., 2016). Participatory research with children draws attention to how children value 'using their intellect and their senses (visual, kinesthetic, and auditory)' (Wong & Piscitelli, 2019: 425). Children's emotional, and multisensorial involvement promotes their deep engagement with objects, which in turn facilitates conceptual learning and recall (Alice, 2018; Lynda et al., 2006; Pagano et al., 2019; Roberta et al., 2019; Veronika & Doris, 2011). Joint adult-child sensory experiences often prompt exploratory talk about objects (Povis & Crowley, 2015) and sustained shared thinking (Degotardi et al., 2019).

Children's engagement with objects is sustained through interactive design features, such as: audio-visuals (buttons to press that make things happen) (Degotardi et al., 2019); exploring and making (Rönkkö et al., 2016); scientific experiments for children to conduct; recreating authentic objects using fabrics, paints, dressing-up clothes, construction blocks, mirrors, torches (Clarkin-Phillips et al., 2018; Letourneau et al., 2020; Piscitelli & Penfold, 2015) and playing with art objects (Lifschitz-Grant, 2018). However, some children want 'to explore the 'real' as well as the 'play' aspects of the museum' (Kelly et al., 2006: 6).

Digital technologies that offer rich opportunities for children's playful engagement with museum objects include: microscopes and remote controlled cameras (Dockett et al., 2011); digital photography (Larsen & Svabo, 2014); light boxes, webcams, and projectors (Piscitelli & Penfold, 2015); touch-screen devices presenting animated stories; interactive Mobile Guide Systems (MGS) with problem-solving quests, and using mobile phones to make pre-visit plans and track pathways through museum spaces (Andre et al., 2017).

Displays and exhibits that prompt children's embodied, fun and multi-sensory involvement with museum objects reflect new museology museum design, where children's curiosity, play, creativity and imagination are valued as core to their museum experience. Yet despite a growing emphasis on playful and multi-sensory experiences, the tropes of talk and learning remain strong across the literature. Exceptions to this tendency can be found in papers framed by post-human conceptualisations, which report on how children's imaginations are engaged through touch and sight, and how children, objects and places become entangled in silent ways during museum visits (Hackett et al., 2018).

Planning for playful and multi-sensory museum experiences may therefore entail a profound shift in what has traditionally been valued in museums, where looking but not touching has been the historical norm. As Larsen and Svabo (2014) suggest, multi-sensory design is needed to compensate for the 'separation of senses' that is typical in museum galleries. If touching precious objects is not an option, then museums can design displays to capture the haptic imagination, where the eye 'feels' without actual physical touch (Hackett et al., 2018). The review literature further suggests the need

to encourage accompanying adults to understand play as a process that is experimental, unpredictable and social, rather than an outcomes-driven pursuit (Piscitelli & Penfold, 2015).

Child agency

Participatory research has highlighted many young children's preference for space and time to explore museum spaces and exhibits on their own (Wong & Piscitelli, 2019). This aligns with observations that young children need freedom to explore museum spaces and to choose which objects they engage with (Griffin, 2004; Hope, 2018; Lifschitz-Grant, 2018; Piscitelli & Anderson, 2001). If free to roam, children often walk or run in seemingly random ways, but stop to gaze at exhibits before moving on (Watson et al., 2002). They develop walking patterns as they revisit museums, and these pathways become an important product and resource for their learning (Kelton et al., 2018). Over time, thickening lines of wayfaring, whether by children on their own or by families, lead to 'deep embodied knowledge, memories and rituals attached to museum spaces by the children and families' (Hackett et al., 2020: 4).

As well as enjoying freedom to roam, Wong and Piscitelli (2019) found that children enjoyed sharing their newfound knowledge when introducing their parents to the cultural arena of the museum. Children also recognized the diversity of competing agendas at play during museum visits (learning, pleasure, play, recreation and leisure). This echoes Degotardi et al.'s (2019) observation that family museum visits may need challenging negotiation when adults and children are attracted to different exhibit spaces.

Creating enjoyable museum experiences with learning objectives may therefore require a fine balance between structure and agency (Griffin, 2004; Munley, 2012), where child agency is fruitfully balanced with elements of structure (Andre et al., 2017). One way to achieve this balance is for children to have time to explore museums on their own terms, but adults can introduce children to exhibits and concepts during pre-visit activities and consolidate learning in post-visit sessions (Piscitelli & Penfold, 2015; Wöhrer & Harrasser, 2011), such as classroom museum-making and curating (Clarkin-Phillips et al., 2018; Eckhoff, 2008; Hope, 2018), and open-ended activities where young children design their own museum exhibits (Letourneau et al., 2020).

