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Young children's agency in the science museum: insights from the use of storytelling in object-rich galleries

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ABSTRACT
This paper draws on a multi-phase project that sought to understand and increase young children's engagement with Science, Technology, Engineering and Mathematics (STEM) objects. The paper presents findings from one aspect of this project that involved using storytelling to support young children's agency with STEM objects in a UK science museum. The qualitative research involved observing and interviewing 25 children aged 4–7 years in family and school groups. The findings demonstrate the importance of acknowledging and promoting young children's agency in museum settings. They suggest that providing children with opportunities to exercise agency by them taking control and activating their prior knowledge and interests during museum visits increases their engagement, enjoyment, and confidence. The study also highlights the important role that adults, including parents, teachers, and museum staff, play in facilitating children's agency and increasing their engagement with museum objects and spaces.

Introduction

There is an increasing awareness of the need to engage the public with science, technology, engineering and mathematics (STEM) to promote an equitable society in which all citizens, including children, understand and can contribute towards socio-scientific issues. It is acknowledged that formal education alone cannot achieve this aim (Bell et al., 2009). Museums can be seen as informal learning institutions that collect, safeguard and make accessible specimens and object collections (Falk et al., 2007). The amount of time spent engaging with science during the early years and in primary school settings is short, suggesting the importance of considering science engagement in informal settings such as museums (Bevan et al., 2013). Museums generally aim to inspire and educate their visitors (Museums Association, 2021), and they also have a public duty to offer access to their collections for diverse audiences of all backgrounds and age groups (National Heritage Act, 1983). Young children make up a large percentage of annual museum visitors in the UK, with young children visiting museums as part of school groups and with their families. The aim and public duty to reach diverse audiences, and a large number of young children already visiting museums, highlights the importance of optimising opportunities for young children to engage with museum collections.

Many museums house large and varied object collections. For example, the science museum where the research took place has a significant object collection that includes over seven million objects related to STEM and medicine. With such a rich object collection, this science museum, as other museums, is increasingly interested in encouraging young children's curiosity around STEM-related objects by designing spaces and developing activities that spark children's interest and imagination. One of the aims of the science museum at which the research took place is to effectively use its object collection to engage visitors, including young children, with STEM. This aim is situated within broader aspirations across the STEM field to engage more people and more diverse people of all age groups with STEM. Supporting access and engagement with object collections in science museums for the early years age group entails great potential to support STEM engagement.

Research indicates that young children enjoy having the freedom to engage with museum spaces and objects on their own terms, such as choosing which trajectory to follow, where to focus their attention, and how to interact with objects (Bevan et al., 2013). Such opportunities for independent choice and action constitute essential elements of children's agency in museums. Young museum visitors are more interested and engaged when they have opportunities to make their own choices in museums and actively participate in activities (Lifschitz-Grant, 2018). Children's active participation in museum experiences serves both as a strategy for increasing their ownership of experiences and as a way of helping them to engage with new ideas and perspectives (Dockett et al., 2011). Museums are increasingly recognising the importance of acknowledging and supporting children's agency, including for the early years age group. For example, audience engagement strategies at the science museum where the present research took place outline the need for museum experiences to be relevant and inclusive for intended audiences, and embrace children aged 4–7 years, with a commitment to treat young children as visitors in their own rights and to support their needs.

Despite the noted importance of considering the unique experiences and need for agency of the early years age group, research on how young children can take an active role during museum visits, particularly in science museums, is limited. This paper contributes towards advancing understanding of the role of agency in children's museum experiences. It reports on the research that forms part of a larger project named 'Early Years and Objects'. The project started in June 2019 and ended in April 2022. The larger project considered how young children aged 0–8 years engage with museum objects related to STEM, and what innovative ways can be found to enhance young children's curiosity and engagement with museum objects. The project involved an assessment of peer-reviewed publications on young children's engagement with objects (Flewitt et al., 2019), a review of practitioner research on young children's engagement with museum objects, initial research at a Science Museum and the development of 18 diverse approaches to support children's engagement and enjoyment around objects. The development of these approaches was based on the reviews, the initial research, as well as a workshop with 19 experts, including practitioners and academics.

This paper draws on one of these approaches – namely the 'Helicopter Stories Approach' that explores how children's agency and participation can be supported in a science museum. This approach originates from work by Vivian Gussin Paley (Paley, 1990) that explores how pre-school teachers can tap into young children's creative resources and fantasy worlds through storytelling. Paley's original approach has since been used in the UK Early Years and Foundation Stage of education, and includes children making up stories, adults scribing the stories and children then acting them out (see e.g. www.makebelieveart.co.uk). In this approach the child is viewed as a 'helicopter' who dictates stories to an adult – hence the name 'Helicopter Stories Approach'. The main research questions that this paper sets out to answer are:

1. How do young children exercise agency in the Helicopter Stories Approach?
2. How does increased agency affect young children's experiences of the Helicopter Stories Approach?
3. What is the role of adults in mediating young children's agency in the Helicopter Stories Approach?

