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The Use of Fictional Stories in Science Exhibits: The Emperor Who Only Believed His Own Eyes
MAI MURMANN AND LUCY AVRAAMIDOU

Abstract  The authors explore how fictional narratives (stories) can be used as a learning tool in the context of informal science environments and specifically science centers. They base their argument on an analysis of the theoretical, structural and epistemological properties of stories and how those can serve to establish a story as a cognitive tool. They offer an example of an application of these properties to a story-based learning design called “The Emperor who only Believed his own Eyes” in the context of a large, public science center, and specifically an exhibition about “senses”. This paper focuses on the idea of a “hack,” a museum sanctioned strategy for exploring the potential and implications of narrative-based design as a way to reinterpret science exhibits in a way that can engage young users in content exploration and offer recommendations for future research.

INTRODUCTION

In this paper we explore the potential of narrative as a learning tool to overcome challenges in engaging students in learning activities in informal science environments. In recent years, a number of researchers and institutions have shown an interest in science learning that occurs within informal settings (out-of-school) which operates across a broad range of contexts and disciplines and reaches out to people of all ages. Bell, Lewenstein, Shouse, and Feder (2009) argued that across informal social settings, such as on trips to museums and zoos, in the home, in activities with friends and community projects, learners may develop awareness, interest, motivation, social competencies and practices. These places, commonly referred to as informal science environments, have unique characteristics and advantages when compared to formal science environments (Avraamidou & Roth, 2016). In a report published by the National Research Council, Fenichel and Schweingruber (2010) argued that:

One of the goals of informal science environments is to introduce learners to scientific skills and concepts, the culture of science, and the role science plays in decision making. While some of this can be learned in school, informal settings have an advantage in that they can reach people of all ages, with varying levels of interest and knowledge of science (p. 7).

Even though there is a long tradition of studying informal science learning in museums, the field continues to explore whether there are new or different effective strategies to realize this goal. Despite this history, some the field continues to explore whether there are new or different effective strategies to realize this goal? In the present study, we explore a new set of strategies and related tools to help practitioners in informal settings support engaged learning for your? We address these questions through a study of narrative (fictional stories) as a youth-targeted learning tool in informal science settings. Specifically, how narrative can be applied to exhibits in
science center context for the purpose of scaffolding young students’ science learning (Figure 1).

THEORETICAL UNDERPINNINGS

The American psychologist, Jerome Bruner argued that as human beings we are born with certain mental schemas that we also apply to stories. We use these schemas in order to help ourselves to organise our experiences and as something we can rely on whenever we need to. Bruner claimed that stories are organised representations of human experiences that cool down the chaos that arises when actions, emotions, and thinking are mixed together (1986). According to Bruner stories accomplish this by creating an action that implements problem, temporality, and solution. When we tell a story, not all details from our reality can be present. We have to make selections, create hierarchies, and make a sequence. We create beginnings and endings to ensure coherence and in order to understand the world and hence, stories then support us when we try to remember the past and when we seek to figure out where to go in the future. The term narrative has been used for a number of purposes in the context of various disciplines and hence, a wide range of definitions of this term exist. As suggested by Avraamidou and Osborne (2009) a narrative is commonly defined as a story or part of a story and may be spoken, written, or imagined, and it can be viewed from one or even several perspectives. Schank and Berman (2002) described how stories are used every day as a way of making sense of and communicating events in the world, and can be found in movies, books, television, and everyday conversations.

Egan (1989) also explored the value of stories in education. He argued that the use of stories in education form a natural vehicle and means of educating students not only about their cultural and historical roots but also about the scientific descriptions of ‘reality’. Egan’s (1997) book, ‘The Educated Mind’ expands on Vygotsky’s theory that human beings make sense of the world by using “mediating intellectual tools” that

Figure 1. The exhibit is divided into seven learning areas that focus on animal senses
in turn affect the kind of sense we make of the world, or put different our understandings of the world. Egan proposed the development of an increasingly more complex set of cognitive processes that lead to understanding: Somatic understanding, Mythic understanding, Romantic understanding, Philosophic understanding and Ironic understanding. As he described, every child is born with some Somatic understanding, the physical sensibility (pre-linguistic) of the concrete world. Mythic understanding develops with the acquisition of language and enables children to navigate between myth, fantasy and in and out of communities of magical and mythical beings as a basic hierarchical understanding of systems. Romantic understanding develops as a child builds their skills with literacy and rational thinking, a period when children are pre-occupied with human achievements and qualities and the use of heroes and heroic achievements as elaborated hierarchies that typify social systems and processes. It is this romantic phase of cognitive development that typically emerges between that serves as the context of the work reported in this paper. In adolescence, children develop a philosophic understanding where principles themselves, a type of thinking that is convergent with the development of a certain set of communication tools as well as scientific thinking. In the work that followed this publication, Egan (2006) argued for an imaginative approach to teaching, and specifically fostering more creative thinking in classrooms through the use of stories as cognitive tools. In defining stories, he emphasized their value in orienting our emotions:

Stories are unique kinds of narratives in that they have, in their basic forms, ends that satisfy some tension generated by their beginnings. They can thus fix the hearer’s affective orientation to the events, characters, ideas, or whatever, that make them up. They allow us the satisfaction that life and history; which are, without the stories we try to lay on them, just one damn thing after another; deny us. The story was perhaps the most important of all social inventions, in that it provided the bond for languaged people to tie themselves into more complex societies than extended kin-groupings, emotionally committed to shared social and cosmic stories. Stories, basically, are little tools for orienting our emotions (Egan, 2001, p. 6).

