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Research Article

Navigating science education: motivations and challenges for primary school gifted children in Chinese science museums

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Abstract

This paper delves into the motivations and challenges faced by parents in the context of science museum visits for primary school gifted children in China. The study aims to provide insights into why parents of primary school gifted children opt for science museums and examines the factors influencing their decision-making process. Conducting interviews with parents visiting a university-affiliated science museum, the research explores three key themes about science education for primary school children: situated learning, reliable information sources, and parent-child interaction. Besides, the study identifies the challenge of museum fatigue among primary school gifted children visitors, emphasizing the importance of addressing children's limited attention spans and cognitive abilities when designing science museum exhibitions. The paper concludes by proposing strategies to enhance the quality of public education activities in science museums affiliated with primary education institutions. In essence, this research provides valuable insights into the motivations and challenges faced by parents, offering guidance for improving science education activities within the context of primary school settings.

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Introduction

Elevating the comprehension of science processes holds greater significance for gifted children in primary school than mere acquisition of content knowledge(Melber, 2003). Particularly in the context of augmenting science literacy among gifted children, previous research suggests that exposure to real-world experiences and engagement with open-ended problems can offer a more enriching science education(L. Andre et al., 2017; VanTassel-Baska & Johnsen, 2007). However, conventional primary schools often struggle to provide the interactive environments necessary for the optimal development of gifted children. In this regard, science museums emerge as exemplary venues for cultivating the science literacy of gifted children. Equipped with professional tools and materials, alongside adept educators, these museums offer an ideal setting for fostering the intellectual growth of gifted children in the realm of science.

Recognizing the paramount importance of museum education, scholars have undertaken empirical studies to enhance the quality of public education activities in Chinese museums. A significant demographic among Chinese museum visitors consists of minors, frequently accompanied by their parents(Feng & Tang, 2021). Among the diverse array of museums, science museums have gained popularity among parents, driven by the strong emphasis on science,

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technology, engineering, and mathematics (STEM) subjects in Chinese society(Hou et al., 2014; Ji et al., 2014; Lv & Li, 2011).

Consequently, it becomes crucial to discuss what roles science museums are acting in the cultivation of gifted children, especially in the context of China. The existing literature on this topic is extensive, and focuses particularly on two themes: the design of museum education activities and the influence of museum visits on gifted children(Lucija Andre et al., 2017). A number of studies have examined the association between well-designed education activities and children's learning experience, and strategies and technologies like augmented reality, hands-on activities, interactive games, and mobile guiding systems enhance gifted children's experience in museums(Flewitt et al., 2023; Gilligan-Lee et al., 2023; Moorhouse et al., 2019; Sung et al., 2010). As for the latter focused theme, the influence of museum visits on gifted children, has been widely investigated in empirical studies. Considerable evidence has accumulated to show that museums has positive impacts on gifted children, both academically and psychologically(Lacoe et al., 2020; Ozel & Dogan, 2013).

Taken together, these studies support the notion that visiting well-designed museums benefits gifted children in all aspects. However, little is known about how to attract gifted children to visit. Since children seldom visit museums independently, it is significant to delve into the motivations and challenges faced by parents opting to take their gifted children to museums. Recent research focusing on gifted children's museum learning experience has started to take parents as another important factor, switching from' child-centred' to'family-centred'(Lucija Andre et al., 2017; Gong et al., 2020).

Therefore, this study aims to address the gap in existing literature by focusing on a crucial aspect of science museum visits for gifted children: understanding the motivations and challenges faced by parents when choosing to visit science museums with their primary school gifted children in China. By examining the motivations and challenges encountered by parents, we aim to shed light on the underlying dynamics shaping gifted children's access to science museums and the implications for public education initiatives. This research question not only contributes to a deeper understanding of the role of science museums in impacting gifted children but also offers practical insights for museum practitioners and policymakers seeking to enhance the accessibility and effectiveness of museum education programs.