Children's agency and its relevance to museum practice

Agency can be described as a socially situated capacity to act (Manyukhina & Wyse, 2019). This definition acknowledges the individual and the structural elements influencing whether and how people exercise their agency in a given context at a given time. The individual element refers to one's sense of agency – a person's belief in their capacity to act independently and exercise choice, informed by their life experience and background. The structural element is defined by the contexts in which individuals find themselves at the time when they contemplate or engage in an action. Acknowledging both the individual and the structural aspect of agency is essential for understanding the conditions under which manifestations of children's agency in a museum environment can occur. Children may bring a sense of agency into a museum space, but translating this sense of agency into an action necessitates actual opportunities to exercise agency. Museums may go to great lengths to create opportunities for children to exercise agency, yet these opportunities will remain unrealised if children do not perceive themselves as agents capable of independent choice and action. When opportunities are available to children and when children recognise the potential for agency inherent in them, opportunities become affordances. It is only then that the exercise of agency can occur. The key implication of this theoretical point for museum practice is that both contextual opportunities as well as children's individual psychologies need to be considered when designing activities and experiences aimed at facilitating children's agency in museums.

The relevance and importance of agency for children's experiences in museums is increasingly recognised by museum practitioners. Museums in general actively try to support children's engagement with museum spaces and objects, such as through labels, self-guided activities and other interpretation. Interpretation can be defined as provision that aims to communicate meaning and relationships between objects and information, which often involves the narration of thematic content (Chang et al., 2008). This narration of thematic content can involve a range of provision, such as simple panels, multimedia content, mechanical devices and various activities and events (Villagra-Islas, 2011). Different types of interpretation leave different scope for children's agency. Some interpretations recognise children as experiencers, while others put children in the position of learners (Birch, 2018). Some interpretations promote interaction and participation, while others may restrict children's access and engagement. The most effective interpretation works by appealing to children's prior knowledge and interests, and by enabling children to actively participate and establish ownership over their experiences (Dunn & Wyver, 2019; Yates et al., 2022). From the viewpoint of children's agency, these strategies work by accommodating the two key elements of agency: (1) children's sense of agency, since they feel empowered to act independently within the museum environment (e.g. choosing where to go and what to look at, contextualising objects in their own terms, building on their existing understanding and interests), and (2) actual opportunities to exercise agency through activities and experiences that encourage active participation (from hands-on and interactive activities to actual museum-making and museum curatorship). Dockett et al. (2011) note how even when opportunities to directly engage with museum exhibits are lacking, children find other ways to display active participation, such as by looking through railings or climbing stairs, and in doing so, they gain enjoyment.

Although in the literature engagement and agency are often used interchangeably or in parallel without clear distinctions, engagement does not always involve a meaningful and/or deliberate exercise of agency, as seemingly agentic actions may be habitual or purely performative (Klemenčič, 2015, p. 2017). Engagement may be thought of as one aspect of agency, alongside choice, control, ownership, initiative, and self-motivation. Links between children's agency, engagement, and enjoyment in museums are supported by a robust body of evidence from academic and practitioner research. Lifschitz-Grant's (2018, p. 265) study of children's visits to a historic home found that children become more engaged and excited when given the opportunity 'to get actively involved, answer questions, make sounds, and act it out'. Hope's (2018) research exploring children's experiences of being museum curators demonstrates the benefits of active participation and choice for

children's engagement and learning. It describes how curatorial experiences encouraged children 'to create their own meaning from the objects by choosing where they are "set" and how they are used, rather than allowing the teacher to decide their purpose' (Hope, 2018, p. 33). Hope's conclusion is echoed by Della Croce et al. (2019) who observed how museum programmes in which children acted as museum guides for adults promoted children's empowerment and active learning by giving them an opportunity for self-expression, choice and experimentation in managing the museum visit.

Griffin's (2004) review of a decade of research on school group visits to museums provides evidence of the benefits of free-choice activities for children with varying learning abilities across different museum types. Reporting on a study involving children with special educational needs, Brooke and Solomon (2001) maintain that the visits to a science centre by pupils with severe learning difficulties were successful to a large degree because they were not being told what to do or not do. Instead, children were afforded the freedom to engage with the activities they found interesting and intriguing. In line with these findings, Anderson et al.'s (2008) study emphasises the importance of allowing children to take the lead at some points during museum visits so that they can experience and benefit from the free-choice elements of the museum environment. Having consulted young children (0–5 years) about their experiences and expectations of a play/learning space in a natural history museum, Dockett et al. (2011) also concluded that young children prefer museum experiences which allow them to exert choice and control. In a decade-spanning review of literature on children's learning in museums, Andre et al. (2017) highlight research demonstrating children's particular fascination with opportunities to handle objects, look at them critically, and discuss their features with peers and museum curators. Evidence shows that hands-on museum environments and activities enhance children's enthusiasm, excitement and enjoyment in museums (Rönkkö et al., 2016; Watson et al., 2002). In Piscitelli and Anderson's (2001) study, exhibitions focussing on objects and topics that linked with children's pre-existing knowledge and experiences were among the most popular. Similar conclusions were drawn by Carter (2018) who found that children were attracted to objects associated with familiar concepts, and Della Croce et al. (2019) whose research suggests that children are most interested in topics they find relevant.

Adults, including family members, teachers and museum staff, represent a key element of the structural context surrounding children's agency in museums. Adults may take different roles during museum visits, such as co-explorers, informal teachers, guides. They can shape children's experiences by directing them through museum spaces, structuring conversations, and mediating their engagement with objects (Flewitt et al., 2023). Depending on the roles that adults take in relation to children, the nature of children's engagement with museum spaces and objects varies. Hence opportunities to exercise agency are shaped differently. These different adult roles may affect how children experience their visit and how they feel about it. It is important to recognise that adults' roles may vary and shift depending on the goals of visits, the nature of the activities that children engage in, and the needs of individual children (Jung et al., 2022). These variations and shifts in adults' roles may influence whether and how children exercise their agency at different points during the visit. Adults' roles as part of the structure surrounding children's agency can be utilised to maximise the benefits of museum experiences for children. For example, adults can help to inform and structure parental talk, as demonstrated by Callanan et al. (2017, p. 1502): 'those parents who used evidence, personal connections, and requests for explanation, had children who showed deep interest and engagement'. Appealing to children's prior knowledge and interests can be an effective way to achieve specific learning outcomes, such as encouraging imaginative thinking in children (Eckhoff, 2008). Understanding how adults may influence children's agency during museum visits is critical to design experiences and activities that bring children the most enjoyment and benefit.

