An Exploration of Teaching Strategies Used to Teach Natural Sciences at the Science Centre in Pretoria, South Africa

Hasani J. Bilankulu[1] & Thuli G Ntuli[2,*]

[1]National Zoological Garden, Pretoria 0001, South Africa

[2]University of South Africa, Pretoria 0003, South Africa

*Correspondence: Lecturer at University of South Africa, Pretoria 0003, South Africa. Tel: 27-12- 482-1582

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Abstract

This study aimed to examine the teaching strategies employed to teach natural sciences at a science museum in Pretoria, South Africa. Science museums have collaborated with the Department of Basic Education to enhance the quality of science education in the country. A qualitative case study design was adopted to gather data from the science museum. Using a purposive sampling strategy, two education officers responsible for teaching and learning at the museum were selected as participants. Data collection methods included semi-structured interviews and observations. The findings revealed that education officers predominantly used a teacher-centred approach and a show-and-tell method to teach natural sciences. Additionally, lecturing and questioning formed a significant part of their instructional strategies. The study also noted the reliance on one-way communication methods, where learners were passive listeners and only engaged in conversation when prompted by questions. The article recommends training education officers to adopt facilitation roles and explore more effective teaching strategies. Such training could enhance the quality of natural sciences teaching and foster active engagement and deeper learning among learners.

Keywords: science museum, teaching strategies, natural sciences, education officer

1. Introduction

To fully understand how children learn natural sciences, it is essential to consider non-formal learning environments such as museums and science centres, alongside formal education in schools. Science centres and museums play a significant role in enhancing learners' comprehension of science concepts and fostering their interest in the field (Insulander & Ohnmam, 2022). In South Africa, schools frequently visit science museums as part of annual educational excursions. The Department of Basic Education (DBE) encourages these visits for academic purposes, recognizing their potential to complement and enrich school-based science education.

This article examines the teaching strategies employed at a science centre in Pretoria to teach natural sciences to visiting school groups. According to Nice (2020), extracurricular learning experiences, such as those gained from field trips, significantly influence learners' knowledge, comprehension, attitudes, and learning goals. Learners often regard science excursions as the most enjoyable and impactful form of learning. The educational methodologies and settings in science museums are intended to complement classroom science teaching (Insulander & Ohnmam, 2022). In South Africa, schools are encouraged to visit science museums and related centres to broaden learners' scientific understanding (DST, 2018). The Department of Science and Technology (DST) and the DBE collaborate to enhance science literacy and learner performance in natural sciences (DST, 2018).

Despite these efforts, there is concern about the quality of science education in South Africa, with learners continuing to underperform in science and mathematics (Reddy, 2021). Schulze and Heerden (2015) emphasize the urgent need to improve science teaching and learning. DST has mandated science centres to popularize science and make it more engaging for school learners (DST, 2018). However, little is known about the specific teaching strategies employed at these centres to communicate scientific concepts to visiting school groups.

Schools visit science centres for various reasons, including reinforcing curriculum content and sparking learners' motivation and curiosity about science topics (Macdonald, 2020; Nice, 2020). The way museum staff engage with

learners during these visits is crucial. Visits to science centres often leave lasting impressions on learners, promoting a deeper understanding of scientific methods and their relevance to everyday life (Braund & Reisis, 2005). Outdoor learning environments provide vital links between theoretical science and practical, real-world issues (Macdonald, 2020). Braund and Reisis (2005) argue that science museums can develop scientific understanding, attitudes, and values, fostering a more informed and proactive population on topics such as citizenship, climate change, and sustainable development.

At the science museum in Pretoria, education officers are responsible for making science engaging for learners. These officers lead educational activities and guide learners through exhibits, offering experiences not typically available in a classroom setting (Macdonald, 2020). Pfeiffer (2011) notes that effective teaching practices significantly impact learners' attitudes towards science. Constructivist learning environments, where educators act as facilitators, emphasize a partnership between teachers and learners in the educational process (Liang & Matthews, 2021). Teaching involves helping learners access, understand, organize, and apply information (Killen, 2015), making education officers pivotal in creating enriching learning experiences at science museums.