Method

Research Model

To effectively explore the intricate nuances of educational motivations driving parental decisions to visit science museums with their children, a qualitative methodology was deemed indispensable. Qualitative methods offer the flexibility and depth required to delve into the multifaceted aspects of human experiences and perceptions, which quantitative approaches may overlook (Lichtman, 2012). Specifically, the utilization of open interviews without a predefined interview outline was chosen deliberately in this research. Since the research question is highly contextual, the interview should not be influenced by researchers' prior value judgments. This approach fosters a natural and unrestrained dialogue, allowing participants to express their thoughts and perspectives organically. By eschewing preconceived notions and rigid structures, the open interview method empowers participants to articulate their unique insights and motivations authentically, ultimately enriching the richness and validity of the study's findings(Cohen et al., 2002).

Context and Participants

This study took place at a science museum affiliated with a prestigious university in Beijing, China. The museum is popular among minors and their parents in this city due to its well-designed public education activities every week, and its in-depth collaboration with local schools. Annually, during July or August, coinciding with the summer vacation, the museum extends invitations to residents of the local community, particularly pupils and their parents. Interview recruitment and data collection took place in July 2022. The researchers recruited several participants who visited the science museum with their pupil kids after two large-scale public education activities. The pupils were in a special

talent cultivation program, and were regarded as gifted children by their school teachers. In selecting interviewees, the study takes into account the heterogeneity of cases, aiming to cover pupils' parents and to present a comprehensive view of museum education from different perspectives. Table 1 provides basic information about the respondents.

Data Collection

Each interview was an open face-to-face interview lasting 20-40 minutes.The topic of the interviews was the educational motivation for taking children to visit science museums. The researchers did not assume any position and did not give any orientation guidance to the interviewees. After obtaining the informed consent of all respondents, the researchers obtained the original audio recording data, then converted it into text data, and encoded the text data for induction analysis. In order to verify and correct the analysis results, the researchers recorded the parent-child interaction behaviour through the participatory observation method under the premise of obtaining parents' consent. The researchers invited two more interviewees to check the theoretical saturation of current data and found that no new key information was uncovered, and existing research questions had been answered. There is no direct interest relationship between the researchers and the interviewees. Interviews were conducted one-on-one, ensuring that the responses of different interviewees would not interfere with one another.

Table 1. Basic information of interviewees

Numbering	Identity	Age of the Child	Occupation
P01	Mother	7	Writer
P02	Father	9	Engineer
P03	Mother	10	Primary school teacher
P04	Mother	10	Product Manager
P05	Mother	10	Housewife
P06	Father	12	Museum staff
P07	Father	13	University professor
P08	Mother	13	University professor
P09	Mother	13	Programmer

Data Analysis

We engaged a grounded theory approach to data analysis, to identify the motivations and challenges hidden in the interview materials. Interview transcripts were imported into qualitative data analysis software NVivo 14 for coding analysis. We adopted an open, axial, and selective coding scheme to analyze the open interview data(Corbin & Strauss, 2014). Open codes flagged the details of beliefs, norms, and practices about visiting science museums with their children. Axial codes were used to build relationships between open codes in grounded theory, flagged the subconscious motivations and considerations of the interviewees. Selective codes were used to conceptually thread together axial code relationships, building our theoretical explanation framework of the finding and discussion section(Corbin & Strauss, 2014; Leyva et al., 2021). Table 2 provides examples of codes that emerged in our analysis.

Table 2. Examples of open, axial, and selective codes

Open Codes	Axial Codes	Selective Codes
Visible objects	Situational environment	Motivation: Situated Learning
Stories or explanations		
Visitor Route		
Interaction with docent	Interaction	
Interaction with equipment		
Multi-sensory experience	Multi-sensory experience	
Trust in museums	Positive: professional presenter	Motivation: Reliable Information Resource
Trust in research universities		
Complaints about information sources like social media	Negative: complex sources	
Shared topics	Communication	Motivation: Parent-child Interaction
Equal relationship		
Compensation for busy work	Time together	
Public behaviour		
Creating delightful memories	Family leisure	
Absent-minded	Psychological	Challenge: Museum Fatigue
Information-overloaded		
Tired	Physical	

Findings and Discussion

We organize our findings in four sections according to the selective codes of the qualitative data analysis(Table 2). Three sections address the motivation of parents visiting science museums with gifted children, including situated learning, reliable information resource, and parent-child interaction. The last section addresses the challenge the interviewees meeting during their visit.