Storytelling and Stories are a vital part of most young children's early lives, for example children's early engagement with nursery rhymes and fairy tales which are mediated by adults and communicated by children in a variety of ways including through emergent writing and drawing

(Bradford & Wyse, 2020). Children's natural play is often built around the narratives of stories, indeed it is often argued that stories are a vital part of being human (e.g. Delistraty, 2014). The links between children's natural affinity with storytelling and story, and with objects in their environment were built on as part of the design for The Early Years and Objects project.

The Early Years and Objects project focused on the importance of creating museum experiences that appeal to young children's knowledge and interests, and that provide children with opportunities to exercise agency through independent choice and action. This paper reports the outcomes from research on one of the project's approaches, namely the Helicopter Stories Approach, which was analysed for its potential to enhance children's agency. We describe how the activity created opportunities for children to exercise agency in the galleries by enabling them to take ownership and activate their knowledge and interests, how increased agency affected children's experiences, and the role of adults in mediating children's agency in the museum environment.

Methodology

Early years and objects project

The Early Years and Objects project involved: (1) assessing publications on young children's engagement with objects (Flewitt et al., 2019), (2) a review of practitioner research on young children's engagement with museum objects, (3) initial research, and (4) the development of 18 approaches to enhance young children's engagement and enjoyment with STEM objects. These approaches were developed based on the reviews, the initial research and a workshop with 19 experts, including practitioners and academics. A total of 263 young children in family and school groups took part in research involving the 18 approaches. All research followed ethics advice by the British Education Research Association (2011) and the science museum's Audience Research and Advocacy Team Research Ethics Framework, including informed consent, child-friendly research methods, anonymity and confidentiality.

This paper focuses on the Helicopter Stories Approach, which is one of the approaches that was developed as part of the Early Years and Objects project. The Helicopter Stories Approach was led by a professional storyteller who introduced the activity, provided facilitation throughout and looked at and read out the stories created by the children. At the beginning of the Helicopter Stories Approach the storyteller asked children in family and school groups to choose an object from the 'Mathematics' gallery or the 'Flight' gallery at the science museum. The storyteller did not give examples of gallery objects so as not to influence children's choices. The Mathematics gallery focuses on the works of mathematicians in the broadest sense, from salespeople to sailors, aircraft engineers to bankers, and gamblers to garden designers. It includes objects spanning the past 400 years, including hand-held mathematical instruments to a 1929 experimental aircraft. The Flight gallery traces achievements in the history of aviation, and includes, for example, the world's most authentic Antoinette monoplane from 1909 and a complete slice of a genuine Boeing 747 jumbo jet. Neither the Mathematics gallery nor the Flight gallery are specifically designed for the early years age group. Both galleries are object-rich in that they focus on objects and contain only limited interactive exhibits.

Once children in family and school groups had chosen an object to tell their story, the storyteller asked them to closely look at and talk about it. To support looking and talking about their chosen object all children in school groups were also provided with post-it notes to write about or draw anything they wanted about their chosen object. Children could stick the post-it notes on their chosen object, or its object case. The storyteller then asked children in family and school groups to write or ask their adults to write their story in a book that they decorated. For example, one five-year-old in a family group selected the model of Globtik Tokyo from the Mathematics gallery as their chosen object (see Figure 1). When it was completed in 1973 the Globtik Toyo was the largest ship in the world. The child and her parents then created a story book about this object (see Figure 2).

Figure 1. Example of object selected by a five-year old in a family group.

Children could decide whether to take their book home or leave it at the museum. All children in the two school groups were also invited to act out their stories. The adults in the school group selected three children in one school group, and two children in the other school group to act out their stories to the rest of their group. Due to time constraints, it was not possible for all children who wanted to act out their stories to do so.
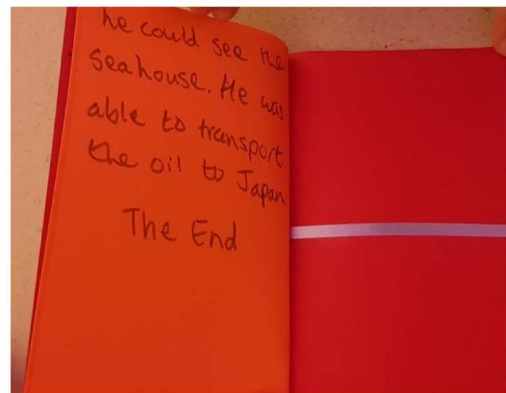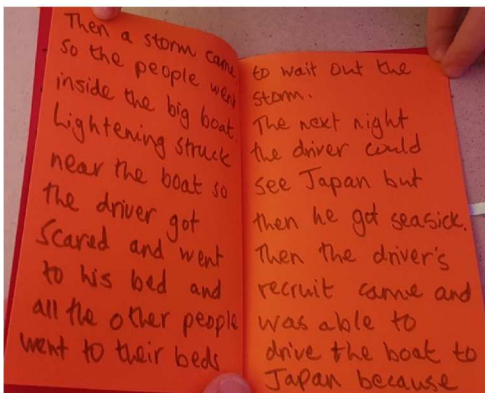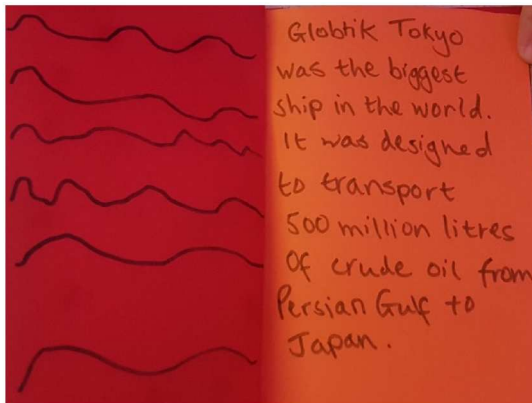