As Karr (2011) argued about the role of museums contributing to the value of developing observational skills and relevant memorable experiences:

The most important knowledge will tell us stories of aspiring, unfinished lives, in situations of change. I want to know the content that draws them, the language they use to describe what is happening to them, and the processes they use to make changes in their minds and thoughts. These may be small changes, likely to be invisible to the eye, but they will have immediate value to the person who constructs a changing life (p. 9).

STORIES HOLD GREAT POTENTIAL FOR CREATING MOTIVATION, IMMERSION AND A SENSE OF AGENCY

Knowledge presented in the form of stories, given stories sociocultural nature and status, hold great potential for creating motivation, immersion and a sense of agency. With the use of stories students can create a “landscape of actions” and a “landscape of consciousness” (Bruner, 1986) that they carry with them throughout the activity. Moreover, the emotional properties of stories provide students with a sense of personal meaning.
about engaging with a learning activity. Stories provide a feeling of being in charge and being influential, especially when students play a part of the story, which would probably be motivating. In addition, as summarized earlier, students create elaborated mental images of the narrative that seems to create the basis of their understanding of the learning activity. These mental images represent an emotional attachment to their characters, which again creates an emotional goal for solving different assignments. Stories could also provide structural guidance for both students and teachers. They can provide a number of explicit and implicit directions for students during the learning activity, which makes it easier for students to interpret their own role in the activity and create a common reference within the class and during group work. As Mandler (1984) described, the story grammar makes it possible for students to foresee future elements in the educational activities, and it serves as a memory tool for past actions.

In attempting to offer a structural analysis of narratives (written stories), in this paper we use Avraamidou and Osborne’s (2009) conceptualization of narrative as composed by the following components:

*Purpose*: to help us understand the natural and human world. In the case of the natural world, narratives help the reader to invent new entities, concepts and some picture of the scientist’s vision of the material world

*Events*: a chain or sequence of events that are connected to each other

*Structure*: an identifiable structure (beginning, middle, end) where events are related temporally

*Time*: narratives concern the past

*Agency*: actors or entities cause and experience events. Actors may either be human or material entities who act on each other

**Narrator**: the teller who is either a real character or alternatively, a sense of a narrator

**Reader**: the reader must interpret or recognize the text as a narrative (p. 1693)

This structure instead of a more open-ended narrative with no structure, was used as the basis for the design of *The Emperor* given that it was intended for use with young school aged students. Based on this narrative concept, we developed three basic assumptions that guided the design and analysis of *The Emperor* which was used as part of an exhibit about senses at *Experimentarium*, a large, public science center in Copenhagen. (Appendix)

- A story can be used as a tertiary cognitive tool in a learning activity and provides structure and direction.
- The connection between story structure and cognition provides a gateway to design narratives that act as cognitive tools for learning
- When using a narrative as a cognitive tool for learning, it provides a number of properties, such as familiarity, understanding, interpretation, immersion, and motivation.

**THE PRESENT EXPERIMENT**

We present here, an overview of the experiment and learning outcomes. We note that the specific findings of this study formed the basis of one of the author’s dissertation research published earlier (Murmann & Avraamidou, 2014). Therefore do not present the specific data in this paper, but rather, the process and inference that were derived from that work and how that strategy adds to current trends in museums known colloquial as a “hack” or an “occupy” strategy.
that adds a new layer of interpretation to an exhibition to facilitate specific learning outcomes (Figure 2).

To pursue this experiment, and as directed by the Science Center management, the story design was developed as a companion set of school materials to expand learning opportunities for young children by guiding their exhibit experience. At the Center, school materials are usually supplied as a series of text-based folders, audio recordings, websites, or videos that support teacher led student visits. Sometimes the materials are exclusively to be used at the Center, and sometimes they incorporate pre- and post-visit activities at the school. In the case of the Senses Exhibit we created a text-based exercise book featuring a series of activities for use in schools and a set of activities to pursue while visiting the museum.

The exhibit and related materials were tested with seven school classrooms as part of a qualitative research study, aimed at exploring the use of stories as tools for science learning in the context of informal science environments (Murmann & Avraamidou, 2014). The design was based on three areas of interest: (a) the story as a tool for learning; (b) the student as subjects engaging with the story; and (c) the context in which the story learning activity takes place. In this study, students were engaged in a themed exhibit about human and animal senses at a public science center.