DISCUSSION AND CONCLUSIONS

This rapid evidence review is limited in its scope and focus but was successful in locating a body of literature reporting empirical evidence about how 0–8-year-old children engage with museum objects related to STEM. The rapid review procedures, as described in the Methodology section, resulted in the final REA sample of 48 papers published 2000–2020. We recognize the limitations of rapid review processes, including the exclusion of publications written in languages other than English, books, book chapters and gray literature, and to the consequent predominance of peer-reviewed academic journal articles in the review sample. Only papers reporting empirical studies were included, and purely theory-oriented papers were excluded, which again limits the review scope. Both

qualitative and quantitative studies were included, with some peer-reviewed papers from museum practice. There was variation in the quality of the review papers, with some lacking methodological detail or robust theorisation. This did not necessarily disqualify them from inclusion, but only studies assessed as medium to high quality were included. We developed the main synthesis with better quality papers and used the remaining studies as supporting evidence.

Bearing in mind these limitations, the REA found a reliable body of empirical research evidence indicating that young children's engagement with STEM museum objects relates to many different factors, which can be summarized as ranging from the characteristics of museum objects, forms of display, connections between museum objects and children's knowledge and interests, the nature of peer and adult-child interaction and the degree of agency children have to explore museum spaces and objects. Children also value being able to handle exhibits, to experience them sensorially, and often revisit objects during return visits to a museum, so the unfamiliar becomes familiar.

Studies in this REA also draw attention to how sustained shared attention, dialogic conversations and playful co-enquiry with families, teachers, peers and museum staff, before, during and after museum visits, can deepen children's interest in museum objects and enrich their curiosity, knowledge and understanding, whereas overly didactic exchanges can diminish children's interest.

The review findings offer clear implications for museum practice, policy and future research. For museum practice, this review identifies that children's interest in museum artifacts is enhanced and sustained by dialogical and collaborative activity with peers and adults. However, rather than relying on children's talk as evidence of their interest or learning, museum educators also need to take into account children's sensory, emotional and cognitive engagement with objects, and the need for children's agency to explore museum spaces in 'the rich and complex experiential textures of children's museum visits' (Kirk & Buckingham, 2018: 3). Some free-choice activities (such as pressing buttons or operating objects for no tangible purpose) can lead to confusion and frustration, so providing elements of structure through display design and responsive, flexible adult support can be beneficial. In this respect, museum signage and sensory guides can also contribute positively to young children's museum visits.

Policymakers would do well to bear in mind the breadth of factors that are at play in young children's engagement with museum objects, a finding that supports Carr et al.'s (2018: 558) argument that museums can no longer be justified as cultural 'banks' of artifacts where docile gazers receive information about distant lives, places and times. Rather, museum policy might reconsider how museums' rich object collections can be made more readily accessible and culturally familiar for diverse young children, who, as participatory research with children has indicated, expect museums to be 'places that accommodate people with different interests and needs' (Wong & Piscitelli, 2019: 428).

In relation to future research, the review found a tendency in many studies to focus on demonstrable signs of child learning as evidenced through talk, such as children's use of more complex

language structures or talk duration. This adult-oriented perspective stands in contrast to the findings of participatory research with children, which evidences the importance for children of sensory engagement, emotions, humor and embodied experiences with objects and spaces in museums. We suggest that future empirical research with children could enrich our understanding of how children feel in museum spaces, the significance for children of free space and time, what makes museum visits enjoyable for different groups of children, how repeat visits can empower children to become not only knowledgeable about museums and the rich objects they house, but also to articulate and share their preferences about the objects and activities offered to visitors. Future research might further explore how concepts such as sustained shared thinking involve bodies and emotions as well as minds, how knowledge is distributed amongst children and adults, and how shared understandings are built collaboratively through multi-sensory experiences over time. Such research could in turn help museum professionals and policymakers to value and foster the dynamic and interactive nature of museum visits by young children, their families and teachers. Future action research with multiple stakeholders (museum educators and managers, parents, early childhood educators, children, designers, performance artists) and across academic disciplines (such as arts, design, education and human geography) could fruitfully explore how STEM museum spaces and exhibits might be redesigned to enhance young children's, families' and early educators' engagement with the richness, diversity and significance of the objects in science museum collections.

