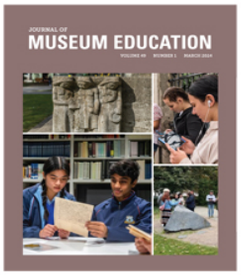

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ABSTRACT

Narratives, or stories, are used every day by people as a way of making sense of and communicating events in the world. Narratives can be highly useful as a learning tool in science education. Though research on narrative-based pedagogy in science education and communication is very common, most of that research was done in formal settings. Our study followed fourth-grade students who visited the science museum on a field trip, entitled "The Life of Leonardo Da Vinci," which used narrative-based pedagogy (e.g. the story of Leonardo da Vinci) as a common thread throughout the visit. Interviewing the students after the visit revealed that most students remembered facts mentioned in the narrative, and the narrative had a long-term effect. The students remembered this visit better than other visits. In addition, more than half of the students used vocabulary that could be associated with the visit. This study supports the idea that art-based research methods can be effective. Using photos and images proved to be more engaging for students, and all students used the photos of exhibits and other images to create their own stories.

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Introduction

Narratives, or stories, are considered a main form of communication and have been studied in numerous fields, such as education, sociology, psychology, philosophy, history, fiction, film, etc.[1] People use stories as a way to communicate and to understand the world. Storytelling is prevalent in conversations, movies, books, and television.[2] In fact, "narrative is a meta-code, a human universal on the basis of which transcultural messages about the nature of a shared reality can be transmitted."[3]

Narratives are a series of actions and experiences made by real or imaginary characters. A narrative can be spoken, written, or imagined, and it can be viewed from a single or even several perspectives. Narratives can be defined as representations of events in a certain chronological order connected by causality.[4] The representation of characters and their experientiality, such as their thoughts, feelings, intentions, and motivations, are important;[5] events and characters are necessary for a narrative.[6] Norris and colleagues[7]

refer to a narrative as having the following elements: purpose, events, structure, time, agency, author, and narrator.

Narratives are believed to facilitate information processing and memory by increasing interest, relevance, and attention.[8] For decades, narratives featured prominently in educational studies.[9] Due to the educational benefits that narratives may promote, scholars have argued for a greater use of narratives in science education[9] and as a tool to make science accessible to the public.[10] However, the standard form of a narrative needs to be adapted to be used in science education. Generally, there are two types of scientific narratives: (a) historical stories, such as biographical narratives of scientists and their work; and (b) imagined stories that illustrate scientific concepts.[11] Avraamidou and Osborne argued that narratives should have a purpose, which is "to help us understand the natural and human world." [12] In the context of science education, narratives should present a specific scientist's vision of the world. The teller can be a character or a narrator. The story, comprising a chain of interconnected past events, is told in a recognizable structure (beginning, middle, and end), as actors (or characters) in the story cause and experience events. These actors can be "human or material entities who act on each other."[13]

Studies on narrative-based pedagogy in science education and communication are common. However, most research has been done with school (or preschool) children in formal settings. Studies exploring narratives in informal settings usually involve follow-up activities and do not necessarily focus on the informal environment itself. This study explores the use of narratives during a visit to a science museum.

Narrative-based pedagogy in science education

Traditionally, science education has focused on the development of scientific literacy and on promoting access to scientific communities. Thus, students must learn how to communicate within the science community.[14] Narratives become "part of how people understand the world they live in, and they serve as a way of communicating that understanding to others,"[15] thereby providing a meansof accessing the scientific community, in an ordinary, non-threatening way.

Yang and Hobbs[16] demonstrated the power of stories by exploring how consumer attitudes and behaviors differed when information about agricultural biotechnology (specifically, gene editing) was presented in the form of story from when similar information was framed logically and scientifically. Although a logical-scientific frame typically emphasizes rigorous scientific research, narrative formats are inherently easier to comprehend, more interesting and engaging and, therefore, more persuasive.