Education officers at the museum should employ strategies that deepen scientific understanding and engage learners actively. Killen (2015) distinguishes between teacher-centred approaches, where the educator controls the teaching process, and learner-centred approaches, which emphasize inquiry and discovery. Science education reform advocates for hands-on, inquiry-based learning that keeps learners' curiosity alive and encourages critical thinking and problem-solving (Reimer, 2020; Budhai, 2021). According to Adams and Gupta (2017), effective teaching involves establishing relevance by linking scientific concepts to real-life applications, current events, and practical examples. Inquiry-based teaching has emerged as a central strategy in science education, fostering meaningful learning experiences and developing learners' understanding of the nature of science (Gillies, 2023; Kamarudin et al., 2024). The role of education officers in science museums is, therefore, crucial in shaping learners' scientific knowledge and attitudes through engaging, hands-on, and inquiry-driven teaching approaches.

2. Method

This article employs a qualitative case study research methodology. According to Yin (2016), this approach uses context-specific information to generate a general understanding by interpreting data in the form of words to uncover local meanings. Braun and Clarke (2013) describe qualitative research as exploratory and open-ended, producing comprehensive, rich, and detailed data that supports evidence-based claims. This methodology was chosen because it aligns with the study's objectives and research questions. Richards and Morse (2013) emphasize the importance of aligning the research purpose with the selected methodology. A multiple case study design was adopted to explore the teaching strategies employed by education officers at a science museum to teach natural sciences to visiting school groups. Each case was treated and analysed independently, as this was not a comparative study.

Data were collected from two education officers who regularly interact with school groups. A purposeful sampling strategy was employed to select these participants. Data collection involved two primary techniques: semi-structured interviews and observations. This triangulation approach, which utilizes multiple data sources, enhances the depth and breadth of understanding, corroborates findings, and builds a holistic picture of the phenomenon under study (Billups, 2014). The education officers were interviewed both before and after their lesson presentations and were observed during their teaching sessions. These methods provided an in-depth understanding of the strategies employed to teach natural sciences to visiting school groups. The data were analysed using an ethnographic approach. Richards and Morse (2013) liken ethnographic data analysis to assembling jigsaw pieces to create a comprehensive, rich, and detailed description. Each case was examined individually to gain deeper insights into the teaching techniques used by the science museum to enhance science education. This detailed examination contributes to a better understanding of the instructional practices that can improve learners' engagement and comprehension in natural sciences.

3. Results and Discussion

3.1 Case 1. Mary

Mary, an education officer at the science museum, is responsible for overseeing educational activities. When asked about her experience and qualifications, she stated, "*Some of us do not have that experience in teaching, but I have qualifications in natural sciences up to the honours level*."

In response to a question about the considerations she considers before presenting a lesson, Mary explained that she

always evaluates the learners' grade level and their prior knowledge. She emphasized that these factors guide her in structuring her presentation effectively, ensuring the lesson content is appropriately tailored to the learners' needs.

Mary:

"*You can't be presenting a lesson the same way for the grade threes the same that you would be presenting it to the grade sevens. So, to know the kids' age, their level of understanding and mainly the teaching method to use. You could ask the teachers the language they use, and they will tell you ok, they use this, they use English. So, I feel like that's the most important thing, then that's when you can lay out your presentation properly."*

When asked about the challenges she faces when presenting lessons on reptiles, Mary explained that capturing learners' attention is often difficult because many are afraid of reptiles. She shared that she adopts a gentle and approachable demeanour to help ease their fears and engage their interest.

In response to how she addresses learners' misunderstandings, Mary stated that she uses comparisons or relatable scenarios to explain lesson content. She noted, "*I feel like when teaching reptiles, you must use scenarios that kids are able to relate to. It's not just about telling them all those scientific names and everything, but you must make it relatable for them*." Mary also highlighted that she avoids being overly technical, choosing instead to simplify scientific concepts to ensure they are accessible to the learners.

When asked about the teaching methods she employs in her lessons, Mary explained:

"I prefer to go hands-on. I don't just give information to kids. I want them to be able to touch whatever that I am using but in doing so I make sure that there is order, there has to be order because kids can't be like… I make sure ok I give them what they must know yet they become hands-on during the lesson"

Mary frequently emphasized the importance of hands-on learning, repeatedly stressing that learners should touch and feel the models she uses to teach about reptiles. She believes this tactile approach enhances understanding and engagement.