Future research might also serve to reconceptualise young children's museum experiences by challenging traditional humanist boundaries between the human, the animal and the material, and by gesturing to new ways of understanding how children's bodies and emotions are inseparable from their experiences of place. We venture to suggest that a post-human perspective offers rich potential to understand the assemblages and entanglements of the social, material, embodied, sensory and affective dimensions of children's museum visits. This work also points to the need for museums to be responsive to children, to be adaptable and to improvise:

> *Improvisation should be absolutely at the heart of working with young children in museums. Instead of asking how museums could ensure certain kinds of educational outcomes, we could focus our energies on creating spaces and experiences that anticipate and are sensitive to the potential for emergent connections. (Hackett et al., 2020: 9)*

In terms of research location, the narrow range of countries in the REA sample and the absence of studies conducted in emerging economies suggests that more studies into young children's engagement with museum objects and collections in diverse locations are needed in order to understand what opportunities are available to children around the globe in different cultural, social and economic contexts. Most of the studies in this REA were conducted in Oceania, Europe and North America. We found no empirical research published in English into young children's engagement with museum objects in, for example, India, mainland China or Singapore – despite the existence of excellent museum facilities in some developing nations e.g. *Science City* in Kolkata. In the quest to promote civic engagement and build social capital through children's learning, future research might also explore how children growing up in diverse cultural and social communities might be encouraged

to make connections between their heritage and host cultures. Robust empirical research into young children's learning with virtual and digital museum artifacts is also currently lacking.

To conclude, although this review of research found a modest yet steady rise over the past two decades in research papers reporting on young children's museum visits, there is rich scope for further research to build empirical knowledge and theory in this field and to offer 'a more sophisticated understanding of the complex relationships between culture, communication, learning and identity that will support a new approach to museum audiences' (Hooper-Greenhill, 2007: 1).

Footnote

This rapid evidence assessment (REA) provides a snapshot of research from 2000-mid2020. A new search conducted end 2022 identified a still constant yet modest flow of studies that enhance the breadth of enquiry into young children's engagement with objects in science museums. These include, for example, Eadie et al.'s (2022) report on how museum facilitators plan for and perceive the learning opportunities inherent in programs that are tailored to enhance young children's museum visits. In this study, museum educators noted young children's fascination with museum objects, the importance of experiential learning, of building concepts into the early childhood program both before and after the visit and creating opportunities for children to ask questions and discuss artifacts during high quality interaction with museum staff who have content expertise. This finding is echoed in Lee's (2020) research at the Children's Art Museum in Taipei (CAMIT), where artistic concepts were translated into interactive galleries for children and their families. Parents in Lee's study reported they needed more knowledge about the exhibits and clearer articulation of the educational strategies so they could support their children's learning, showing that parents are not only facilitators of their children's visiting experiences but are also learners.

Drawing on post-human theory, Wallis and Noble (2022) show how three- and four-year-olds individually and collectively made sense of their experience of being in museum spaces and the artifacts within them through mark making, which created opportunities for them to share, compare and interact with other people's experiences. The authors argue that museums can seem inaccessible and overwhelming for young children, so inviting them to leave their own marks and traces in different ways helped to transform their relationship with and movement within the museum.

The recent pandemic has sparked interest in virtual learning in museums, such as Lee et al.'s (2021) development of online and offline experiential Augmented Reality (AR) learning tools to enable children aged 6–12 years to explore museum artifacts. Lee et al. make a strong case for the benefits to young children of moving away from visuocentric, one-way information delivery and towards using online/offline AR tools, which, they suggest, offer revitalizing alternatives for experiential learning.

The findings of these newly identified studies align closely with the review literature, suggesting that the REA questions and findings remain highly topical for practice, policy and research priorities. END

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CONFLICT OF INTEREST

None of the authors have a conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as it is a review of literature that is openly available. No new data were created or analyzed in this study.

REFERENCES

Association for Children's Museums. (2015). Toolkit for Reimagining Children's Museums. https://issuu.com/associationofchildrensmuseums/docs/rcm_print_publication

Critical Appraisal Skills Programme. (2018). CASP Qualitative research Checklist. https://casp-uk.net/wp-content/uploads/2018/01/CASP-Qualitative-Checklist-2018.pdf. (Accessed 27.04.2022).

Eadie, P., Young, S., Suda, L., & Church, A. (2022). Facilitator and teacher perspectives on museum programs for Young children. *Journal of Museum Education*, 47(1), 103–112.