To facilitate an understanding of the physiology of the common cold, Walan and Enochsson[17] used a story about a girl who caught a cold after being infected by a rhinovirus. Results indicated that storytelling promoted an understanding of immunity concepts and that the structure and flow of the story stimulated the students' imaginations, which facilitated the learning process. Similarly, Prins et al.[18] showed that students developed a scientific understanding of natural selection and perceived a narrative as easier to comprehend than a textbook. Storytelling combined with hands-on activities can be used as a tool to provide students with different perspectives on issues or scientific concepts that are relevant to them.[19] Indeed, everyday experiences should be considered a starting point for elementary school students' science learning.[20]

Science centers and museums are valuable resources for first-hand scientific exploration. These settings offer students the opportunity to be surrounded by stories captured and shared through the museum's exhibits and artifacts, and to connect these stories to their own learning.[21] In Murmann and Avraamidou's study,[22] a story was created to support students' engagement and interaction with an exhibit about human and animal senses at a science center. The stories fostered motivation, immersion, and a sense of agency, providing the students with a sense of meaning as to why they must engage in learning activities. These results emerged from the strong, obvious connections between the story and the scientific concepts in the exhibit.

Studies have shown the cognitive benefits of narrative-based pedagogy in informal settings. Glick and Samarapungavan demonstrated how fourth graders developed a more sophisticated perspective of the biology and conservation of wolves while participating in a narrative-based natural phenomena exploration in a nature center.[23] Hu et al.'s study showed that mystery-type stories have tremendous potential to evoke interest and promote interactivity while facilitating learning in a science center.[24] Moreover, they illustrated the benefits of using anthropomorphism to help children access and understand complex concepts and connect unfamiliar phenomena with their own experiences. They used mystery-type stories to explore the death of a star and found them to be a rich stimulus, leading to significant improvement in the children's understanding of astronomy concepts.

The life of Leonardo da Vinci – context of the field trip

Our study followed fourth-grade students who visited a science museum on a field trip entitled "The Life of Leonardo da Vinci." We examined the use of a narrative-based pedagogy and how it was reflected in the students' interviews. Students in our study were, on average, 10 years old, and came from a marginalized under-resourced community.

This analysis is part of a larger study in which fourth to sixth graders visited the Carasso Science Park, a science museum in Be'er-Sheva, the largest city in southern Israel. The visits occurred six times over a three year-period. Each grade visited the museum twice a year. This paper refers to 73 fourth graders' second museum visit, involving a narrative-based field trip about the life of Leonardo da Vinci. The participants, all Hebrew speakers, came from four different schools in the city. All four schools were defined by the Ministry of Education as serving populations of low to medium socioeconomic status.

A field trip to the science museum is three hours long and comprises four activities of 45 minutes each. The first activity took place in the museum lab, where the museum educator (ME) briefly introduced Leonardo da Vinci as a "Renaissance man," followed by the screening of an animated film on Leonardo da Vinci. The second activity was a scavenger hunt for Leonardo da Vinci's inventions in the Mechanics Exhibition Hall. The scavenger hunt connected the clues to aspects of the animated film and the overall narrative. Upon completion of the scavenger hunt, the students received puzzle pieces, which revealed the image of the Mona Lisa when assembled. The third activity was a hands-on activity in the lab. Da Vinci's codex was presented again (the sketches had already been introduced in the animated film and the exhibition hall). The students built a model parachute, based on a sketch by da Vinci. They took their parachutes homes as souvenirs. The fourth activity took place in the Etya Tech Hall, an exhibition hall with eclectic exhibits unrelated to the theme of the visit.

Data collection and analysis

All 73 students were interviewed at their respective schools up to two days after the museum visit. Interview Part 1 included general questions about the visit and the students' likes (or dislikes). As some of the students struggled to answer the questions, the interviewers (the authors of this paper) offered prompts and used visual aids (e.g. photos of various exhibits). Photos and images were available to the students, taking into account the connection between creative, visual, and narrative processes while integrating verbal and visual ways of knowing.[25] For a detailed account of the interviews, see Shaby, Ben-Zvi Assaraf and Tal.[26] Interview Part 2 specifically addressed the story of Leonardo da Vinci.

