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Museum Experience and Reasoning about Evolution: A Case Study of Educated Indonesians

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ABSTRACT

This qualitative case study examines how educated Indonesians reason about evolution and the influence of informal learning experiences at a natural history museum on their reasoning. Two participants who engaged in free-choice museum visits were compared with two others who did not visit the museum. Interviews were analyzed using a coding scheme that identified three reasoning patterns: Informed Naturalistic Reasoning (INR), Novice Naturalistic Reasoning (NNR), and Creationist Reasoning (CR). Findings indicate that museum-goers predominantly employed INR, demonstrating a clearer understanding of evolution through concepts like gene mutation and inheritance. In contrast, non-museum-goers more frequently used NNR and CR, reflecting intuitive and religious perspectives. The study highlights the role of museums in facilitating scientific understanding and suggests that informal learning environments can effectively complement formal education in fostering scientific literacy.

Keywords: *evolution, informal science learning, museum, scientific literacy, quality education*

INTRODUCTION

Understanding how individuals reason about complex scientific concepts like evolution is crucial in science education. Evolution remains a challenging concept to grasp due to various factors, including pre-existing misconceptions, mistrust of and denial of science, cognitive obstacles, language and terminology, religious worldviews, and cultural or societal pressures (Hanisch & Eirdosh, 2023; Hartelt et al., 2022; Newall & Reiss, 2023). Research indicates that naïve theories and intuitive psychology significantly impact individuals' understanding of evolution. Naïve theories consist of coherent sets of rules or knowledge that people learn and believe about their physical world through personal and direct experience with their surrounding environment (Scheuch et al., 2021; To et al., 2017). These theories can lead to concepts such as essentialism, teleology, and intentional reasoning in the understanding of evolution (Guilfoyle & Erduran, 2021; Tenenbaum et al., 2015).

Essentialist views hold that individual organisms are unique and static, thus evolution occurs through the transformation of the individual organism rather than through variation within species (Shtulman & Schulz, 2008). Teleological reasoning posits that biological changes occur in response to organisms' needs, such as the belief that giraffes evolved longer necks to reach higher branches (Gresch, 2020). Intentional reasoning suggests that evolution results from organisms' desire and effort to adapt their bodies to better suit their environment, such as the belief that some giraffes evolved longer necks because they "wanted" to, and others did not (Tenenbaum et al., 2015).

Sociocultural perspectives also influence individuals' thinking about evolution. Creationist reasoning, which holds that a deity created the universe and the process of evolution, is one such view (Barnes et al., 2017; Guilfoyle & Erduran, 2021; Pennock, 2023). This view is prevalent among both religious and nonreligious individuals (Tenenbaum et al., 2015; Pennock, 2023). Regions with large religious populations, such as the Asia-Pacific, including Indonesia, are likely to adopt creationist views (Pew Research Center, 2012).

These misconceptions contrast sharply with evolutionary theory and thus cause significant misunderstandings about evolution. Research has shown that individuals frequently blend their understanding of evolution by incorporating multiple epistemologies in their reasoning based on the ideas mentioned above (Hohenstein & Tenenbaum, 2023; Parraguez et al., 2021; To et al., 2017). This combination of ideas, which varies depending on the organism being discussed, is referred to as target-dependent reasoning (Tenenbaum et al., 2015).

In recent decades, there has been increasing interest in how informal learning environments, such as science and natural history museums, contribute to the public understanding of evolution (Friedman, 2020; Groß et al., 2019; Massarani et al., 2022; Nesimyan–Agadi & Assaraf, 2022). Museums offer unique learning opportunities through free-choice activities, where visitors engage with exhibits at their own pace and according to their interests (Bell et al., 2009). These environments provide a context-rich setting that can support the construction of scientific knowledge, potentially leading to shifts in understanding and reasoning about complex topics like evolution (Pickering et al., 2012; Massarani et al., 2022). Studies have shown that museum visits can significantly impact visitors' conceptual understanding of evolution and address common misconceptions (Evans et al., 2009; Groß et al., 2019). However, while existing research has focused on the public understanding of evolution, there is limited exploration of the nuances of individual reasoning processes about evolution.

This study aims to address this gap by investigating how individuals reason about evolution after engaging in informal learning experiences at a natural history museum. The museum is designed to showcase the natural history of living things from the ice age to the present and future. Specifically, the research questions guiding this study are:

1. How do participants reason about evolution concepts in various organism cases?
2. How does the museum experience influence participants' reasoning about evolution?