To introduce her lesson, Mary began by asking learners questions, encouraging participation and interaction. Some learners responded to her questions, setting the tone for an interactive session. This is how she introduced her lesson:

Mary: I am ma'am Mary. I am going to teach you about reptiles. Ok, who can tell me what is a reptile? What kind of an animal is it? What does it look like? Explain to me what kind of an animal a reptile is. You can say anything. (She asked the questions with authority, showing that she oversees everything around her)

Learner 2: Crocodile.

Mary: Crocodile… another one…

Learner 3: Lion.

Mary: Lion on the reptiles? Another one? Ok

Learner 4: Lizard.

After her introduction, Mary proceeded to explain the different groups of reptiles to the learners. She said, "*So, we have three types of reptiles. The first one is Crocodiles and Alligators. The crocodile's mouth is shaped like a V. Can you see how it is shaped? However, the mouth of an alligator is shaped like a U. You can tell the difference by looking at the shape of their mouths—this one is not a crocodile; it is an alligator*.".

She then employed a question-and-answer method to explain the second group of reptiles, engaging learners interactively. She stated:

"Who can tell me where can you find a tortoise? Where does it live? Where do you see it often? You find turtle in salt water, Terrapin in water that does not have salt. What about tortoise?"

The teacher-centred approach is commonly referred to as a direct teaching method, where the education officer controls the teaching and learning process. In contrast, the learner-centred approach is associated with discovery or inquiry-based learning, placing the learner at the heart of the process (Killen, 2015).

During her lesson, Mary introduced the topic by asking learners a series of questions: "*Who can tell me what is a reptile? What kind of an animal is it? How does it look like? Explain to me what kind of an animal a reptile is*." She posed these four questions simultaneously, expecting immediate responses from the learners. This approach was not a discussion but rather a questioning technique that demonstrated her authority on the subject matter. According to Zhai and Dillon (2014), questioning and dialogic inquiry are effective techniques in science education when employed correctly, as they can maintain learners' attention and stimulate curiosity. However, for questioning to

foster collaborative discussion, the educator should not act as the sole source of knowledge but instead encourage learners to express their contributions. In this instance, Mary's questioning primarily required learners to recall information and did not promote exploratory dialogue. Zhai and Dillon (2014) suggest that educators should strategically balance authoritative instruction with dialogue to actively engage learners in building knowledge.

In a teacher-centred approach, educators often ask closed questions that require predetermined, concise answers to evaluate learners' prior knowledge. Conversely, a learner-centred approach typically employs open-ended questions that invite learners into a broader classroom discourse (Chin, 2004). Mary's questions about reptiles aimed to assess learners' existing knowledge but were presented authoritatively, with the expectation that learners would reproduce information. She subsequently proceeded to deliver a lecture on the three categories of reptiles, introducing terms like Testudine and Squamata. Throughout the lesson, learners remained passive, attempting to process the dense content presented to them. This lecturing approach aligns with the teacher-centred method, which, as Erduran and Jimenez-Aleixandre (2007) argue, limits opportunities for learners to think critically or generate new information.

When asked about her teaching method, Mary stated: "*I prefer to go hands-on, I don't just give information to kids…*" Science centres and museums offer significant potential for hands-on, exploratory science learning in a relaxed, non-evaluative environment (Shah and Campus, 2021). Research suggests that hands-on and inquiry-based learning enhances critical thinking and problem-solving skills while making science education more meaningful (Gillies, 2023). Reform in science education advocates for methods that allow learners to engage in hands-on activities, preserving their natural curiosity and encouraging the generation of self-initiated questions (Budhai, 2021).

While Mary incorporated a hands-on activity at the end of her lesson, allowing learners to touch and feel the exhibits, the effectiveness of her teaching could have been improved with multiple hands-on activities interspersed throughout the lesson. Such an approach would have fostered greater engagement and provided learners with opportunities to interact with the content in a meaningful way.