For this school visit learning tool, the story was created to deepen students’ engagement and interaction with the themed exhibit. The story was specially designed to provide opportunities for designing and conducting inquiry-based investigations through pre- and post-activities at school and at the science center. Seven classes (20–25 students each) from third to sixth grade participated in the study. Four classes where fourth graders. Grades 3, 5, and 6 were each represented by one class. Data were collected through observations, teacher and student interviews, lesson plans, and assignments in a period of six months and were analyzed by means of open-coding techniques. The analysis of the data showed that three parameters influenced the use of the story: (a) the ways in which teachers used the story; (b) students’ and teachers’ understanding of the story-based learning activities; and (c) structural and design components of the story. These findings illustrate the value of stories, as learning tools, in science education and have implications for story-based learning designs in formal and informal learning.
environments. In this paper, we explore what does that mean in terms of practice and we highlight the design structure and components of this story-based exhibit (Figure 3).

THE CONTEXT AND THE STORY

In the design of the story we first had to implement the narrative structures into the existing structures of the science center. We did this by designing a story called “The Emperor” for an exhibition about senses, where students had to learn about the differences between human and animal senses. A structural outline of the story follows:

The story describes an Emperor who does not believe that others may perceive the world differently than he does. It starts by describing how he becomes furious whenever someone claims to experience something that he cannot perceive. One day his dog claims to be able to smell a bone buried in the garden that the Emperor cannot smell. The Emperor becomes furious and decides that the dog is lying. He punishes the dog by cutting off its nose and sending it to jail. But soon, he discovers that all the animals in his kingdom are able to sense things he cannot and he removes their ears, eyes, and noses. To get help regaining their senses, the animals decide to contact the kids at a nearby school and ask them for help. This results in an exchange of letters between students and animals. Students can choose to help the snake, the rat, the bee, the scorpion, the dog, or the squid by explaining the Emperor about the lost sense of the animal and how it differs from human senses. In a final letter the animals invite students to visit a laboratory at Experimentarium, where the Emperor studies the animals’ senses. Here, students can test their hypothesis on animal and human senses. As students come back from the laboratory, they realise that the Emperor has decided to get rid of all the deceiving animals by frying them in his big black pot. The animals can only be saved if students will defend them in a court of law. Thus, the story climaxes, as students have to use their knowledge from Experimentarium to create arguments demonstrating that the Emperor is mistaken. A dramatic trial follows that ends when the Emperor is finally convinced. He now tries on the many different ears, eyes, and noses and discovers that it is quite true that animals do sense differently than humans.

Two issues were crucial to the design of the study, and the role of animals in the story. These were highlighted implicitly through the task of the students to help the animals through their engagement in the activities, but also through more explicit discussions with the teachers about the issues of animal cruelty and violence. The first issue has to do with the concept of animals’ *umwelt* (literally “around-world” or “surrounding world”) a concept that supports students developing awareness that other living organisms do not perceive the world we (humans) do and, if this awareness develops, it lays the foundation for developing a sense of empathy for that animal’s experience of the world. Structurally, the story attempted to foster admiration for senses that may perceive aspects of the world that are outside of human perception (e.g., dogs have a stronger sense of smell than humans). The design sought to accomplish this by directly presenting the issue of violence towards animals as an act that may require legal intervention. The story used in this paper is based on the following problem:

Once upon a time there was a distant realm where the Emperor fell out with the animals that lived around his palace. It was not really because the Emperor was particularly evil or cruel, but he had difficulty understanding why others could experience the world differently than he.

One could argue that this, indirectly, might portray an unethical message regarding the
Figure 3. A page introducing the narrative in the student textbook.
treatment of animals. However, we argue that this fictional story serves to communicate the fact that the Emperor was in disagreement with the animals only because he could not understand them. The students’ assigned role, through activities and teacher guides, is targeted as an altruistic “helper,” the heros of the story with the capacity to help the animals as advocates working to help the Emperor understand the animals’ umwelt. It is this heroic role that we proposed would support the learning about natural history and wildlife biology.

The exhibition was developed by the Experimentarium, an Institute of Natural Sciences and a Natural History Museum. It was created with both families and schools in mind, but it was specifically targeted toward children aged six to twelve. The Senses Exhibition sought to use informal encounters to expand understanding of how sensory perception informs action. The exhibition team described it as:

Our senses detect information (in stimuli) from the environment (and make us act appropriately). Some stimuli we can detect very well, for some stimuli our senses are limited and some stimuli we cannot sense at all while animals can sense them... The core message of the Senses Exhibition is translated into interactive exhibits so visitors will experience all the different stimuli present in the environment and learn that humans do not “use” them all to get information from the environment.

The exhibit concept report describes the exhibition as a set of seven distinct areas. Five areas demonstrated the classic senses of smell, taste, sight, touch, and hearing. Two areas offered interactive experiences that sought to present the more exotic senses of magnetism and thermoreception. The areas were each defined by different surface textures, such as wool, fake snakeskin, and wood. The animals, (highlighted as actors in the materials created for the school visits) were represented in the exhibition as plush animals, through videos and photographs of real animals. The core values of the exhibition presented scientific experiments, and emphasized visitors’ free exploration of information. The Experimentarium’s pedagogy could be considered a “classic” science center where exhibitions are developed according to constructivist guidelines. The story-based material, on the other hand, and the educational considerations in the development of the story (i.e., The Emperor) aimed to instigate self-directed inquiry during visits by creating a fictional narrative and challenge to students (outlined in Appendix A) (Figure 4).