This paper presents our analysis of Part 2 of the interview, using an art-based research method. In art-based research methods, the researcher uses prompts using additional modes of communication (not just verbal). In this research we provided students with photos of the museum exhibits and images from the animated film and asked them to tell us a story about Leonardo da Vinci. Art-based data collection methods are often used with children who have difficulty expressing themselves verbally. These methods are also used with students with learning disabilities and students from marginalized, under-resourced communities to aid them in finding their voice and expressing their views.[27]

We wanted to examine the narratives from two perspectives: (a) the use of a narrative-based pedagogy and the way it is reflected in students' interviews; and (b) to use narratives as an art-based research method to collect data in the interview.

Interviews were audio recorded and were later transcribed by the first author. Any field notes taken by the interviewers were added to the transcripts. We used a thematic analysis to systematically identify, organize, and offer "insight into patterns of meaning (themes) across a data set."[28] Thematic analysis reveals participants' thoughts, emerging from the data and not from a pre-existing coding scheme.[29] We coded the data with NVivo1.5.2, following Braun and Clarke's six-stage analysis: familiarizing yourself with the data, generating initial codes, searching for themes, reviewing potential themes, defining, and naming themes, and producing the report.[30]

Findings and discussion

The following story, told by Student 49C in the interview, is the example through which we will present our findings:

> Leonardo da Vinci was a man who was born in Italy. He was a lot of things: a Renaissance Man, a painter, a sculptor, an inventor, and a researcher. He did things in many fields. Leonardo was a curious young man and started using his talents by painting. He painted the Mona Lisa and even a self-portrait. He grew older and achieved even greater things. He moved to a different field of inventions. He invented the glider, which at first didn't work, but he kept on trying and finally was able to plan the glider, so he discovered that he had an architect inside him. As time goes by, Leonardo already invents another invention, the parachute. This invention doesn't work at the beginning either, and he again finds himself to be an architect. Here we can see Leonardo's drum [points at a photo of the exhibit]. His drum was used to lift heavy weights at that time, and thanks to all those [i.e. the previous inventions] – the bicycles! [points at image], the tanks, the parachutes that are used to this very day, the gliders as well. [People] decided to put him on a banknote. He is well remembered to this very day. He is one of the most important people on earth.

What the students remembered

During the visit, students were introduced to various facts about Leonardo da Vinci, who was presented as a Renaissance man by the ME, as an artist and scientist in the animated film, and as an inventor in the exhibition hall and hands-on activity.

The 73 interviewees mentioned 217 facts about Leonardo da Vinci, as illustrated in the example above: born in Italy, painted the Mona Lisa, was a Renaissance man (on many occasions pronounced incorrectly), was an inventor, and was a researcher.

Thirty-nine students mentioned the exhibits in their story, for example: "Here we can see Leonardo's drum [points at a photo of the exhibit]. His drum was used to lift heavy weights at that time." Thirty-one students mentioned the hands-on activity (e.g. " … parachutes that are used to this very day"). These findings are in line with other studies that found that narratives facilitate information processing and memory by increasing interest, relevance, and attention.[31,32] Although we assumed that the fourth graders had first learned about Leonardo da Vinci during their second visit to the science museum, they may have had previous encounters with him in other contexts, leading them to mention previously acquired facts during the interview. For example, during the fourth graders' first museum visit, they visited the Mechanics Exhibition Hall where several exhibits showcased Leonardo da Vinci and some of his inventions. The walls of the exhibition hall were decorated with sketches from da Vinci's codex. However, Leonardo da Vinci was not mentioned by the ME during that first visit. The students had not learned about Leonardo da Vinci in school, as our informal interview with the teachers confirmed.

The semi-fictional story presented in the animated film included various fictional plot elements. For example, as Leonardo da Vinci could not be the sole character in the story, other characters were introduced: there was a child apprentice who tested the glider and broke his arm; and there was a chase to find Mona Lisa's face, which finally turned out to be face of the apprentice's mother. These are clearly fictional elements employed to move the story along and keep the audience engaged. However, fourth-grade students do not necessarily differentiate facts from fiction. We coded 37 fictional elements from the animated film that were repeated in the students' stories. This is in line with Prins et al.,[33] who found that there was confusion about the fictional elements in a narrative that students did not identify as such, creating difficulty in separating facts from fiction.