Teaching is described as a process of helping learners find, understand, organize, and apply information (Killen, 2015). However, this lesson diverged significantly from that ideal. Learners were primarily presented with facts and concepts to memorize, such as the three groups of reptiles, the terms cold-blooded, venom, and anti-venom, and other related content. A more interactive and inquiry-driven approach could have enriched the learning experience and aligned more closely with contemporary educational best practices.

3.2 Case 2

Lebo, an education officer at the science museum, is responsible for facilitating science engagement activities. Although she does not hold formal teaching qualifications, she shared during the pre-interview that she has two years of experience teaching environmental education at an environmental centre in Gauteng.

When asked by the researcher about the factors she considers before presenting a lesson, Lebo responded:

"Of all, you should check also the language of the students. And then also you should be able to, in your lesson, you should let them engage with you than you teaching them. So, you should ask them questions or let them come up with answers. And I also make sure that after each lesson I ask them if they don't have any questions. So those are the things to consider"

The researcher asked Lebo about the teaching method she employs when presenting lessons at the science museum. She responded by saying:

"The method was to… Ok. I told them about the flight of vultures. And then I also showed them some things. I didn't ask questions on things that I felt were too difficult for them. But I also got them to participate. So, I demonstrated to them some things but in some they had to come and do that activity to show me their level of understanding."

Lebo was observed introducing her lesson by saying, "*We are going to talk about vultures*." She informed the learners that the lesson would take the form of a discussion and encouraged them to respond to her questions. She also reassured the learners that they were free to answer in any language, including their home language.

She then proceeded to assign roles, saying:

"Ok, and then, ummm, please do not hold secret meetings. I should be the only one talking unless you raise your hand. And please do not eat while we are having a lesson"

Lebo used the question-and-answer method to engage with the learners. She asked several questions to gather background information and assess the learners' prior knowledge.

Lebo: Are you guys familiar with the term 'vortex'?"

Learners: “No!”

Lebo B: “Le kele labona (have you ever watch a tornado movie) movie ya-tornado?”

Learners: (mumbling)

She continued with her lesson, posing questions to the learners, asking, "*Can anyone tell me what makes vultures interesting or what sets them apart from other birds? Are you familiar with vultures*?"

After receiving responses, Lebo began providing information about vultures, explaining how they are adapted to their environment and their unique flying abilities. She utilized her knowledge of aerodynamics to explain the mechanics of flight to the learners.

To further illustrate, Lebo used an analogy comparing the vortex created by vultures in flight to the movement of a tornado. She explained the flight dynamics of vultures, saying, "*Vultures create a vortex similar to a tornado, which helps them soar and conserve energy while flying*."

When the researcher asked Lebo how she responded if she noticed that learners were struggling to understand certain concepts, she replied, "*If I notice they don't understand, I will pause and try to explain it in a simpler way or use an example that they can relate to*.",

“First of all, I had to change my language, first because most were from schools in the townships. So, if you must be too formal with them some might be ignorant, some might be interested but not understand at all. So, I kind of had to adjust the language that I use and apply examples that they see every day in their lives. So that’s the approach I used.”

According to Killen (2015), teaching is the process of helping learners find information, understand it, organize it, and apply it. Learners should not be viewed as passive recipients of knowledge. As Cobb (1994: 4) argues, "*Teachers are guilty of transmission if they do more than stimulate students' reflection and problem-solving*."

Lebo’s teaching approach primarily involved providing learners with information throughout the lesson. When introducing the concept of vultures, she began by saying:

“So, in the world we have two groups of vultures. We have new world vultures which occur in South and North America. And then we have old world vultures which occur in Africa, Asia and Europe.”

There was little to no interaction with the learners regarding the information provided. She continued to treat the learners as passive recipients of knowledge, akin to empty vessels waiting to be filled (Brophy, 2014). Education Officer B stated:

“…*The talons, we don’t call these the feet or the toes we call them the talons. So, these talons are tough. They enable them to walk smoothly on the ground while searching for dead animals. And then, this one, the Cape Vulture from the old world it relies on sight or on vision to track down food. Hence, it spends most of the time flying high in the sky. And also, the talons they are not as tough as the ones of new world because they spend most of the time flying searching for food up high in the sky.”*

The teacher-centred approach is often referred to as direct instruction, where the education officer has full control over the content and delivery of the lesson. In this approach, the focus is on transmitting information from the educator to the learners, with little input or interaction from the students. In contrast, a learner-centred approach emphasizes discovery and inquiry learning, where the role of the learner in the learning process is central.