**STRUCTURAL GUIDELINES**

The story of The Emperor follows the structural guidelines described earlier in this paper. The temporality of a story defines the borders of time by creating a beginning and middle and an end in order to create tension and excitement (Larsen, 2003). By establishing the visit to the science center as the middle of the story, school activities acted as the beginning and the end of the story. This was done to support student understanding of the narrative universe and the scientific concepts, before the visit to the science center. Other narrative components were placed strategically within the activities.

The structural organization of The Emperor, demonstrates how the story is designed based on the classic story schema of a fairy tale. The story creates tension and follows a classic story grammar by being divided into units of events, as described by the Hollywood model. This model begins with a prelude that captures the viewer and outlines the general
Aktiviteter  Her er en gennemgang af, hvad eleverne kan opleve i SE-området:

I Bærplukker kan eleverne konkurrere om, hvor gode de er til at skelne farver, når deres farvesyn svækkes, fordi lyset bliver svagere.

I Farveskifer undersøger eleverne, hvordan farver ændrer sig, når de ændrer sammensættningen af rød, grønt og blåt lys.

De kan spille Nektarjøger og samle nektar med og uden UV-syn. Og de kan lære mere om UV-lysets egenskaber i Kan du se UV? og UV-mønstre i naturen.

Eleverne udfordres i Den infrapæde-labyrint, hvor kun guldfliskens infrapæde syn kan se vejen. I Infrapæd graffiti laver eleverne graffiti med fjernbetjening og mobiltelefoner.

Øjegalleriet viser eksempler på, hvor forskellige dyser øjne kan være.

Endelig får eleverne en kunstnerisk oplevelse omsluttet af lys i Sans lyset.

Fakta  Mennesker og dyr bruger synet til at finde vej, vælge den rigtige fede, spotte bytte- og rovdyr m.m. De fleste dyr har øjne, som minder om menneskets. Men nogle primitive dyr såsom fladorme har lysfølsomme celler, der sidder i bunden af et hulrum og danner et såkaldt primitivt øje. Indo- sekter har facetjøne, der består af tusindvis af små enkeløjne, hver med en sansecelle.


Gennemgang af udstillingen 5

Figure 4. an activity page for student exploration at an interactive station in the museum.
premise of the story to be told. Then a presentation of the agents and an escalation of the conflict follow. When the story reaches its “point of no return,” the entire scenario of the conflict is set and the readers’ attention is caught to such a degree that she needs to get to the end. Then the conflict escalates even further toward the climax of the story in which the hero achieves the goals. Finally, the story fades out in order for the reader to say goodbye (Larsen, 2003) (Figure 5).

The story begins with a prelude (lines 2–3) in which the Emperor and his temper are introduced. This ensures that the reader becomes aware of the forthcoming conflict. After the prelude, the actors/characters are further introduced (lines 3–4) and the conflict of the story is established (lines 5–6). This happens when the dog claims he is able to smell a bone, which the Emperor cannot smell. The conflict escalates as the Emperor discovers that several animals claim that have the ability to perceive the world differently than he does, which ultimately makes him cut off the instruments (noses, ears, etc.) of their senses and throws them all to jail (lines 6–8). The story reaches a point of no return as students are asked to engage in the story by writing letters in order to help out the animals and go to the Emperor’s laboratory to plead their case (lines 9–15). The conflict escalates further once the students are back from the Emperor’s laboratory. Here, they realize that the Emperor wants to fry the animals in his big black pot (lines 15–18). Thus, the story climaxes as students engage in a trial against the Emperor by creating arguments for the animals’ survival (lines 18–20). When they succeed in this, the story fades out with a happy ending in which the Emperor acknowledges that animals do sense the world differently than humans and
Figure 6. A student’s letter reads: We have been to the laboratory and we know how snakes see (sense heat) and catches it’s prey. The Emperor has other priviliges than the snake, but humans are also able to do things, that a snake cannot do. LOSER.

Figure 7. Another student wrote a threatening letter. If you remove the senses from the animals Freddy Kruger will drown you in dry gin. You die if...
consequently releases them from imprisonment (lines, 20–22). The story also establishes a number of other classical, narrative components, such as temporality and agency. By establishing temporality, the story defines the borders of what students need to consider and what is to be expected. It provides a sense of where they are in time.

The story also places emphasis on the agency by following the Actantial model (Figures 6 and 7).

The model outlines the objective of the story, the heroes, the opponents, and the helpers. The agents do something that moves the story forward. Clearly, the opponent of the story is the ill-tempered Emperor who has captured the animals. The goal of the story is to provide a solution to the problem and free the animals. Students are the subjects or the heroes that able to achieve this goal. However, the students have to defeat the Emperor in order to achieve this goal. To do that, the students ‘need the help’ of scientific knowledge about the senses (Figure 8).

As described by Avraamidou and Osborne (2009), a plot ties the events and agents of the Hollywood and the Actantial model together. In *The Emperor* the plot is the task of finding a way to convince the Emperor that the animals are actually able to sense differently from human beings. The plot also defines the purpose of the story namely as emphasized by other researchers (Avraamidou & Osborne, 2009; Chatman 1980; Norris et al., 2005). In this story, the students are agents themselves and as such they can influence the story, as long as they stay true to the purpose of the story and make sure that their actions are aligned with the plot. As these structures of the story are followed, we assume that the story aligns with our cognitive story schemas and, hence it can be introduced to a learning activity as cognitive tool. The intention is that by highlighting these structures students use the story as a way of organizing information and communicating their understandings of that information to others.