Flewitt, R. S., Manyukhina, Y., Bangpan, M., & Wyse, D. (2019). Early Years Learning at the Science Museum. Rapid Evidence Assessment. Final Report for the Science Museum Group and Helen Hamlyn Trust.

Graham, J. (2011). Early years: A growing audience for museums and galleries. *Journal of Education in Museums*, 32, 54–62.

Hackett, A., Holmes, R., & MacRae, C. (2020). *Working with Young children in museums: Weaving theory and practice*. Routledge.

Hooper-Greenhill, E. (2007). *Museums and education: Purpose, pedagogy and performance*. Routledge.

ICOM. (2019). *Creating a new museum definition*. https://icom.museum/en/resources/standards-guidelines/museum-definition (Accessed 27.04.2022).

IMF (International Monetary Fund). (2020). *World Economic Outlook: The Great Lockdown*. Washington, DC, April.

Ingold, T. (2004). Culture on the ground: The world perceived through the feet. *Journal of Material Culture*, 9 (3), 315–340.

Kirk, E., & Buckingham, W. (2018). *Snapshots of museum experience. Understanding child visitors through photography*. Routledge.

Latour, B. (2004). *Politics of nature: How to bring the sciences into democracy*. Harvard University Press.

Lee, J., Lee, H.-K., Jeong, D., Lee, J. E., Kim, T. R., & Lee, J.-H. (2021). Developing museum education content: AR blended learning. *International Journal of Art and Design Education (iJADE)*, 40(3), 473–491.
Lee, T. S.-C. (2020). Curriculum based interactive exhibition design and Family's learning experiences: A case study of the Children's art Museum in Taipei. *Curator: The Museum Journal*, 63(1), 83–98.
Macdonald, S. (2007). *A companion to museum studies*. Wiley-Blackwell.
Macrae, C., Hackett, A., Holmes, R., & Jones, L. (2018). Vibrancy, repetition, movement: Posthuman theories for reconceptualising young children in museums. *Children's Geographies*, 16(5), 503–515.
Pluye, P., Robert, E., Cargo, M., Bartlett, G., O'Cathain, A., Griffiths, F., Boardman, F., Gagnon, M. P., & Rousseau, M. C. (2011). Proposal: A mixed methods appraisal tool for systematic mixed studies reviews. *Montréal: McGill University* 2, pp. 1–8.
Rathmann, C. (1915). The Educational Museum of the St. Louis Public Schools. Bulletin No. 48. Whole Number 622. United States Bureau of Education, Department of the Interior.
Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. Oxford University Press.
Science Museum Group. (2019). SMG Annual Review 2019. https://www.sciencemuseumgroup.org.uk/wp-content/uploads/2019/06/smg-annual-review-2019.pdf (Accessed 27.04.2022).
Thomas, J., Brunton, J., & Graziosi, S. (2010). *EPPI-Reviewer 4.0: software for research synthesis*. EPPI-Centre Software. Social Science Research Unit, Institute of Education, University of London.
Tricco, A. C., Antony, J., Zarin, W., Strifler, L., Ghassemi, M., Ivory, J., Perrier, L., Hutton, B., Moher, D., & Straus, S. E. (2015). A scoping review of rapid review methods. *BMC Medicine*, 13(1), 224. https://doi.org/10.1186/s12916-015-0465-6
Varker, T., Forbes, D., Dell, L., Weston, A., Merlin, T., Hodson, S., & O'Donnell, M. (2015). Rapid evidence assessment. *Journal of Evaluation in Clinical Practice*, 21(6), 1199–1204. https://doi.org/10.1111/jep.12405
Wallis, N., & Noble, K. (2022). Leave only footprints: How children communicate a sense of ownership and belonging in an art gallery. *European Early Childhood Education Research Journal*, 30(3), 344–359.
Weil, S. (1999). From being about something to being for somebody: The ongoing transformation of the American museum. *Daedalus*, 128(3), 229–258. http://www.jstor.org/stable/20027573