Figure 2. Example of story book created by a five-year old in a family group.

Data collection and analysis

The data collection was conducted in February 2022 and consisted of data gained from family and school groups. For family groups the researcher approached families with young children entering the gallery and invited them to take part. The researcher then informed the families about the research aims, and verbal consent was obtained from the child and an adult in the family groups. School groups were recruited to take part in the Helicopter Stories Approach prior to their visit through the museum's educational booking system. School groups were met at the gallery entrance with verbal consent being obtained from the children and adults in the school groups. Data collection consisted of systematic observation of the children and adults taking part in the Helicopter Stories Approach and subsequent semi-structured interviews with children and adults. No time limit for how long families or school groups could take part in the Helicopter Stories Approach was given. However, school groups generally had a more limited time available, with families engaging in the activity for a mean duration of 1.5 hours and school groups for a mean duration of one hour. The researcher observed children and adults while they engaged in the approach and took observation notes using a previously developed observation guide based on the existing literature on young children's engagement and agency. The observation guide prompted the researcher to observe and take written notes on the following: (1) the actions, verbal and non-verbal expressions that children and adults made in relation to the object; (2) the actions, verbal and non-verbal expressions that children and adults made in relation to the activity; (3) the durations of interactions; (4) the initiator of interactions (child or adult); (5) the facilitators of interactions (e.g. the object, the activity); and (6) aspects of the wider museum environment that influenced the Helicopter Stories Approach. The semi-structured interview lasted for a mean duration of 7 minutes and involved the researcher asking children and adults about their experiences, views and suggested improvements in relation to the Helicopter Stories Approach. During the interview, the researcher took notes that were structured by the interview questions. Interviews were not audio-recorded as within the often busy and noisy Mathematics and Flight galleries the sound quality of audio-recordings is generally poor.

A total of 25 children took part in the Helicopter Stories Approach. Children were aged 4–7 years, with an overall mean age of 5.3 years (see Table 1).

The research did not involve gathering detailed information about families, such as their socio-economic status, their ethnicity or whether they are regular museum visitors. However, visitor profiling at the museum on the days that the research was conducted indicates that most family visitors were from a medium – high socio-economic and educational background.[1] It can therefore be assumed that the families who took part in the research most likely align with these visitor characteristics. The school groups were state primary schools from two areas nearby to the museum.

Following the completion of the research with family and school groups, the storyteller was interviewed to gather her views on the Helicopter Stories Approach. The storyteller was asked for her experiences using the approach with family and school groups, for her suggestions around adapting the approach for different galleries and museums, and for her views on how the approach could be improved overall. The interview lasted for one hour and the researcher took written notes.

Children's agency theory (Manyukhina & Wyse, 2019) was an overarching a-priori influence on the data analyses. An important aim for the analyses was to capture an authentic view of children's

Table 1. Research participants in the Helicopter Stories Approach.

	Participants	
	Participants in Family Groups	Participants School Groups
Number of groups	4 family groups	2 school groups
Number of adults	6	6
Number of children	5 (3 girls and 2 boys)	20 (10 girls and 10 boys)
Children's mean age	5.2 years	5.4 years

views and lived experiences, and in particular their engagements with the Helicopter Stories Approach. Codes were created and assigned inductively to data extracts in the interview and observation notes data (Atkinson & Delamont, 2005). The following data sets were generated during the research: (1) Written notes from interviews with adults and children; (2) Written notes from the interview with the storyteller; (3) Observation notes; and (4) Children's post-it-notes and storybooks. These data sets provided the basis for analysis that informs the findings reported in the paper. The analysis is based on a qualitative thematic approach (Braun & Clarke, 2006; Merriam, 1998) that involved the following steps: (1) Organisation of the data sets by type; (2) Initial coding, with codes derived inductively directly from the data; (3) Grouping codes into higher-order themes; (4) Further coding and re-coding, based on emerging codes and themes; (5) Refining codes and higher-order themes; and (6) Final re-reading and checking of codes and themes.

The qualitative data analysis for this project focused on examining data for patterns and meaning by developing codes. This approach reflects recent data analysis approaches used in prior research that considers young children's play, engagement and learning in museums (e.g. Rushton & King, 2020). Codes were assigned to the interview and observation notes to determine aspects linked to the research question by bearing in mind the noted prior research on children's agency. Codes were then grouped into themes with a focus on providing answers to the research question, as is common in qualitative research (Merriam, 1998). Appendix 1 outlines the codes that were generated and their definitions. Thematic analysis in this way identifies meaningful patterns across types of data (Braun & Clarke, 2006). Rather than counting instances of young children's behaviour or views this data analysis allowed for children's views and lived experiences to be captured authentically. This approach allowed for the collection and analysis of rich, meaningful data necessary to examine young children's experiences and use of the Helicopter Stories Approach.