**NARRATIVE-BASED DESIGN**

**The setting**

The intention of the design phase is to create the strongest possible story design by analysing the existing learning activity and imagining how a story scaffolds student learning. To ensure that our considerations were aligned with the needs of the school classrooms we had engaged in an on-going dialogue with three teachers from different schools. The first step in the design phase was the establishment of the current situation at schools and science centres. This informed the design process and serve as a tool for the interpretation of empirical data when we put the design to use. In the following paragraphs we describe the characteristics of the science center and the school curriculum. At the same time, we highlight some problems related to these settings that must be considered in the design of a story-based learning activity. The focus on learning about scientific phenomena is especially prevalent in the exhibition considered in this project: the Senses Exhibition. According to the sketch report, the vision and exhibition core message was:
Our senses detect information (in stimuli) from the environment (and make us act appropriately). Some stimuli we can detect very well, for some stimuli our senses are limited and some stimuli we cannot sense at all while animals can sense them. The core message of the Senses Exhibition is translated into interactive exhibits so visitors will experience all the different stimuli present in the environment and learn that humans do not use them all to get information from the environment.

The exhibit concept report describes a scenography, where the exhibition is divided into seven areas. Five areas demonstrate the classic senses of smell, taste, sight, touch, and hearing. Two areas demonstrate the more exotic senses of magnetism and thermoreception. The areas are defined by different surface textures of the exhibits, such as wool, fake snakeskin, and wood. In order to emphasize the role of the animals they are represented in the exhibition as stuffed animals, moving objects, and through photographs. The core values of the center and the exhibition are visitors' free exploration of scientific phenomena and experimentation. Consequently, as an institution for learning, the science center can be considered a “classic” science centre in which exhibitions are constructed according to constructivist guidelines. While the exhibit was not structured as a story, it offered opportunities for inquiry learning through interaction with objects and manipulation of materials. It also allowed the pre-visit story to structure a purposeful open-ended exploration of the exhibit content that could guide learning.

Integration of narrative structures and school curriculum

The aim of the design phase was to create a design that fits into the existing learning ecology or context. To do so, we developed the narrative structure to highlight the exhibit learning stations into the school curriculum. Our goal was:

To create a story-structure that motivates students for the learning activity by emphasising personal relevance and interest in the subject “senses,” enhances students ability to reflect upon the scientific phenomena of the Senses Exhibition, support students in the process of scientific inquiry, experimenting, and in creating arguments about the topic senses, reduce the novelty effect by considering students’ prior knowledge about senses, and orient students to the trip setting prior to the visit to the exhibition.

The story demonstrates how The Emperor follows the classic story schema of a fairy tale. This structure was intended to be easily recognizable to students and obvious enough that they would expect each of the components to appear within the story (Mandler & Johnson, 1977). The story creates tension and follows a classic story grammar by being divided into units of events. As described by the Hollywood model: the story begins with a prelude (lines 2–3) in which the Emperor and his temper are introduced. This ensures that the reader becomes aware of the forthcoming conflict. After the prelude, the characters are further introduced (lines 3–4) and the conflict of the story is established (lines 5–6). This happens when the dog claims to be able to smell a bone, which the Emperor cannot smell.

The school curriculum emphasizes a process of learning where students work independently in open-ended activities and are instructed by the teacher in more close-ended activities. As a consequence, the Emperor is created with open and closed sequences
whereby the teacher read parts of the story to the class and prompts students to then use the structures from these closed sequences to explore the context and interact freely with each other in open-ended self or social exploration to work toward the learning outcome. The intention is to use the open activities in the beginning of the program to reduce the novelty effect of the topic “senses” and the

**STUDENTS MAY NOT THINK OF THE STORY AT ALL BUT MAY FOCUS ON THE TASKS INITIATED BY THE STORY.**

science centre setting. The activities were developed to allow students’ the opportunity to share prior knowledge about the topic before the visit, orient students to the trip setting, give students a measure of choice and control during the visit, and offer students opportunities for group work to enhance their motivation and scaffold academic discussions during the visit (DeWitt & Osborne, 2007).

In interactive computer games this model integrates two different layers; what the story dictates and what users do. It does so through short tutorials that reveal a small part of the story before making an interactive universe available to the user. These little story bits are called “cut-scenes” familiar to game players (e.g. Resident Evil and Tomb Raider) (Dickey, 2006). In these cut-scenes the user is offered relevant information that might inform their action in the following interactive part of the story, and this creates a level of control for the designers of the story. However, the development of interactive elements affords students “agency.” That is, students are able to choose their actions individually, and those choices might influence their perception of the story. According to Macfayden, Stranieri and Yearwood (2008), this means the narratives is a background story that guides the experience but does not dictate the full story. Students may not think of the story at all but may focus on the tasks initiated by the story. Only if they are in doubt of how to solve a certain task or are moving between tasks is the story present. The story scaffolds the overall aims of the activity and sequence of choices they make, but recedes into the background as soon as they engage in the task (Macfayden et al., 2008). The idea of creating “cut-scenes” as a narrative supports the original idea of intertwining story sequences that link interactive sequences in the exhibit to the school material.