What the students learned

Leonardo da Vinci's traits as a person and as a scientist

During the museum visit, neither the ME nor the animated film referred to any of da Vinci's personal traits. However, positive personal traits (e.g. important person, smart, well-remembered) were mentioned seventeen times by students. Moreover, the findings revealed 23 mentions in the students' interviews of da Vinci as a talented scientist, also noting that he was "a curious young man" who worked in many fields and "kept on trying even if something didn't work at the beginning."

Vocabulary

The findings revealed 41 instances of field trip-related vocabulary, for example: *Renaissance man* (which was mispronounced at times); *inventor* and *researcher* (not commonly

used in daily contexts in Hebrew); and *self-portrait* (22 students used the term *self-portrait*, while 51 others stated that "he painted himself)."

Effectiveness of art-based research methods

Using photos and images in the interview

Using photos and images proved to be more engaging for the students. All the students used photos of exhibits and other images to create their stories. In the example above, we see how pointing to photos and images helped Student 49C tell the story. In some cases, students were not able to remember the names of paintings or exhibits. Visual prompts allowed them to respond to the interview question. The photos also helped students create their own visual story, offering a way of engaging with the activity in a non-verbal manner.

Telling a story proved to be a more compelling way to respond to the interview questions. The students' stories in Part 2 of the interview were (on average) three times longer than their responses in Part 1. Similarly, other studies also found that using photos as representatives of the learning environment students have experienced before to create a poster proved to elicit discussions among the students, engaging them in evolutionary ideas.[34]

Creating a story

As mentioned in the literature review in the Introduction, a narrative includes the following elements: purpose, events, structure, time, agency, author, and narrator.[7] As students are very familiar with the elements of stories, it was surprising to see that only twelve students attempted to truly create a story. All other students merely listed facts:

> Leonardo was a painter, engineer, inventor, and scientist. Here, you can see some of his paintings [points to photos] and here a sketch of the drum with gears. He invented the glider and was a scientist. He had a lot of professions. (Student 13A)

Those twelve stories show various levels of sophistication. Some students, such as Student 26B, used a typical fairy tale structure, starting with a traditional opening line and ending that framed a list of events: "Once upon a time there was a man who invented a helicopter. He painted his self-portrait, and his name was Leonardo da Vinci. Later he painted the Last Supper and then the Mona Lisa. The end." Other students clearly included more story elements, such as events, structure, time, and agency. One such story, by Student 49C, appears at the beginning of the "Findings and discussion" section.

Another, Student 67D, told the following story:

> Once upon a time, there was a man maned Leonardo da Vinci. He was hungry, so he ate and then went to his room to sketch a parachute. He tried to build the parachute, and then he met a woman called Mona Lisa and suggested that she try out the parachute. The Mona Lisa tried the parachute and didn't succeed, so Leonardo moved to gears. He succeeded in building a gear, and then he tried to play with it a bit. Then [people] saw that he was famous, so they put him on a banknote. No matter which direction you look at the Mona Lisa from – she will be looking at you.

Notice that Student 67D created fictional events in his story (e.g. da Vinci was hungry); introduced other characters (Mona Lisa parachuting); and used verbs that indicate the passing time.

The simple storytelling forms employed by the participants are referred to as annals and chronicles,[3] as they only include a few elements of a narrative.

As this was a longitudinal study that tracked the students over a period of three years, we could denote the long-term effects of the narrative in future interviews in the following years. Therefore, to examine the long-term memory effects of the narrative-based pedagogy we used data from all six interviews reported in previous publications.[35,36]

For example, during an interview with the sixth graders, one of the students mentioned learning about Hannah Szenes, a British special agent who had parachuted into Yugoslavia during WW2. This reminded the student of the parachute they had made during their museum visit in the fourth grade. Another student recalled that when they had been asked to choose a famous historical character to research and present in class, he and his friends had chosen Leonardo da Vinci because they had found him interesting when they visited the museum in the fourth grade. Overall, of the six visits, the Leonardo da Vinci field trip was the most memorable and enjoyable (for more details, see previous publications).[37,38]

Conclusions and recommendations

In this study, we examined the potential of a narrative-based pedagogy during a museum visit. We sought to highlight four aspects of how narratives can potentially support and facilitate science learning: First, most students remember facts mentioned in the narrative, and as revealed by the longitudinal study, the students remembered this visit better than other visits. Second, more than half of the students used vocabulary that could be associated with the visit. Third, the narrative presented aspects of the Nature of Science (NOS, the ways science and scientists work),[39] which were mentioned by the students as traits that scientists possess. And fourth, this study supports the idea that art-based research methods can be effective: Using photos and images proved to be more engaging for students, and all students used the photos of exhibits and other images to create their stories.