Lebo used a teacher-centred approach in her lesson on vultures, primarily providing information about vultures and their adaptation to the environment. There was no interaction with the learners; instead, she gave a lecture, asserting her authority on the subject matter. According to Insulander and Ohnman (2020), for quality learning to occur, education officers must deliberately engage learners in intellectual activities that encourage participation and critical thinking. However, in Lebo’s lesson, this did not happen. Instead, she continued to deliver a large amount of information without helping learners process or filter it, as suggested by Killen (2015), who emphasizes the importance of helping learners sift through vast amounts of knowledge.

Macdonald (2020) argues that teaching in science centres and museums should create a fun, interactive environment, in contrast to the more formal and authoritative atmosphere of traditional classrooms. However, Lebo's lesson was strict and serious in tone. Before starting her presentation, she set roles for the learners, speaking in a very authoritative manner. She stated:

Lebo*: Ok, and then, please do not hold secret meetings. I should be the only one talking unless you raise your hand. And please do not eat while we are having a lesson, alright?”*

There was no sense of fun in Lebo's lesson; it was conducted in a serious, controlled atmosphere. She dominated the conversation, with the learners' role being limited to listening. Incorporating fun into science lessons is essential, especially in a science centre setting, because it helps learners relate to and retain the information they learn in a more relaxed environment (Rennie & McClafferty, 2016).

When asked about the teaching method she used to teach about vultures, Lebo said:

"I told them about the flight of vultures. And then I also showed them some things. I didn't ask questions on things that I felt were too difficult for them. But I also got them to participate. So, I demonstrated to them some things but in some, they had to come and do that activity to show me their level of understanding."

From her response, it is evident that Lebo did not have a specific teaching method in mind. Although she mentioned a demonstration approach, it did not materialize during the lesson. She had an aeroplane model that she could have used to illustrate the forces she discussed with the learners, but she did not make use of it. Instead, she missed an opportunity to engage her learners with a hands-on activity that could have helped explain the forces acting on a flying object.

4. Conclusion

The responsibility of education officers at science centres and museums is to deepen learners' scientific understanding and enhance their learning experience through effective strategies (Pfeiffer, 2011). However, the use of the lecturing method was evident in this study. Education officers employed a teacher-centred approach, where communication was one-way, with learners passively listening and only responding when asked a question. Learners were instructed to remain seated and listen without interruption, and their role was limited to responding to questions posed by the education officers. They were bombarded with information without being given an opportunity to ask questions. Cobb (1994) and Macdonald (2020) warn against this approach, suggesting that the role of education officers should be to facilitate learners' investigations and exploration in a science centre environment. Learners should not be treated as passive recipients of knowledge. Cobb (1994) argues that education officers are guilty of transmission if they do more than stimulate learners' interest and problem-solving in the natural sciences.

The study also observed that education officers employed a show-and-tell strategy in teaching science at the museum. They displayed resources to the learners, explained what the exhibits were, and asked if the learners were familiar with them. Despite stating in interviews that they preferred a hands-on approach, their observed practice leaned heavily on show-and-tell, with little or no interactive engagement with the resources. In addition, education officers used questioning as part of their instructional strategy. However, most of the questions posed were closed-ended, requiring direct answers. These questions mostly asked learners to recall information they had already learned in school, rather than encouraging them to apply their thinking. Closed questions empower the education officer, while open-ended questions stimulate curiosity and keep learners actively engaged (Zhai and Dillon, 2014). As a result, learners remained passive during the lesson. This article recommends that education officers review their teaching strategies. They should be trained to adopt more facilitative approaches, using teaching methods that engage learners with the resources and encourage deeper interaction to enhance the teaching and learning of natural sciences. The centre should offer training and workshops to expose education officers to better facilitative teaching strategies.

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