To consider young children's agency it is essential to ensure that the young children themselves have sufficient opportunities and encouragement to voice their views. To achieve this aim, the current research utilised specifically developed interview guides that directly asked children for their views and experiences in a playful manner. Providing additional time, analysing additional relevant non-verbal information, such as children's use of gestures and movement, and embedding questions and opportunities for young children to reflect on experiences into the existing activities that an approach, such as the Helicopter Stories Approach affords might be a way to gain deeper, additional insights directly from young children (e.g. see Hunleth, 2011; Punch, 2002).

Findings and discussion

The Helicopter Stories Approach created opportunities for children to exercise their agency in two main ways: by taking control over different aspects of the activity and by activating their prior knowledge and interests. In this section, we present the findings related to each of these ways of expressing agency, followed by a consideration of the role of adults in shaping children's agency in museums.

Taking control

The Helicopter Stories Approach provided children with opportunities to exert control over different aspects of the activity by choosing objects of interest, creating their own stories and where possible writing them down, scripting and acting out their own scenes, and establishing ownership over their creations. This afforded children the freedom to engage with the activity on their own terms.

Firstly, children took control by choosing where to focus attention. Thus, no specifications or directions were given to children at the start of the activity to inform their walking trajectory or choice of objects to look at, interact with, and use as a source of inspiration for their stories. Children could roam freely around the gallery and choose where to stick their post-it notes according to their own preferences, as reflected in the following quotes from the young visitors: 'I like over here' (child 6–7

years, school group, Flight Gallery); 'I want to use this and that one there was a man who loved flying and crashed' (pointing at a case with birds) (Child 6–7 years, school group, Flight Gallery).

Secondly, children were in control during the process of writing stories and creating storybooks. They made their own choices defining what the story will be about: 'I want my story to be cool – how planes come to life' (Child 6–7 years, school group, Flight Gallery); how to organise content: 'I'm doing it on the front because it's about space' (Child 5–7 years, family group, Mathematics Gallery); and how to decorate their storybooks: 'Can I put a string through it?' (Child 5–7 years, family group, Mathematics Gallery).

Thirdly, children had opportunities to exercise control during performance time. They could choose whether and when to come up on stage, e.g. 'I am going to read ending' (Child 6–7 years, school group, Flight Gallery). Further, they expressed their preferences when it came to dividing the roles: 'I want to be an archer'; 'I want to be a knight' (Children aged 6–7 years, school group, Flight Gallery). As authors of their stories, children gave instructions to their peers on how to act out different roles, thus demonstrating authority and control over their creative outputs.

Finally, children demonstrated a sense of control by claiming ownership over their creations. This is revealed by the young participants' claims to the story books and craft materials: 'Do we get to take these home?'; 'Can I keep this forever?' (Children aged 6–7 years, school group, Flight Gallery). One child corrected the name of their story misread by the storyteller: 'Flights not Flight' (Child 6–7 years, school group, Flight Gallery). These quotes demonstrate that children assign importance to their creations, that they care about their authenticity and perceive them as their own, and that they wanted to be in control of what happens to their creations and how they are used.

The above examples of children taking control over their museum experiences allow reflection on the conceptual distinction between a sense of agency and an exercise of agency presented earlier in the paper. On the one hand, the Helicopter Stories Approach provided tangible opportunities for children to exercise agency by taking control over different aspects of the activity. On the other hand, children's sense of agency, that is their inner belief that they could act constructively on their own behalf and according to their individual preferences, has been an essential element co-creating their manifestations of agency. Quotes such as 'I want to use this', 'I'm going to read ending', 'I want to be an archer', and 'Can I keep this forever?' (Children aged 6–7 years, school group, Flight Gallery) demonstrate children's appreciation of themselves as individual agents who have the capacity to take actions and control their outcomes.

The freedom of exploration and self-expression that the activity afforded to children was highlighted by accompanying adults, who noted during the interviews that 'instructions were very broad, not overly prescribed or specific' (male adult, family group with children aged 6 and 8, Mathematics Gallery) and that '[the activity] gave the children the freedom to go off and do whatever they wanted and put things in their own words' (male adult, family group with children aged 6 and 8, Mathematics Gallery). Another adult emphasised the open-ended and unrestrained nature of the activity: 'there are no right or wrong answers. There were no inhibitions' (female adult, family group with child aged 6, Mathematics Gallery)

The main implication of providing children with opportunities to exercise agency throughout the activity is that it increased their interest and enjoyment. This is essential for museum practitioners to be able to support STEM engagement amongst young children. Children (5–7 years, school groups, Mathematics and Flight Galleries) referred to the act of choosing their preferred object of interest with a sticky note as one of the most pleasurable aspects of the activity. When asked which part of the activity they liked most, children responded: 'Sticking the post, could say what you think about something'; 'I liked putting the drawings on the cases'; 'I like when we stick stuff on display'; 'Looking for something to make our, our story about'. Children also highly enjoyed the process of creating and writing down their own stories: 'I really enjoyed doing stuff. It was fun doing stuff'; 'I loved making books'; 'Making up your own stories, I like it'. Finally, establishing a sense of ownership over their creations was an important factor contributing to children's enjoyment, as illustrated by the following comments: 'Got to make up ourselves,

didn't have to copy people'; 'Liked making stories, got to write down ourselves'; 'I liked telling my story'. The link between children's sense of ownership and enjoyment is further supported by a contrasting example from one young visitor (child 6–7 years, school group, Flight Gallery). When asked to recall the least favourite part of the activity, the child responded: 'When we were acting out, because I didn't get to do mine, I wanted to do mine'. This suggests that being a passive observer as opposed to an active participant in an experience may detract from children's enjoyment.