Motivation 1. Situated Learning

Most interviewed parents emphasised that science museums offer ideal opportunities for situational learning, surpassing the traditional confines of textbooks. Situated learning theory asserts that knowledge is an activity that emerges from social situations, rather than a static object. It is an interactive process that develops through the dynamic interplay between individuals and their environment(Sawyer, 2005). Science museums provide an immersive environment conducive to situational cognition and informal science learning. A significant aspect of situational learning is the incorporation of narratives, which play a vital role in knowledge transmission and discovery. Stories aid children in documenting the path of the discovery process and provide a meaningful framework for retaining learning content(McLellan, 1994). Popular science explanations within science museums often revolve around the historical background of the exhibits or anecdotes about renowned scientists. Through these narratives, children absorb scientific knowledge and swiftly assimilate, establish connections, and apply that knowledge. One interviewed father aptly expressed:

A few days ago, I watched a documentary about the Cambrian period with my son. There are trilobites, strange shrimp and hallucigenian. While all the children were screaming, my son whispered to me that we had seen their fossils at the science museum yesterday（another science museum in a university）. After watching the documentary, my son told me that we would go to the science museum again in a few days. At that time, he did not understand the hallucigenian. After watching the documentary, he remembered and suggested that we should go to see the fossil again to confirm.(P02)

The science museum played a pivotal role in facilitating the acquisition of situational knowledge in the field of palaeontology for the son. Through his visit to the museum, he immersed himself in a context that allowed him to grasp this knowledge in a tangible and practical manner. Subsequently, when he encountered a new context while watching a documentary, he seamlessly made connections and effectively applied the scientific knowledge he had previously acquired.

Another significant aspect of situational cognition is the concept of legitimate peripheral participation. According to the perspective of certain anthropologists, learning is a process of legitimate peripheral participation within a community of practice(Lave & Wenger, 1991). In the case of children's visits to science museums, they are not mere passive recipients of information. Instead, they actively engage and participate to some extent in the community of practice established by the "Science Museum Exhibition." Through interactions with knowledgeable docents and their involvement in science-related activities provided by the museum, children become integral participants in this vibrant learning community. As expressed by one of the interviewed mothers:

"Look, listen, touch and think" is not only the best magic weapon for children to understand works and art in museum exhibitions, but also the four necessary skills for their future study -- careful observation, patient listening, feeling with body, thinking with heart... The child enjoyed answering the questions of the docents. During this process, she was very excited and proud. She could feel that she had participated in the exhibition process.(P01)

The girl had legitimate peripheral participation by interacting with docents. Although her scientific knowledge did not yet support her participation in the community of practice of science fairs as a centre member, this participation helped her engage in active learning.

Motivation 2. Reliable Information Source

Another compelling motivation identified among the interviewed parents for their visits to science museums with their children is the museums' ability to provide high-quality professional information, which plays a crucial role in fostering children's scientific literacy and honing their information processing skills. Remarkably, this parental viewpoint aligns with the findings of numerous researchers. Several scholars emphasise the significance of information as a fundamental component of scientific literacy and recognise it as a legitimate objective of science museums. This recognition stems from the fact that science exhibits within museums present information in a coherent and comprehensive manner(Levinson, 2010; Navas Iannini & Pedretti, 2022). For example, the case museum interacts very closely with the Department of the History of Science at the university. Since its opening, a number of permanent exhibitions and special exhibitions have been curated by faculties from the Department of the History of Science. In addition, students from the School of Materials, the School of Fine Arts, and the School of Architecture of this research university also participated in museum activities such as the restoration of scientific instruments and the exhibition of scientific photography. The participation of these professors and college students in the design of the case science museum's exhibitions enhances the credibility of the information.