As museum visits tend to be one-time events, stories leave a more powerful impression and lasting memories. Considering these findings, we recommend using narrative-based pedagogy during field trips in the following way:

- Create a compelling narrative related directly to exhibits or activities in the museum. Make explicit connections between the activities and exhibits and the narrative.
- Introduce scientific vocabulary that is not commonly used in everyday lives, but is used within the scientific community, in a non-threatening way.
- Integrate elements of the Nature of Science in the narrative, explicitly or implicitly.
- Use art-based methods to elicit responses from visitors, especially from marginalized communities.

While developing such pedagogical activities, one must be mindful about the duration of the visit, considering that fact that effective storytelling may require more time for visitors to construct their story, and therefore might not be able to construct full story at the exhibition.

Notes

1. Avraamidou and Osborne, "The Role of Narrative in Communicating Science," 1683–707.
2. Schank and Berman, "The Pervasive Role of Stories in Knowledge and Action."
3. White, "The Value of Narrativity in the Representation of Reality," 5–27.
4. Abbott, *The Cambridge Introduction to Narrative*.
5. Fludernik, *Towards a "Natural" Narratology*.
6. Bilandzic, Kinnebrock, and Klingler, "The Emotional Effects of Science Narratives," 151–63.
7. Norris et al., "A Theoretical Framework for Narrative Explanation in Science," 535–63.
8. Ibid., 1.
9. Ibid., 7.
10. Ibid., 6.
11. Hu et al., "Once upon a Star," 7–25.
12. Ibid., 1.
13. Ibid.
14. Norris and Phillips, "How Literacy in Its Fundamental Sense Is Central to Scientific Literacy," 224–40.
15. Prins, Avraamidou, and Goedhart, "*Tell Me a Story*: The Use of Narrative as a Learning Tool for Natural Selection," 20–33.
16. Yang and Hobbs, "The Power of Stories: Narratives and Information Framing Effects in Science Communication," 1271–96.
17. Walan and Enochsson, "The Potential of Using a Combination of Storytelling and Drama, When Teaching Young Children Science," 821–36.
18. Ibid., 15.
19. Walan, "Teaching Children Science through Storytelling Combined with Hands-on Activities – a Successful Instructional Strategy?" 34–46.
20. Na and Song, "Why Everyday Experience? Interpreting Primary Students' Science Discourse from the Perspective of John Dewey," 1031–49.
21. Hamilton and Margot, "Learning to Teach in a Museum: Benefits of a Museum–University Partnership," 462–75.
22. Murmann and Avraamidou, "Animals, Emperors, Senses," 66–91.
23. Glick and Samarapungavan, "Wolves Are Beautiful and Proud," 199–207.
24. Ibid., 11.
25. Mannay, *Visual, Narrative and Creative Research Methods: Application, Reflection and Ethics*.
26. Shaby, Ben-Zvi Assaraf and Tal, "A Student's-Eye View," 1625–45.
27. Nind, Boorman and Clarke, "Creating Spaces to Belong: Listening to the Voice of Girls with Behavioural, Emotional and Social Difficulties through Digital Visual and Narrative Methods," 643–56.
28. Braun and Clarke, *Thematic analysis: A practical guide*.
29. Creswell and Poth, *Qualitative inquiry and research design: Choosing among five approaches*.
30. Ibid.
31. Ibid., 7.
32. Ibid., 15.
33. Ibid.
34. Nesimyan-Agadi and Ben Assaraf. "Making an Impression: What Do Students Who Attended an Informal Evolution Enrichment Program in the Sixth-grade Recall from the Experience 3 Years Later?" 252–84.
35. Ibid., 26.
36. Shaby, Ben-Zvi Assaraf and Tal, "'I Know How It Works!' Student Engagement with Exhibits in a Science Museum," 233–52.
37. Ibid., 26.
38. Ibid., 36.
39. Ibid., 1.

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