Evidence presented in this section contributes to the literature establishing links between agency and enjoyment discussed earlier in the paper. In line with prior research, the Helicopter Stories Approach demonstrated that providing children with opportunities to make their own choices, create their own meanings, actively participate and exert control during activities contributes to their interest and enjoyment. Museum practitioners can utilise these insights by developing storytelling approaches, such as the Helicopter Stories Approach, to enable and encourage children's agency around museum objects and therefore supporting STEM engagement.

Activating prior knowledge and interests

An essential aspect of the design of the Helicopter Stories Approach was affording children the freedom to choose which objects to engage with and write about – in other words, the freedom to choose objects according to their own preferences. As the storyteller commented: 'Allowing them to choose immediately means they can target the session to the object/s which interest them most'. Indeed, children's interview responses reveal that they felt most drawn to the objects that resonated with their interests and prior knowledge and experience. When asked to explain their choice of objects, children (5–7 years, school and family groups, Flight and Mathematics Galleries) commonly referred to their hobbies and interests: 'Because I like books'; 'Because I like flying planes'; 'I like the WW1'; 'Because I like space and I like the planets'. Children's prior knowledge and experience were also an important source of inspiration for the choice of objects. For example, one child was drawn to an old coin collection which reminded him of his grandad's old coin collection, another child picked up sparkle pens which were frequently used at home: 'I've used up all of my sparkle pens at home', another child focussed on skulls because of their association with Halloween: 'Because it's Halloween and they're scary'. Another interesting example comes from a young participant who picked a feature of the gallery that they could not recognise, marking it with a post-it-note: 'I don't know what this is called' (child aged 5–6 years, school group, Mathematics gallery). The feature of the gallery that the child selected was a pillar on gallery that is a structural part of the museum rather than a museum object. This act denotes agency in that it reveals the child's genuine preference and individual choice, uninhibited by the lack of understanding of the nature of the museum feature.

Children's freedom to bring their individual interests and prior knowledge into the Helicopter Stories Approach extended beyond the choice of objects, featuring equally strongly in their story-writing. Children (5–7 years, family and school groups, Mathematics and Flight Gallery) often connected their story plots to what was familiar to them, such as their home setting: 'I love my story in my kitchen' or a well-known children's novel: '[the story] was based on *The Nightmare Before Christmas*'. The choice of story genre and topic was often informed by children's individual interests. One child was keen on non-fiction, another on stories about sharks, another expressed their interest in flying by picking an air ship and a boomerang among the objects and finally choosing to write about a glider: 'I was thinking doing a story about that one in 1699 there was a man who flew a glider like this … I like that he flew in it'.

The potential of the activity to tap into children's individual interests and prior experience and thereby increase their engagement was noted by adults. One adult expressed surprise that the activity 'held his daughter's attention' (adult in family group with child aged 6, Mathematics Gallery); another adult remarked on 'how involved everyone was' and how their younger sibling 'wasn't

interested in this [gallery] floor before' and that 'acting out made him think more' (elder sibling of child aged 5, family group, Mathematics gallery). When asked to reflect on why the activity was successful in engaging her daughter, parents noted the connection between her daughter's story and her everyday life: 'My daughter included her brother in the story. Also, calculators … [She] and her brother play with calculators at home'. Similarly, another adult in a family group felt the activity was appealing to their daughter because it spoke to her passion for creative pursuits: 'It was the creative side of the activity. [She] likes colouring and creating and telling stories' (adult in family group of a child aged 6, Mathematics Gallery).

By providing children with opportunities to actively engage their minds and draw on their individual interests and abilities, the Helicopter Stories Approach offered a space for children to reveal and realise their potential. One parent said that her daughter 'had wanted to tell a story for a long time before this, and this really helped allow her to write a story' (mother of child, 5 years, family group, Mathematics Gallery). Another adult in a family group noted that the activity gave children 'a chance to use their imaginations' (adult in family groups with child aged 6 years, Mathematics Gallery). One adult remarked how the activity prompted her child 'to think about what it would be like to wear a space suit and float around in space' and how she 'was coming up with her own ideas' (adult with child aged 6 years, family group, Mathematics Gallery). Examples of children's imaginative ideas include the following opening line from a 6-year-old child: 'Ges what I am I am an astrehnaht [sic]' (family group, Mathematics Gallery) and another child's story: '699 years ago, lived a man, he loved flying, when he flied, crashed in Egypt … ' (6-7 years, school group, Flight Gallery). The storyteller's feedback also emphasised that 'children could respond in any way they wanted and so all the stories varied in style enormously', describing the Helicopter Stories Approach as 'really filled with joy' and 'a day of busy industry and children being creative'.

Pursuing areas of interest and fascination resulted in enhanced positive emotions for children, such as a sense of achievement and taking pride in their work. Remarks on how writing their own stories made their children feel 'more confident' and 'more proud' were common among the adults reflecting on the benefits of the Helicopter Stories Approach. One adult specifically commented on how the activity helped their child become 'a bit more confident with story making/telling skills and more knowledgeable about the museum than when he first came in' (accompanying adult to a child aged 5, family group, Mathematics Gallery). Another adult in the same group also felt that the activity helped their 5-year-old child to realise 'that she is capable of storytelling'. 'It's helped grow her confidence, that she can do these sorts of activities', said the parent (family group, Mathematics Gallery). Similarly, another adult accompanying a child aged 6 felt that the activity brought to their child 'a lot of positive reinforcement within the museum' (family group, Mathematics Gallery).