**Narrative reasoning: the alignment of story structures and learning goals**

Designing a story-based learning activity demands a delicate balance between the story structures and the learning goals of the activity. The main design challenge considers how each of the learning activity elements can be integrated with the narrative elements. During development, the activity is a constant process of considering how these elements interact, if they are equally represented and if they make sense in relation to one another.

The design of *The Emperor* aimed to provide students and teachers with what the team referred to as *narrative reasoning*. Narrative reasoning in this process meant alignment of story structures and learning goals. It sought to ensure that each goal or task should be grounded in both narrative structures and educational learning strategies. It sought to avoid a story that was ‘sugar-coated’, where students either play along but learn nothing, or recognize
that the playful nature of the activity is only ‘sugar-coating’ and feel misguided or cheated. That is to say, the story-based learning activity was structured so educational tasks and the story do not run in two parallel tracks without interaction. In the Emperor this was accomplished through an activity that tasked students with writing letters about the senses to animals who need knowledge to mount their defence against the emperor’s dictates. The letter writing created a connection between the story and the learning opportunities presented in the exhibits.

When using fictional narratives to support open-ended explorations in exhibitions, the goal was to create a story that could act as a tertiary cognitive tool while providing students with a meaningful context. That is, the design focus for this task was development of a “a narrative learning objective.” In a traditional education setting, teachers tend set up narrative objectives where learning objectives are the same as the narrative objective. As an exhibition stimulus, however, the goal is to construct learning objectives focused on students learning outcomes, while the narrative objective serves as a motivating stimulus to pursue knowledge acquisition. Traditional narrative objectives in this type of approach are often linked to a reward or goal like freeing the princess or winning half the kingdom.

For The Emperor the intended learning outcome was to increase understanding of scientific phenomena in the topic senses and to contribute to students understanding of scientific experimenting, thinking and language. Hence, the learning objectives aimed to help teach students who to prepare an empirical evidence-based investigation based on a question. In this case, the narrative learning objective: Save the animals and help them regain their senses by doing investigations that makes the Emperor realise that human and animals sense the world differently. It was the core hypothesis of this experimental intervention that the fictional story established enough of a fantasy that children felt motivated to diligently pursue investigations and learning about the senses. It established the goal of freeing the animals and helping them to regain their senses.

The approach also considered narrative reasoning is the physical context. In this case, narrative information from the story was anticipated to be present in the learners’ consciousness, a theory described by the situation model (Graesser at al., 2002). The Emperor aimed to foster narrative reasoning regarding the physical context by incorporating the school environment into the story and having the students “receive” letters from the animals as they pursue their investigations at school. This strategy did not change the physical surroundings (i.e., school classroom, exhibit), but rather, used them as settings for the story. This was considered central to the strategy because the fictional story universe could easily collapse if the school setting does not live up to the narrative description. In this case, exhibition environment was described as the Emperor’s laboratory with each exhibit component described as laboratory equipment in the narrative. This strategy helped support the shift between the real environments at the school and the science centre exhibitions while maintaining a coherent fiction (Figure 9).

DISCUSSION

In this paper we explored the idea of using fictional stories as motivational learning tools as a strategy to encourage active learning in a science center. In doing so, we offered an example from the development of a narrative-based design called “The Emperor who only Believed his own Eyes” that reinterpreted the exhibit context of a in a large public science center. The goal of
this supplementary design tool was to create a story structure that motivated students for the learning activity by emphasising personal relevance and interest in the subject “senses”, enhances students ability to reflect upon the scientific phenomena of the Senses Exhibition, support students in the process of scientific inquiry and construction of scientific explanations, reduce the novelty effect by considering students’ prior knowledge about senses, and orient students to the trip setting prior to the exhibit visit.

Even though the argument for the use of narrative as a learning tool in informal settings is compelling it raises more questions than answers given that this research area remains largely unexplored. As Allen (2004) argued, even though narrative offers a powerful exhibit technique, it has had a less prominent role in science museums. We believe this study demonstrates that exhibits offer...
many opportunities for occupation by narratives that aren’t necessarily the primary exhibit theme, but deepen opportunities for engagement. We suggest that future research might challenge how fantasy hidden or secondary narratives hold for exhibit design.

Based on our experience developing the Emperor, we suggest that during the design phase the use of narrative structures should be considered carefully. Designers should create a narrative-learning objective, emphasizing potential motivating structures to help make the scientific topic personally meaningful in context. In order to promote immersion into the story universe, the structural components of the story-based design should create a part for students to play out, and create emotionally relatable characters. Similarly, this experiment demonstrated that story with a central plotline that is easy to remember can help guide students in their self-directed tasks and help advance the story through their tasks. An ideal plotline should act as a common reference for students and teachers in their discussions, inquiries, and any presentations they might make. We recommend that adopting this form “narrative reasoning” allows interaction between factual real world experience applied to the fictional narrative. In addition, based on our experience testing implementation of the Emperor, we recommend that narrative-based design for learning consider teachers’ familiarity (or lack thereof) with the use of stories as learning tools. Teachers may need to be made aware of their role as mediators of the story and the potential that the story holds as a scaffold. Moreover, the design of the series of tasks poses a challenge because it contrasts with traditional education pedagogy and how students’ expect they will be taught science.