Preliminary research suggests that a single museum visit can result in modest changes in visitors' scientific views on evolution (Lelliott, 2016). By employing a qualitative case study approach, the study seeks to capture individual experiences and reasoning patterns. Through this study, we hope to contribute to the broader discourse on the effectiveness of informal science education and its potential to complement formal education in fostering a more scientifically literate society.

METHODS

Four individuals were purposefully selected to explore variations in reasoning about evolution among educated Indonesians. Participants were aged 25 to 30 to maintain cognitive and educational homogeneity, ensuring they had completed higher education and possessed the intellectual maturity to engage with complex scientific concepts. This age range also represents young adults who have completed formal education but may still be refining their scientific reasoning through informal learning. All participants held at least a bachelor's degree from universities in Indonesia or Malaysia. All participants were Muslims, reflecting Indonesia’s status as the country with the largest Muslim population in the world (Pew Research Center, 2012). Informed consent was obtained from all participants, including agreement for voice recording and the use of data for research reports. Participant names in this study are pseudonyms.

Two participants visited the nearest natural history museum, while the other two did not. The museum features various exhibitions about the region’s past, present, and future, with one exhibit, “The Nature of the Region”, particularly relevant to evolutionary concepts. This exhibition presents the region’s natural history, including plants, animals, geology, geography, and climate from the Ice Age to the present. The participants who visited the museum did so in a free-choice learning setting, with no instructional directions, worksheets, or any other tasks. They were free to choose any exhibition that interested them and could spend as much time at the museum as they wished.

A week after the museum visit, all four participants were interviewed on the same day. The interview included five questions adapted from Tenenbaum et al. (2015) and To et al. (2017) to explore participants’ reasoning about some evolutionary cases (see Table 1). These questions focused on species origins, natural selection, environmental changes and their consequences for organisms, extinction, and species-environment fit.

Table 1. Interview questions adapted from Tenenbaum et al. (2015) and To et al. (2017).

No	Organism	Interview Questions	Evolution Concept
1	Tiger	The last Tasmanian tigers died in the 1930s, making the species extinct. This marsupial, similar to kangaroos, looked like a wolf and had stripes on its back. Why do you think wolf-like marsupials were only found in Tasmania?	Species origin; Species-environment fit
2	Seals	In the next few hundred years, global warming will cause the ice caps to melt, making the Arctic much warmer than seals are used to. What do you think will happen to the seals in this scenario?	Effect of environmental changes; Species-environment fit
3	Finches	The Galapagos Islands, located off the coast of South America, are home to a species of finch that scientists have studied. Initially, they found that the finches had small beaks. After a severe drought wiped out most of the plants that produce small seeds, only tough seeds requiring larger beaks were abundant. When scientists returned a few years later, they found that more finches had larger beaks. How do you explain the increase in finches with larger beaks?	Natural selection

4	Humans	Scientists believe that humans and chimpanzees shared a common ancestor as recently as 5 million years ago. How do you think both humans and chimpanzees could have evolved from the same ancestor?	Species origin
5	Algae	Yellowstone Lake hosts many types of algae, but scientists discovered a kind of algae in this lake that is not found anywhere else. These algae first appeared 14,000 years ago when the climate was warming. How do you think this new kind of algae came to exist in Yellowstone Lake?	Species origin

Interviews were recorded, transcribed, and coded into three primary reasoning patterns using a coding scheme adapted from To et al. (2017). Each participant's reasoning for each question was coded into one or more of the following: informed naturalistic reasoning (INR), novice naturalistic reasoning (NNR), and creationist reasoning (CR). These codes were not mutually exclusive, allowing participants to employ multiple reasoning categories in a single explanation, such as INR/NNR or NNR/CR. Table 2 provides examples of these categories and their subcategories, along with operational definitions for each.

Informed Naturalistic Reasoning (INR)

Responses indicating the idea that an organism evolves because of "naturally occurring variations within a population of species" were coded as INR (To et al., 2017). Concepts such as inheritance, common ancestry, evolution, and extinction fall under this category. Species variation occurs through genetic mutation or sexual recombination, which can be beneficial, neutral, or harmful to the individual. Individuals with beneficial traits are more likely to survive and reproduce, leading to a population with a higher frequency of these advantageous traits over time, while individuals lacking beneficial traits are more likely to become extinct.