Thus, by allowing children to capitalise on their prior knowledge and interests, the Helicopter Stories Approach promoted children's engagement while boosting their sense of confidence and achievement. This has important implications for children's sense of agency, which they bring into museum spaces during every visit. As outlined earlier in the paper, one's sense of agency is shaped by prior experiences of exercising agency and the extent to which these experiences felt successful and rewarding. One's sense of agency then plays a crucial role in determining whether an individual chooses to take an action or refrain from it. Similarly to how learning success leads to increased levels of confidence and self-efficacy in students (Honicke & Broadbent, 2016; Howitt et al., 2017), children's successful experiences of taking control may translate into a stronger perception of their own agentic potential, which, in turn, may contribute to children's propensity to manifest agency in the future. Thus, by providing opportunities for children to exercise control museum practitioners can create positive feedback loops to encourage children to take a more active role during museum visits.

Adults and children's agency in museums

Children's sense of agency varies depending on their life backgrounds and experiences, and while some children are better placed and/or prepared to recognise opportunities for exercising agency

and actively capitalise upon them, other children may find it difficult to initiate or sustain independent choice and action. That children's individual characteristics vary and may affect their engagement was acknowledged by the adults attending the Helicopter Stories Approach. As one teacher noted: 'Sometimes with children, some are creative, and some need a bit more structure' and 'Some children are less able than others, so they require more input' (teacher of school group, 6–7 years, Flight Gallery). Researcher observation notes also highlight that while some children engaged in the activity without further prompting, others appeared to need some encouragement to start writing or crafting. Younger children (4 years) especially benefited from adults' participation in the activity. By acting as examples for the children who felt less confident engaging in the activities, adults helped them ease into the session and become more actively engaged. This suggests that adults, including parents, teachers and museum staff, can play an important role in promoting children's agency and engagement during museum visits.

The testing of the Helicopter Stories Approach revealed that tasks such as using stationery may create opportunities for children to express what support they need to be active agents, such as when a young visitor needed help with a stapler when creating a storybook: 'I need help using this' (child 6–7 years, school group, Flight Gallery). In another instance, a child approached their peer with a request for help with writing: 'Can you teach me how to write?' (Child 5–6 years, school group, Mathematics Gallery). Another young visitor asked an adult to read the label on the casing to help with identifying the object. The adult helper in this case facilitated the child's agency by providing the knowledge the child needed to make an informed choice expressing a genuine preference.

Such explicit requests for assistance are a clear manifestation of agency on the part of the children, demonstrating their ability to identify barriers to their participation and finding ways to remove them. In cases like these, adult help was essential to enable children to engage in the activity in a meaningful way. Assisting children in writing their stories was especially significant for younger visitors who were not English speakers. Children with special education/learning needs constitute another group that may particularly benefit from adult help, as pointed out by a teacher: 'One student had dyslexia and so needed an adult focused on helping them to engage' (teacher of school group 6–7 years, Flight Gallery). By facilitating story-writing for those children who were less able to write, adults enabled a more diverse audience to participate, thus enhancing the inclusiveness of the Helicopter Stories Approach and the overall museum space. Adults also used conversation prompts to stimulate children's thinking and imagination around objects and stories. Examples of question prompts used by the storyteller in the Helicopter Stories Approach include:

What do you want the story to be about?

What object should we use?

Where did he go to fly the plane?

How would we describe garden?

Further, adults in school groups encouraged those children who found story-writing challenging to experiment more with the task: 'You can write anything, or you could even draw it' (adult in school group, 5–6 years, Mathematics Gallery). In these and other examples, adults facilitated children's agency by suggesting various ways in which young visitors could actively engage with the task and succeed at it on their own terms.

While adults can play an important role in supporting children's agency during museum visits, it is important to acknowledge that they may also exert a restraining influence. The Helicopter Stories Approach provided opportunities to observe how children's agency might be inhibited by adults. For example, this tended to be the case when adults attempted to divert children's attention away from children's own preferred objects of focus or proactively assume responsibility for various aspects of the activity. Relevant examples include instances in which adults rewrote children's

sentences or wrote stories for them without children explicitly asking for help. This was sometimes justified as a practical necessity: 'my daughter probably could have written the story herself, but it would have taken a lot longer' (parent of six-year-old, family group, Mathematics Gallery). Such interferences can have negative implications for children's experiences and feelings. Researcher observation notes from the Mathematics gallery describe how a child looked 'frustrated' when prevented from engaging in crafting by the parents. Another young visitor reflected on their story-writing experience: 'Didn't like Daddy having to write it all up. I wanted to write it myself' (child 6 years, family group, Mathematics Gallery). While such instances were rare during the Helicopter Stories Approach, they reiterate the importance of acknowledging adults' potential to both facilitate as well as inhibit children's agency in museums, which can profoundly affect children's experiences and feelings.

The valuable insights concerning adults' role in facilitating children's agency during museum visits need to be carefully considered and taken into account by practitioners when designing experiences and activities for young children. Young children do not visit museums alone. Adults are an essential and critical part of visits to museums by young children. The research presented in this paper shows the place of adults to ensure that children can utilise and enhance their agency to engage with STEM objects in a science museum. Adults can act as critical enablers of children's enjoyment and engagement with museum objects. Therefore, it is important to ensure that adults are made aware of the significance of their active participation to facilitate children's agency. Approaches to support object engagement amongst young children in museums must take into account accompanying adults and encourage adults to become active participants in young children's museum experiences rather than bystanders or supervisors. There is a significant body of prior research that documents the importance of accompanying adults in the family to support joint family learning in museums (e.g. Ellenbogen et al., 2007) and to support children's learning in museums (e.g. Crowley et al., 2001). The present paper extends this research to also show the importance of adults for enabling children's agency in museums, thereby promoting children's engagement with museum objects and spaces.