In designing the story of the emperor, we imagined the story as a tertiary tool, a mental *microworld*, students could use to interpret their surroundings. The outcomes of this study demonstrated that this internalised *microworld* is influenced by a number of aspects from the learning ecology of schools and science centres. Specifically, the outcomes of the implementation showed that in a story-based learning activity the story provides a social, cognitive, tertiary tool, which students and teachers may use as a common reference. The story need not be omnipresent, but rather, provides a frame and a memory tool that students and teachers may use as a common reference as needed. To students the story represents a controlled way of playing where they can still take directions from the teacher. In this context, the teacher/facilitator provides an essential mediation of the story to help students remain immersed in the story and permission their exploration.

Our results demonstrated that the story as a learning tool inhabits a number of qualities from psychology and literary theory, such as immersion, motivation, agency, and structures for cognitive guidance. We note that students’ perception of these properties was influenced by the educational elements, which leads students to maintain a slight emotional distance to the story and only immerse completely into it in their own imagination. The story primarily serves as a tool that teachers and students can rely on to create a sense of agency and motivation, structuring meaningful cohesive educational activities. If the story fails to maintain coherence or relevance in the task, it also fails to scaffold students learning tasks (Figure 10).
Figure 10. The book resolves the pretend condition based on student led reasoning about the science of perception to overcome the moral dilemma in the fictional exercise.
What’s unique about the story-based design described in this paper, is an innovative overlay of a fantasy story that provides access and action challenges that depart from the traditional pedagogy, revealing entirely new learning modalities that are cognitively appropriate for different ages. This paper offers an argument for inhabiting exhibits with alternative stories to scaffold student learning in zone-based discovery areas. The layered story that may not be apparent to most museum users can be used to support student directed inquiry that can enhance museum usership for young children, and guide interrogation with purpose and model potential museum uses as children grow.

Based on the findings reported in our earlier studies and the re-examination of this work in the context of the literature presented here, we propose a set of recommendations for future designers of story based learning supplements to place-based learning:

- Emphasize teachers’ role in facilitating the story and highlight the difficulties and advantages of introducing this genre to learning activities in the subject of science;
- Provide teacher briefing materials to explain how learning activities can be executed;
- Integrate elements that students and teachers associate with science, such as experiments and other hands-on activities;
- Analyse the learning outcomes to ensure that the story-based design offers clues to students on how they can achieve the fantasy outcomes;
- Test the tools to ensure the fictional characters and motivation are personally relevant and emotionally relatable;
- Create an easy to remember plotline as a common reference for students and teachers during discussions, inquiries, and presentations;
- Make sure that the story is mediated during the visit to the science centre, by the teacher, staff, computers, booklets, or other materials;
- Create a narrative-learning objective which emphasises students’ interests and make the scientific topic relevant as a scaffold to reach this objective; and
- Ensure that all parts of the learning activities are grounded in “narrative reasoning” that connects the story structures to the educational content.

CONCLUSION

This paper sought to add a new perspective on the growing the field of informal science education, museum studies, and specifically the use of fictional stories in science learning. Existing literature shows that narrative is a compelling tool for learning and fosters a greater motivation for students. Nevertheless, empirical studies that provide concrete evidence of the impact of narrative on student science learning are limited, especially in the context of informal science environments. We hence recommend that future research be directed towards producing a set of studies that explore the use of narrative as a learning tool within the context of informal science settings such as museums, science centers, museums, zoos and other out-of-school settings.

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APPENDIX. THE EXHIBIT

INTRODUCTION TO SENSES

The senses of the body are fascinating tools that have helped humans survive through generations. They are constantly at work sending a constant stream of information: The traffic lights changes color to red. A friend calls. A kiss on the cheek. A scent of flowers.

IS THERE A SIXTH SENSE, A SEVENTH OR AN EIGHTH?

Your students may know the five senses: vision, hearing, smell, taste, and touch. But human senses detect only a tiny fraction of the information from our surroundings. Many animals experience parts of the world that are unavailable to human perception. Sharks have
a sense that marks tiny electric fields in order to catch its prey. A pigeon feel Earth’s magnetic field by an internal compass to find their way.

Our skin can sense touch, heat, and cold. But if we study the skin under a microscope different receptors detect touch, heat or cold. One kind of receptors detects heat and cold and another kind detects touch. In many animals, these receptors are located in their sensory system. Cats’ whiskers detect such touch, but they do not register when something is hot. And some snakes have special heat sensory organs, similar to human eyes. Even you and I sense the world differently! Human senses have great individual differences in sensitivity.

What do your students experience in the exhibition?