Novice Naturalistic Reasoning (NNR)

Responses reflecting intuitive or naïve evolutionary concepts were categorized as NNR. In this reasoning framework, individual organisms are perceived as "intentional agents who evolve as needed for survival" or as entities that change to better suit their environment (To et al., 2017). Concepts included in this category encompass static adaptation, intentionality, reaction to external factors, movement, similarity, hybridization, teleology, and essentialism.

Creationist Reasoning (CR)

Responses suggesting that a creator or supernatural being is responsible for evolution were categorized as CR. This category predominantly includes religious concepts and the denial of evolutionary theory, either explicitly or implicitly. The code "religious" was assigned to reasoning that attributes evolution to divine intervention, while the code "denial" was used for responses that reject the information or statements presented in the interview questions (e.g., "I don't think it's true").

Table 2. Coding scheme categories and definitions for evolution concepts from To et al. (2017)

Evolution Concept	Operational Definition
Informed Naturalistic Reasoning (INR)	
Extinction or death	References to organisms' inability to adapt, or specific mentions of extinction.
Inheritance	References to traits or characteristics being inherited. Simply mentioning reproduction is insufficient; there must be a specific indication that a certain trait has been passed on to the next generation.
Evolution	References to the underlying mechanisms of evolution. Merely using evolutionary terms without explanation is not included in this category.
Common ancestor	Mentions of a shared ancestry, accompanied by an explanation.
Novice Naturalistic Reasoning (NNR)	
Static adaptation	References to organism-environment fit.
Intention	The use of mental states or intentions to explain changes.
Similarity	References to similarities between organisms.
Reaction or mutated	References to organisms' reactions to external factors.
Movement	Organisms are described as moving either through their own actions, by another organism, or due to land movement.
Teleological	Suggests that change occurs with a specific end-goal in mind.
Essentialist	References to species stability or the idea that a species has always existed as it is.
Hybrid	References to the interbreeding of two unrelated species.
Evolutionary term	Use of terms like "evolve," "adapt," "adaptation," or "evolution" without further explanation.
Creationist Reasoning (CR)	
Religious	References to God or a supernatural being as the cause of evolution.
Denial	Participant rejects information about evolution presented in the questions.

RESULTS AND DISCUSSIONS

This study aims to explore how the museum experience helps individuals' understanding of evolution and how their reasoning compares to those who did not engage in informal learning at a museum. To this end, we present two cases. First, we examine the reasoning of participants who did not visit the museum (referred to as the naturalistic participants). Second, we analyze the reasoning of participants who frequently visit informal science learning venues, such as science centers, botanical gardens, aquariums, and natural history museums (referred to as the museum-goer participants). Following these case presentations, we discuss the use of multiple epistemologies in reasoning about evolution, target-dependent reasoning on evolutionary topics, and the significance of museum visits in enhancing understanding.

Individuals' Reasoning towards Evolution: The Naturalistic Case

Tina, a participant who did not visit the museum, holds a master's degree in visual design from a Malaysian university. Although she is well-educated, her background in science is limited. Table 3 presents Tina's reasoning about various evolutionary concepts, along with the corresponding codes assigned to each aspect of her reasoning.

Table 3. Tina's reasoning about evolution.

Questions	Tina's Reasoning	Code
Tiger	The [tigers] population grew in Tasmanian area, and since it's extinct, people *cannot bring them outside the area*. So the Tasmanian Tiger could only be found in Tasmania.	NNR: movement
Seals	They will survive. At first, *they're going to migrate from one place to another*. But as time goes by, they will *adapt* to the new habitat.	NNR: movement, evolutionary term
Finches	Because of *evolution*, maybe. But I am not sure how the beak's size can change from small to large and what aspects can make it happen.	NNR: evolutionary term
Humans	*Evolution. Darwin's theory*. We (chimps and humans) *share same DNA*, and If I'm not mistaken, they also have *same brain size*.	NNR: evolutionary term, similarity
Algae	Because of global warming, Yellowstone Lake becomes warm again, so the new kind of algae can reproduce. Maybe Yellowstone Lake *has a specific component that could not be found anywhere else.*	NNR: static adaptation

Tina consistently used intuitive reasoning (NNR) across the five questions concerning evolution for different organisms. Her understanding of species origin was based on the ability of organisms to migrate to new locations, as illustrated by her reasoning that Tasmanian tigers could only be found in Tasmania because they could not be transported to other areas, or that seals would migrate to different habitats in response to global warming. Additionally, Tina frequently used evolutionary terms, such as "adapt," "evolution," and "Darwin's theory," but struggled to explain how these processes occur with regard to seals, finches, and humans (coded as Evolutionary term). Specifically, in discussing humans, she noted similarities between humans and chimps but did not explicitly mention a shared common ancestor (coded as Similarity). For the algae question, Tina reasoned that algae could survive for thousands of years due to a suitable environment (coded as Static adaptation), clearly demonstrating a view of species-environment fit.