APPENDIX

PAPERS INCLUDED IN THE REVIEW

Anderson, D., Piscitelli, B., & Everett, M. (2008). Competing agendas: Young children's museum field trips. *Curator: The Museum Journal*, 51(3), 253–273.
Anderson, D., Piscitelli, B., Weier, K., Everett, M., & Tayler, C. (2002). Children's museum experiences: Identifying powerful mediators of learning. *Curator: The Museum Journal*, 45(3), 213–231.
Andre, L., Durksen, T., & Volman, M. L. (2017). Museums as avenues of learning for children: A decade of research. *Learning Environments Research*, 20(1), 47–76.
Braswell, G. S. (2012). Variations in children's and adults' engagement with museum artifacts. *Visitor Studies*, 15 (2), 123–135.
Bunce, L. (2016a). Appreciation of authenticity promotes curiosity: Implications for object-based learning in museums. *Journal of Museum Education*, 41(3), 230–239.
Bunce, L. (2016b). Dead ringer? Visitors' understanding of taxidermy as authentic and educational museum exhibits. *Visitor Studies*, 19(2), 178–192.
Bunce, L. (2019). Still life? Children's understanding of the reality status of museum taxidermy. *Journal of Experimental Child Psychology*, 177, 197–210.

Callanan, M. A., Castañeda, C. L., Luce, M. R., & Martin, J. L. (2017). Family science talk in museums: Predicting children's engagement from variations in talk and activity. *Child Development*, 88(5), 1492–1504.

Carr, M., Clarkin-Phillips, J., Beer, A., Thomas, R., & Waitai, M. (2012). Young children developing meaning-making practices in a museum: The role of boundary objects. *Museum Management and Curatorship*, 27(1), 53–66.

Carr, M., Clarkin-Phillips, J., Soutar, B., Clayton, L., Wipaki, M., Wipaki-Hawkins, R., Cowie, B., & Gardner, S. (2018). Young children visiting museums: Exhibits, children and teachers co-author the journey. *Children's Geographies*, 16(5), 558–570.

Carter, D. (2018). Narrative learning as theory and method in arts and museum education. *Studies in Art Education*, 59(2), 126–144.

Clarkin-Phillips, J., Carr, M., Thomas, R., O'Brien, C., Crowe, N., & Armstrong, G. (2014). Children as teachers in a museum: Growing their knowledge of an indigenous culture. *International Journal of the Inclusive Museum*, 6(4), 1–11.

Clarkin-Phillips, J., Carr, M., Thomas, R., Tinning, A., & Waitai, M. (2018). Fostering the artistic and imaginative capacities of young children: Case study report from a visit to a museum. *International Journal of Early Childhood*, 50(1), 33–46.

Crowley, K., Callanan, M. A., Jipson, J. L., Galco, J., Topping, K., & Shrager, J. (2001). Shared scientific thinking in everyday parent – Child activity. *Science Education*, 85(6), 712–732.

Degotardi, S., Johnston, K., Little, H., Colliver, Y., & Hadley, F. (2019). "This is a learning opportunity": How parent–child interactions and exhibit design foster the museum learning of prior-to-school aged children. *Visitor Studies*, 22(2), 171–191.

Della Croce, R., Puddu, L., & Smorti, A. (2019). A qualitative exploratory study on museum educators' perspective on children's guided museum visits. *Museum Management and Curatorship*, 34(4), 383–401.

Dockett, S., Main, S., & Kelly, L. (2011). Consulting young children: Experiences from a museum. *Visitor Studies*, 14(1), 13–33.

Dooley, C., & Welch, M. (2014). Nature of interactions among young children and adult caregivers in a children's museum. *Early Childhood Education Journal*, 42(2), 125–132.

Dunn, R., & Wyver, S. (2019). Before 'us' and 'now': Developing a sense of historical consciousness and identity at the museum. *International Journal of Early Years Education*, 27(4), 360–373.

Eckhoff, A. (2008). The importance of art viewing experiences in early childhood visual arts: The exploration of a master art teacher's strategies for meaningful early arts experiences. *Early Childhood Education Journal*, 35 (5), 463–472.

Faria, C., Guilherme, E., Gaspar, R., & Boaventura, D. (2015). History of science and science museums. *Science & Education*, 24(7), 983–1000.

Fletcher, T. S., Blake, A. B., & Shelffo, K. E. (2018). Can sensory gallery guides for children with sensory processing challenges improve their museum experience? *Journal of Museum Education*, 43(1), 66–77.

Frazier, B. N., & Gelman, S. A. (2009). Developmental changes in judgments of authentic objects. *Cognitive Development*, 24(3), 284–292.

Griffin, J. (2004). Research on students and museums: Looking more closely at the students in school groups. *Science Education*, 88(Suppl. 1), S59–S70.

Hackett, A., Procter, L., & Kummerfeld, R. (2018). Exploring abstract, physical, social and embodied space: Developing an approach for analysing museum spaces for young children. *Children's Geographies*, 16(5), 489–502.