The research indicates that there is a difference in how adults in family groups and how adults in school groups can support children's agency. There is generally a much higher number of adults per children in a family group than in a school group. In addition, compared to adults in school groups, adults in family groups are likely to share more experiences with their children, and know their children's interests, likes and dislikes more thoroughly. This likely closer connection to children and the less children present in a family group compared to a school group allows accompanying adults in family groups to provide more targeted and individualised support. On the other hand, adults in school groups might be less able to support each individual child but may be more able to link children's experiences in the museum to their experiences at school. Based on the findings presented in this paper, it appears that of the presence of at least one adult per three children is needed to adequately support children's agency and engagement in museums. This presence of at least one adult per three children is more likely to be met in family groups than in school groups. However, there is potential for the Helicopter Stories Approach to be made more suitable for school groups, such as by focusing on children sticking post-it notes on object cases, children working in pairs and children showing and acting out their stories in small groups. These kinds of adaptations could be considered in future research.

Conclusion

This paper draws on findings from research on the use of storytelling in two object-rich galleries at a science museum. The findings demonstrate that providing young children with opportunities to exercise choice, take ownership, and activate prior knowledge and interests during museum visits promotes their engagement, curiosity and enjoyment. These findings reiterate the importance of viewing and treating young children in museums as experiencers who have the need and the

capacity to exercise choice, engage in action, create and take ownership. The analysis has also revealed that adults in both family and school groups have potential to influence whether, and to what extent, children's agency in museums is facilitated or constrained, which in turn may significantly affect children's experiences and engagement during museum visits and with STEM objects.

The research methodology was constrained by general challenges and limitations of conducting research in popular museum galleries. The galleries in which the research was carried out, Mathematics and Flight, were busy at the time that the research was carried out, to recruit families. As families were not recruited in advance, the time that they had available to take part in the Helicopter Stories Approach and subsequent semi-structured interviews varied. Busy galleries, with the associated noise and commotion, also at times made observations and interviews challenging to conduct. This was particularly the case for school groups whose museum visits are inevitably characterised by high levels of noise, commotion and excitement that can make observations and asking questions difficult. Coupled with the limited time that some families and school groups had available for the activity and interviews, data collection was limited, particularly in terms of directly eliciting views from the young children.

Overall, this paper advances understanding around young children's agency in museums. It outlines how storytelling can be used to facilitate children's agency for participation, engagement, and enjoyment during visits to object-rich galleries in a science museum. The paper also highlights the important role of adults in supporting young children's agency and engagement with STEM objects. The storytelling approach can be used and adapted and utilised by museum practitioners to support engagement with STEM objects for young children in family and school groups. The approach also promotes a deeper understanding of how opportunities to exercise agency – or lack thereof – impact children's experiences in museum settings and their engagement with STEM objects.

Note

1. Since the outbreak of the COVID-19 pandemic, the museum uses an online booking system and a post-visit online profiling questionnaire. The questionnaire establishes motivation to visit, key performance indicators and key demographics, including socio-economic status. The questions used have been established internally for many years, with most of the demographic questions being based on those used by the UK Office for National Statistics.

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Appendix 1

Qualitative data analysis codes and definitions

Codes	Description of codes	Main themes	Description of themes
1a. Controlling attention 1b. Control during writing or artwork 1c. Control in performing 1d. Control over creations 1e. Children's feelings when exercising control	Mentions of children choosing where to go/which objects to look at, interact with, and write about Mentions of instances of children exercising control when creating storybooks Mentions of instances of children exercising control during performance time Mentions of children exercising control over what happens to their storybooks and how their stories are acted out Children's descriptions of how they felt when exercising control	Taking control	Children taking control over the different aspects of the activity
2a. Familiarity 2b. Interests and likes 2c. Favourite objects/activities 2d. Disciplinary knowledge (e.g. reference to a historical fact) 2e. Everyday knowledge 2f. Children's feelings when creating storybooks	Statements (either by adults or children themselves) indicating familiarity as a reason for choosing an object/story theme Statements (either by adults or children themselves) indicating children's interests and likes as a reason for choosing an object/story theme Statements (either by adults or children themselves) showing how children's favourite objects and activities informed their reasons for choosing an object/story Statements (either by adults or children themselves) showing how disciplinary knowledge informed children's reasons for choosing an object/story theme Statements (either by adults or children themselves) showing how everyday knowledge informed children's reasons for choosing an object/story theme, e.g. reference to Halloween Statements (either by adults or children themselves) describing how children felt when creating their storybooks	Activating prior knowledge and interests	Children drawing on existing knowledge and interests to inform their engagement with different aspects of the activity
3a. Adults helping children physically 3b. Adults helping children verbally 3c. Adults' statements about helping children during the activity 3d. Children's statements about getting adults' help	E.g. stapling paper, writing down children's stories E.g. using prompt questions, encouraging Adults' justifications/explanations for why they helped children with the activity Children's own comments about how getting adult help made them feel *Adults include:* *Museum staff, teachers, family members.*	Adults and children's agency in museums	Adult's role in shaping children's opportunities to exercise agency in museums