The second naturalistic participant, Ray, is a doctoral student in engineering, thus possessing a high level of education and a strong science background. Table 4 presents Ray's reasoning about evolutionary concepts and the codes assigned to each aspect of his reasoning.

Table 4. Ray's reasoning about evolution.

Questions	Ray's Reasoning	Code
Tiger	In my opinion, *wolf-like animals can be found not only in Tasmania but also in other parts of the world*. However, factors such as *food supply, weather, and habitat conditions shape the wolf*. Hence, the wolves in Tasmania area become Tasmanian tigers.	CR: denial. NNR: static adaptation.

Seals	If conditions worsen, *the seal population will significantly decrease*. It may happen because global warming will change the surrounding weather of the seals' habitat. As it becomes warmer, *not all of the seals can survive*, that's why the number of the seals will be going down.	INR: extinction.
Finches	Why the beaks of the finches become larger may be explained by Wolff's law. According to Wolff's law, the animal or human bone has a system that senses the external loads. *When the loads become constantly larger, it will inform the bone builder cell to build a stronger/larger in order to make a balance reaction to the external loads.*	NNR: reaction or mutated.
Humans	I think *we do not have a similar ancestor with the chimps* since we can find chimps and humans in a similar area. Although it has a different ancestor, *we have several characteristics that may make us think we have a similar ancestor*. One of them is we have a skeletal system that is identical to those of the chimps.	CR: denial. NNR: similarity.
Algae	I think, *when the god firstly put the algae in the world, it come with a similar characteristic*. However, *the place where the algae growth shapes* the algae thus each of them has different characteristics. Meanwhile, the reason why the algae that first appeared 14,000 years ago has the same characteristics with the algae that we can find nowadays is because the algae have an ability to survive on a different climate.	CR: religious. NNR: static adaptation.

Ray exhibited inconsistent reasoning regarding evolution. His predominant reasoning involved a combination of creationist reasoning (CR) and intuitive reasoning (NNR). This mixed approach was evident in his responses to questions about tigers, humans, and algae. Ray rejected the idea that Tasmanian tigers could only be found in Tasmania and questioned the notion that humans and chimps could share a common ancestor, although he acknowledged some similarities between the two species. He also explicitly invoked a religious concept (CR) when explaining that God placed algae in various locations, not just in Yellowstone Lake. He applied a similar rationale to the Tasmanian tiger case, though he did not explicitly mention "God" in that context.

In terms of intuitive reasoning, Ray strongly adhered to the concept of static adaptation, explaining that specific species are suited to particular environmental conditions. He used this reasoning to describe why algae and Tasmanian tigers are found only in their respective locations. Additionally, Ray utilized the idea of reaction or mutation to explain how finches adjust their physical characteristics, drawing an analogy to how human bones adapt to external loads. In contrast, Ray employed scientific reasoning in his response to the seals question, predicting the extinction of the species due to their inability to adapt to environmental changes (coded as INR: extinction).

Individuals' Reasoning towards Evolution: The Museum-Goers Case

Serena, who visited the natural history museum a week before the interview, holds a bachelor's degree in communication from a Malaysian university. Although she is educated, her formal education did not include science-related knowledge. Table 5 presents Serena's reasoning about evolution concepts along with the assigned codes for each of her responses.

Table 5. Serena’s reasoning about evolution.