Haden, C. A., Jant, E. A., Hoffman, P. C., Marcus, M., Geddes, J. R., & Gaskins, S. (2014). Supporting family conversations and children's STEM learning in a children's museum. *Early Childhood Research Quarterly*, 29 (3), 333–344.

Hope, A. (2018). Young children as curators. *International Journal of Art & Design Education*, 37(1), 29–40.
Jant, E. A., Haden, C. A., Uttal, D. H., & Babcock, E. (2014). Conversation and object manipulation influence children's learning in a museum. *Child Development*, 85(5), 2029–2045.
Kelly, L., Main, S., Dockett, S., Perry, B. & Heinrich, S. (2006). Listening to young children's voices in museum spaces. *AARE Conference 2006*, 1–12.
Kelton, M. L., Ma, J. Y., Rawlings, C., Rhodehamel, B., Saraniero, P., & Nemirovsky, R. (2018). Family meshworks: Children's geographies and collective ambulatory sense-making in an immersive mathematics exhibition. *Children's Geographies*, 16(5), 543–557.
Kim, K. (2009). *Museum Signage as Distributed Mediation to Encourage Family Learning*. ProQuest LLC. Doctoral thesis, University of Pittsburgh.
Larsen, J., & Svabo, C. (2014). The tourist gaze and "Family Treasure Trails" in museums. *Tourist Studies*, 14 (2), 105–125.
Letourneau, S. M., ChangChia, J. L., Donnelly, K., Meza, D., Uzzo, S., & McMillan Culp, K. (2020). Museum makers: Family explorations of data science through making and exhibit design. *Curator: The Museum Journal*, 63(1), 131–145.
Lifschitz-Grant, N. (2018). Mornings at the museums: A family friendly early childhood program. *Journal of Museum Education*, 43(3), 260–273.
Marcus, M., Haden, C. A., & Uttal, D. H. (2018). Promoting children's learning and transfer across informal science, technology, engineering, and mathematics learning experiences. *Journal of Experimental Child Psychology*, 175, 80–95.
McInnes, K., & Elpidoforou, M.-E. (2018). Investigating and learning from toddler play in a children's museum. *Early Child Development and Care*, 188(3), 399–409.
Munley, M. E. (2012). *Early learning in museums. A review of literature*, Smithsonian Institution's Early Learning Collaborative Network and Smithsonian Early Enrichment Center (SEEC).
Pagano, L. C., Haden, C. A., Uttal, D. H., & Cohen, T. (2019). Conversational reflections about tinkering experiences in a children's museum. *Science Education*, 103(6), 1493–1512.
Piscitelli, B., & Anderson, D. (2001). Young children's perspectives of museum settings and experiences. *Museum Management and Curatorship*, 19(3), 269–282.
Piscitelli, B., & Penfold, L. (2015). Child-centered practice in museums: Experiential learning through creative play at the Ipswich art gallery. *Curator*, 58(3), 263–280.
Povis, K. T., & Crowley, K. (2015). Family learning in object-based museums: The role of joint attention. *Visitor Studies*, 18(2), 168–182.
Prosser, D., & Eddisford, S. (2004). Virtual museum learning. *Information Technology in Childhood Education Annual*, 2004(1), 281–297.
Puchner, L., Rapoport, R., & Gaskins, S. (2001). Learning in children's museums: Is it really happening? *Curator: The Museum Journal*, 44(3), 237–259.
Rönkkö, M.-L., Aerila, J.-A., & Grönman, S. (2016). Creative inspiration for preschoolers from museums. *International Journal of Early Childhood*, 48(1), 17–32.
Watson, K., Aubusson, P. J., Steele, F. A., & Griffin, J. M. (2002). A culture of learning in the informal museum setting? *Australian Research in Early Childhood Education*, 9(1), 125–238.
Willard, A. K., Busch, J. T. A., Cullum, K. A., Letourneau, S. M., Sobel, D. M., Callanan, M., & Legare, C. H. (2019). Explain this, explore that: A study of parent–child interaction in a children's museum. *Child development*, 90(5), e598–e617.
Wöhrer, V., & Harrasser, D. (2011). Playful experiments: Gendered performances in a children's museum. *Science as Culture*, 20(4), 471–490.
Wong, K. M., & Piscitelli, B. A. (2019). Children's voices: What do young children say about museums in Hong Kong? *Museum Management and Curatorship*, 34(4), 419–432.