When discussing the pursuit of science literacy, scholars put forth four primary arguments. These arguments include the practical argument (acknowledging the necessity of basic scientific knowledge for navigating everyday life in our technology-driven society), the democratic argument (highlighting the importance of citizens' ability to engage with complex science-related issues), the cultural argument (recognising science as an integral part of humankind's cultural heritage), and the economic argument (emphasising the essential nature of science literacy for various professional roles)(Henriksen & Frøyland, 2000). Of particular relevance to visiting science museums is the cultural argument, which centres on the development of children's science literacy. Engaging with science exhibitions can profoundly influence children's understanding of culture and its intersection with scientific concepts, as expressed by one of the interviewed mothers:

The Science Museum welcomes all the people in the world who seek the unknown with an inclusive attitude as much as possible. It provides a three-dimensional and intimate aesthetic scene of freedom. The diversified cultural power and rich content are enough to nourish children spiritually. In this process, children will not only experience the accumulation of

knowledge imperceptitiously, but will have more and more of their own thinking, and constantly try to use more diversified ways to understand the world.(P08)

Science museums are widely recognised as reliable sources of information on science-related topics, particularly compared to the vast and often unfiltered content available on the Internet. Several parents expressed concerns about the quality and reliability of information found online, particularly for children who may lack the necessary discernment skills. These parents emphasised the importance of exposing their children to information that has been carefully curated and vetted by professionals. The case museum holds museum salon activities from time to time, inviting scholars in the fields involved in the exhibition to give popular science lectures. The salon is conducted online and offline simultaneously. Offline visitors can visit the exhibits after listening to the salon, while online visitors can easily understand scientific knowledge without space restrictions. As one father aptly noted, science museums affiliated with universities are particularly trusted sources of information:

Thanks to the development of the Internet, all kinds of information is readily available. But there is so much wrong and misleading information in the mix that it can be difficult for a child to sort out what is trustworthy from various websites and apps. Even I might intentionally turn out for my daughter to rely less on the Internet; her life turns and knowledge pools could easily be mixed out with mixed information. I like to bring her to the Science Museum. Long-term exposure to this kind of scientific knowledge will bring subtle help to improve her ability to information discrimination and judgment, which is of great significance to her lifelong development.(P07)

In conclusion, parents widely recognise science museums as a trusted and valuable source of information, believing that continuous exposure to scientific knowledge contributes to the enhancement of their children's scientific literacy. Additionally, science museums also play a subtle yet crucial role in fostering information literacy, a vital skill in the digital era dominated by the Internet. By engaging with the exhibits and educational activities, children develop critical thinking and information evaluation skills that are essential for navigating and making informed judgments in the vast sea of online information. Hence, science museums serve as catalysts for scientific and information literacy, equipping children with the necessary tools to thrive in the modern age of technology and information abundance.

Motivation 3. Parent-child Interaction

Nearly all interviewed parents expressed their belief that visiting museums provides a high-quality avenue for parent-child interaction. The dynamics of parent-child interaction within the museum context are influenced by various tangible and intangible factors, some of which may be unforeseen. Factors such as exhibit design, learning support activities, teaching techniques, technical assistance, and others can potentially impact the effectiveness of parent-child interaction(Bourque et al., 2014). Researchers have suggested that elements like the positioning of exhibit instructions, the height of display stands, and the incorporation of interactive elements can influence the quality of parent-child interaction in museums. For instance, when carrying out the exhibition of Da Vinci's flying machinery, the case museum organized parent-child painting activities about spaceflight, inviting parents and children to create paintings according to their own understanding of the exhibits. Furthermore, studies have analysed the positive effects of guidebooks, supplementary instructions, and games on fostering meaningful engagement between parents and children(Gutwill & Allen, 2010). A father interviewed reported:

My wife and I are very busy at work. On weekdays, my child's grandparents take care of him. We thought a visit to the Science Museum would be a better way to spend our weekends than shopping and eating in a crowded mall. When we visit a museum, we reach a more equal state with our children. We are both curious about science. Then the exhibits also give us something to talk about, and sometimes on the way home, we will keep exchanging our feelings about the visit.(P02)

Parents firmly believe that museum visits offer valuable opportunities to spend quality time and enhance parent-child interaction. Museum visits have proven to have a positive impact. In fact, museums are regarded as' places where all families are welcome and learn together through play and hands-on activity' by some scholars and professionals(Willard et al., 2019). Science museums provide an environment where families can develop their

own'juicy questions' that no one knows the answer to, and facilitate elaborative talk between parents and children(Fender & Crowley, 2007; Gutwill & Allen, 2010).

Besides, parents interviewed believed that visiting a science museums is an good opportunity to teach children how to behave themselves at public sites.

During museum visits, I teach my daughter to be quiet, to raise her hand when appropriate, and not to touch the exhibits. I think it is necessary for a well-mannered modern citizen to behave in public. Sometimes I verbally teach her to do this at home, and she doesn't take it very well. When we returned from our last visit to the science museum she told me she understood why I had asked her to be as quiet as possible in the museum, because her experience had been greatly affected by two young boys fighting loudly. Through this personal experience, she learned to adjust her own behavior and to be considerate of other people's feelings.(P05)

The statement provided by the interviewee highlights a crucial aspect of parental motivations for visiting science museums with their primary school gifted children: the opportunity to instill important behavioral lessons in a public setting. By setting clear expectations for behavior during museum visits, such as being quiet, raising hands, and refraining from touching exhibits, the interviewee demonstrated a commitment to fostering responsible citizenship and respect for public spaces. Moreover, the interviewee's reflection on her daughter's learning experience following a disruptive incident involving other visitors underscores the value of experiential learning in reinforcing behavioral norms(Rossano, 2012). Through this personal encounter, the interviewee's daughter not only gained insight into the consequences of disruptive behavior but also developed empathy and consideration for others' feelings. Overall, this testimony elucidates the role of science museums not only as venues for intellectual enrichment but also as settings for social and behavioral education, wherein children learn valuable lessons in civility and respect for others.

Challenge: Museum Fatigue

Museum fatigue refers to the subjective experience of decreased interest, mental or physical fatigue, or boredom reported by visitors during or after viewing an exhibition(Bitgood, 2009). This phenomenon has been a topic of concern among museum scholars worldwide, particularly in relation to children. There are several factors contributing to museum fatigue in children. Firstly, children have limited information processing capacity during cognitive processes, making it challenging for them to sustain attention for extended periods(Falk, 2006). For instance, studies on museum fatigue have indicated that adult visitors' interest tends to decline after 30-45 minutes of viewing(Falk et al., 1985), while children's attention spans may be even shorter. Reflecting on this, one interviewed father shared his perspective:

My son is always very energetic and curious at the beginning of the exhibition. But if the time is too long, his mind will wander and he will get bored. Once, when we visited an exhibition with a tour guide, the guide lasted for more than one hour. My son simply did not follow the docent and sat on the ground in a corner by himself.(P06)

The interviewee's narrative provides a vivid illustration of the challenges posed by museum fatigue, particularly in the context of children's limited attention spans. The interviewee's son initially exhibited enthusiasm and curiosity upon entering the exhibition, which aligns with typical behavior observed in children at the outset of museum visits. However, as the duration of the exhibition extends beyond the child's cognitive threshold, signs of fatigue and disengagement become apparent. The interviewee's description of their son's wandering attention and eventual withdrawal from the tour group resonates with existing research on museum fatigue, which highlights the role of exhibition duration and content complexity in influencing visitors' cognitive load and attentional resources(Kim et al., 2020).