Questions	Serena’s Reasoning	Code
Tiger	There must be something or event that makes the Tasmanian tiger extinct (although I don’t know the reason). Wolf like marsupial could only found in Tasmania because *they are the result of genes mutation of Tasmanian tiger that is endemic to Tasmania Island*.	INR: gene mutation / inheritance
Seals	The seals will be extinct due to global warming, or they still exist but not in the form that we know at this moment (*global warming may trigger the genes mutation and cause them to evolve into new type of animal*).	INR: gene mutation
Finches	Originally, the beaks were on the small side, but *there must be some finches that have larger beaks (size variations). Those finches with small beaks were unable to survive and eventually extinct (because they can’t eat the tough seed). Conversely, finches with larger beaks survived. They inherited these genes. As a result, only this kind of finches found at the Island many years later.*	INR: extinction, inheritance, evolution concept
Humans	Chimps and humans have similar characteristics. *Even though the size of the brain is different, the DNA and bone structure are similar. Both are also walking upright with two legs (unlike other primates that still use “hand” to walk). This shows that human and chimps share common ancestor.*	INR: common ancestor
Algae	Evolution could appear due to changes in the environment. In this case, warmer climate is the reason. *The change in environmental heat causes genes mutation in these algae and resulted in the new type of algae that could only found in Yellowstone Lake.*	INR: genetic mutation (somatic mutation)

Despite not having formal science courses in her education, Serena consistently demonstrated scientific evolutionary concepts (INR) in her reasoning during the interview following her visit to the natural history museum. Her explanations of the algae, tiger, finches, and seals cases were grounded in themes of gene mutations and inheritance. Serena showed an understanding of evolution through both hereditary mutations (where beneficial genes are inherited and present in all cells throughout an organism's life) and somatic mutations (where beneficial gene changes occur in specific cells at certain times during the organism's life). In her explanation of the finches’ case, she provided a comprehensive account of evolution, including the extinction of species with less favorable traits, the inheritance of beneficial traits in subsequent generations, and gene mutations. Additionally, she applied the concept of common ancestry when discussing humans and chimps, noting their similarities as evidence of shared ancestry.

The second museum-goer, Yoshi, is a graduate student majoring in science education. Consequently, he has a strong educational background and substantial science knowledge. Table 6 presents Yoshi’s reasoning about evolutionary concepts and the corresponding codes assigned to his responses.

Table 5. Yoshi's reasoning about evolution.

Questions	Yoshi's Reasoning	Code
Tiger	Because *Tasmanian tigers (before they extinct) inherit the wolf-like marsupial genes and these generations stayed at Tasmanian* and *were not able to migrate from the area so that these animals unique to Tasmania*.	INR: inheritance. NNR: movement.
Seals	*The stronger seals (those who can survive warmer environment) will inherit these particular genes to the next generation seals so that they will be able to live in warmer conditions in the future. Then, we can only find seals who can live in warm condition, as the predecessor (who used to live in cold environment) were extinct.*	INR: inheritance, extinction, evolution.
Finches	After the drought, *the population of small beaks finches has decreased due to their inability to feed themselves with tough seeds. On the other hand, the minority of large beaks finches could survive, and they could mate and resulted in more large beaks species, because they inherit the genes of large beaks.* The larger beaks finches, the more mate happened, the more new generations of large beaks exist, which scientists found several years later.	INR: extinction, inheritance, evolution.
Humans	*They share a lot of commonalities in the physical body and skulls.*	NNR: similarity
Algae	When the climate was warming 14,000 years ago, *there were some algae that could survive and lived in warmer environments. They reproduced and resulted in a warmer-survivor algae population in Yellowstone Lake. And these kinds of algae can survive until nowadays.*	INR: gene mutation / inheritance

Yoshi employed scientific evolutionary reasoning (INR) for nearly all the questions, except for the human question, following his visit to the natural history museum. His reasoning prominently featured themes of extinction, inheritance (hereditary gene mutations), and evolution in his responses to the tiger, seals, finches, and algae questions. He explained that these organisms survived due to possessing beneficial traits suited to their environment and passed these traits to their offspring, while species lacking beneficial traits would eventually face extinction. However, in the case of the Tasmanian tiger, Yoshi used a mixed reasoning approach, combining INR with intuitive reasoning (NNR). He suggested that the tigers could only be found in Tasmania because they did not migrate, rather than focusing solely on evolutionary concepts. Additionally, for the human question, Yoshi used intuitive reasoning (NNR) based on similarities between humans and chimps, rather than explaining their shared ancestry.

Use of Multiple Epistemologies in Reasoning about Evolution

How do participants utilize different types of reasoning across the five questions? The results indicate that Tina and Serena used consistent reasoning types for all five questions concerning various organisms. Tina relied solely on intuitive reasoning (NNR) for all cases, while Serena consistently employed scientific evolutionary reasoning (INR). In contrast, the other two participants used a mix of epistemologies. Yoshi combined INR and NNR for the tiger question but used exclusively INR or NNR for the other questions. Ray utilized a mix of creationist reasoning (CR) and intuitive reasoning (NNR) for the tiger, human, and algae questions, while applying INR and NNR exclusively for the seals and finch questions.

Previous research by Tenenbaum et al. (2015) found that high school students often use multiple epistemologies to explain evolution, with fewer than 10% consistently using a single reasoning type across different organisms. They suggested that understanding evolution involves a gradual process of theory revision, and high school students are still in this revision phase, relying on various epistemologies. As they mature into adulthood, they are expected to develop a more coherent understanding of evolution. The present study supports this view, showing that half of the participants employed a single reasoning type, either INR or NNR, across all questions.

Target-Dependent Reasoning

This study also explored whether educated Indonesians used target-dependent reasoning and identified the patterns of reasoning associated with different targets. The results revealed that scientific evolutionary reasoning (INR) was predominantly used for the seals question. Three out of four participants predicted that most seals would become extinct due to global warming, as they lacked traits necessary for survival amidst environmental changes. This finding aligns with previous research, which noted that "seals and finches questions generated more scientific evolutionary reasoning (INR) than other questions about living things" (Tenenbaum et al., 2015; To et al., 2017).

Conversely, intuitive reasoning (NNR) was most commonly used in response to human question. Approximately three-fourths of the participants referenced similarities between humans and chimps without necessarily acknowledging their shared common ancestor. This result is somewhat consistent with past research, where "NNR was most frequently evoked for the tiger question, followed by humans and algae questions" (Tenenbaum et al., 2015). However, Evans et al. (2009) found that questions about humans and chimps were more likely to elicit creationist reasoning (CR) rather than intuitive reasoning (NNR). Supporting this finding, To et al. (2017) reported that questions about humans and chimps prompted more participants to deny evolution (CR). Notably, this study did not observe creationist reasoning for the human question, despite all participants being religious individuals.

The Importance of Museum Visit

Results showed that the museum-goer participants who visited the natural history museum were more likely to use scientific evolutionary reasoning (INR), less likely to use intuitive reasoning (NNR), and unlikely to use supernatural reasoning (CR). In contrast, the naturalistic participants who did not visit the museum were more likely to use intuitive reasoning (NNR) or a mix of NNR and CR and less likely to use scientific evolutionary reasoning (INR). Tenenbaum et al. (2015) reached a similar conclusion, showing that students who visited the museum increased their use of INR and decreased their use of NNR following the visit, compared to their reasoning before the visit.

The consistent pattern of increased INR and decreased NNR observed in both this study and previous research demonstrates the potential role of museum visits in supporting participants' reasoning about evolution. However, as a qualitative study, this research does not seek to establish causality but rather to explore how informal learning settings interact with individuals' reasoning processes. Prior knowledge, educational background, and personal interest in science undoubtedly contribute to reasoning; however, this does not negate the importance of museum visits as a space where individuals engage with evolutionary concepts in meaningful ways. The participants in this study reported visiting most of the museum's exhibitions, including the "Nature of the Region" exhibition, during a three-hour visit. Future research could further investigate how prior knowledge and engagement styles shape learning experiences in informal settings.

CONCLUSION

This study offers valuable insights into how informal learning experiences, such as visits to natural history museums, influence individuals' reasoning about evolution. The findings reveal that exposure to museum exhibits can help scientific understanding and reasoning about evolutionary concepts. The comparative case analysis between participants who visited the museum and those who did not reveal nuanced differences in how informal learning experiences contribute to evolutionary reasoning.

However, several limitations must be acknowledged. The study's case study design focuses on depth rather than generalizability, and reasoning is influenced by multiple factors, including prior knowledge and educational background. Nonetheless, this does not diminish the role of informal educational settings in providing exposure to scientific concepts and fostering engagement with evolutionary reasoning. Rather than making broad claims about causality, this study highlights museums as valuable spaces where visitors interact with scientific content in ways that may complement and enrich formal education.

Future research should address these limitations by employing larger, more diverse samples and longitudinal designs to gain a deeper understanding of how informal learning environments influence scientific reasoning about evolution and other scientific concepts. This study, however, contributes to the broader discourse on science education by highlighting the potential of informal learning experiences to enhance and complement formal educational approaches in fostering a scientifically literate society.

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