In addition to limited knowledge reserves, children often have a partial understanding of the contents presented in museum exhibitions. This lack of comprehension can lead to feelings of boredom, as the exhibits fail to provide the necessary intellectual stimulation.

The science museum exhibit was too much for my son. He had no basic knowledge of physics or chemistry, and except for a few questions deliberately prepared by the docent to appeal to the pupils, everything was completely beyond his comprehension. He is reluctant to visit the science museum again.(P04)

The interviewee's account highlights the critical role of children's prior knowledge and comprehension levels in shaping their museum experiences. The statement underscores the challenges encountered by children who lack foundational understanding in scientific concepts, such as physics and chemistry, when navigating complex museum exhibits. Without a solid grasp of the subject matter, children may struggle to engage meaningfully with the content presented, leading to feelings of frustration and disinterest(Maxwell & Evans, 2002). This narrative underscores the importance of providing supplemental resources and guided experiences to support children's understanding and engagement in museum settings, thereby fostering more enriching and rewarding learning experiences for all visitors.

Conclusions

Through in-depth analysis and interpretation of empirical data, we have uncovered a nuanced understanding of the factors influencing parental decisions to engage in museum visits with their gifted children, particularly within the context of China. Through in-depth analysis and interpretation of empirical data, we have uncovered a nuanced understanding of the factors influencing parental decisions to engage in museum visits with their gifted children, particularly within the context of China.

The findings emphasize that science museums, such as the case museum in our study, serve as valuable spaces for situational learning, contributing to children's knowledge expansion and understanding through hands-on exhibits and interactive activities. The reputation of the case museum, located in a research-intensive university, ensures the quality of information provided to visitors. Moreover, the involvement of professors from the university in the design of exhibitions, along with the majority of docents being faculty members or graduate students, further enhances the quality of public education within the museum. This collaboration between top-tier research universities and science museums strengthens the credibility and accuracy of the scientific content presented, attracting more parents and visitors.

While our research acknowledges the numerous benefits of science museum visits, it also highlights a significant challenge reported by parents, known as museum fatigue. The overwhelming number of exhibits and information can be exhausting, particularly for young children. To address this challenge, we suggest that science museums, including the case museum, consider implementing strategies such as selectively covering exhibits that align with children's understanding and providing breaks or resting areas to alleviate fatigue.

Based on our empirical findings, we propose several recommendations to enhance the public education activities of science museums, including those affiliated with research-intensive universities. Strengthening collaboration with schools to align informal learning experiences with the formal curriculum will reinforce key concepts for children. Furthermore, ensuring the quality and validity of scientific content presented in science museums, in collaboration with renowned research universities, will provide visitors with reliable and trustworthy knowledge. The high level of scientific literacy possessed by museum staff and docents, who are faculty members or graduate students, contributes to effective information conveyance and enables them to answer visitors' questions more comprehensively.

In summary, our research provides valuable insights into the motivations and challenges faced by parents during visits to science museums, including the case museum located in a research-intensive university. These insights can inform science museum practitioners, educators, and policymakers in creating more engaging and accessible experiences for families, ultimately fostering a deeper appreciation for science and learning among gifted children. By advocating for evidence-based strategies to mitigate museum fatigue and enhance visitor experiences, our study provides actionable recommendations for scholars and policymakers. From a theoretical perspective, our study contributes by underscoring the potential of science museums not only as venues for knowledge dissemination but also as platforms for fostering scientific literacy and enthusiasm among diverse audiences, including gifted children and their families. From a policy perspective, our findings underscore the importance of strategic partnerships between

educational institutions, museums, and policymakers to optimize the impact of informal learning experiences on children's cognitive development and scientific understanding.

Limitations

However, it is important to acknowledge the limitations of our study, as the findings are based on a specific sample of parents from one science museum in China and may not be generalizable to other populations or cultural contexts. Future research could expand the scope to include a larger and more diverse sample, encompassing various regions and cultural backgrounds, to obtain a comprehensive understanding of the motivations and challenges faced by parents visiting science museums worldwide.

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