The exhibition SENSES is about how animals and humans sense the world and how the senses fit our needs and helps us to survive. The exhibition is divided into eight areas with more than forty activities. The exhibits examine the sense of vision, hearing, smell, taste, hot/cold and touch along with the two more exotic senses: magnetic sense and sense electrodes. Students can also test their own senses and compare them with animal senses.

SIGHT

This page shows what the students can see in the exhibition area on the perception of sight

- In *the berry picker*, the students compete to see how good they are at distinguishing colors as their color vision is weakened because the light is weaker.
- In *color shift*, the students examine how colors change when they change the composition of red, green and blue light.
- They can play *nectar hunter* and gather nectar with and without UV vision. And they can learn more about the UV light’s properties in “Can you see UV?” and “UV patterns in nature.”
- Students are challenged in the *infrared maze*, where only the gold fish’s infrared vision can see the road. In infrared graffiti, the students make graffiti using remote controls and mobile phones.
- The *eye gallery* shows various animal eyes.
- Finally, the students get an artistic experience in *sense light*.

HEARING

This page shows what the students can see in the exhibition area on the perception of hearing

- In *Superhearer*, students can measure which frequencies they are able to hear and compare it to animals.
- Students can compose high-frequency ring tones for the mobile phone in *ring tones inaudible*—even ones beyond their teachers hearing limit!
- In *DJ Monkey*, the students examine how their voices sound if they change the frequency.
- Students can find animals that are good at communicating over long distance in the *Superyeller*.
- In *Ultrasound*, students shoot moths by using the hearing of bats.
- *Sense the Sound* is also a sound-art installation.
- Finally, students can see examples of ears in the *Ear Gallery*. 
SMELL

This page shows what the students can experience in the exhibit area on the perception of smelling:

- In the **Smell Your Way**, students can investigate how good they are at smelling their way to food and hazards.
- They can test how small concentrations of cannabis they can smell in **How Little Can You Smell**? How good are they compared to a trained police dog?
- In **Can You Smell the Flower**, students get answers to whether they are genetically predisposed to being able to smell the flower Freesia.
- Our language is very limited when it comes to describing smells, but in **Name a Scent**, the students will try it.
- In **Can You Find Smells** the students compete about how good they are at identifying individual odors in a mixture of scents.
- Finally, students can see examples of different animal noses in the **Nose Gallery**.

TASTE

This page shows what the students can experience in the exhibit area on the perception of tasting:

- In **The Taste Area**, students can explore how the tongue is able to taste sour, sweet, salty, bitter, and umami taste in **The Five Flavors**.
- They examine whether they can recognise flavors as vanilla and cinnamon, if they cannot smell anything **smell a taste**.
- They can also locate their own taste buds in the **find the taste buds** and examine whether they are **supertasters** with a drop of the bitter substance PTC that not everyone is able to taste.
- Finally, students can see examples of how different animals perceive taste in the **Tongue Gallery**.

THE LEARNING ACTIVITY

**First part:** Read the first part of the story. You can find it on page 15 under the title **The Emperor Who Only Believed His Own Eyes**. The story explains how the animals in the land of senses have been thrown in jail and deprived of their senses by the Emperor. The Emperor was angry at the animals because they claim the world to be different than what the Emperor is experiencing. Animals ask students to help them get their senses back.

**Task:** Each group chose an animal to help and as a personal contact to the land of senses. The choice of animal determines the group’s sense to become experts in. It is a good idea that the groups have different animals in order to get around all subjects and make the students feel that they are experts in their particular animal.

**Second part:** Give students the letter from the animals they are helping. The letters are on pages, 20–25, entitled, **My Conflict with the Emperor**. In the letter the animals thanks for the students’ answers and describe their conflicts with the Emperor: the bee can see flower patterns the Emperor cannot see. The dog can smell bones, etc.

**Task:** The teams must describe for the animals, how it is to do without a sense. The animals will gather the students’ responses and use them to convince the Emperor of how difficult
it is to do without the senses, in order for him to give them back their senses. The task can be answered orally, in writing or via subscription. The students give you the answers as you promise to pass on to the carrier pigeon so the animals will get the letter.

**Third part:** Read the letter “Strange Worlds” out loud in the classroom. You’ll find it on page 26. The letter tells the animals that the students’ responses have made them wiser about how humans sense the world, but they dare not give the letters to the Emperor yet. They need more and stronger arguments. The animals ask the students to send a letter explaining the Emperor how the human world would be if they all lacked for example vision. Maybe it can get the Emperor to understand how the world is difficult and tedious if all animals and people are senseless.

**Task:** The questions from the animals are distributed to groups and are answered either orally in writing or via subscription. They can also be used to wonder about issues jointly philosophising in class for five to ten minutes.

**Fourth part:** Read the “Invitation to the Emperor’s laboratory” out loud in the classroom from page 28. Here the animals invite students to the Emperor’s laboratory, where the Emperor is in the process of investigating the senses of the animals. In the laboratory, students can explore issues on their own body and find information to convince the Emperor that the animals are not lying. Then give students the assignment “Experiments in the Emperor’s Laboratory” on page 29.

**Task:** The teams must plan their studies at Experimentarium. They must articulate what they already know, that may explain why their animals and the Emperor perceived the world differently. They must describe what they need to find out at the Experimentarium, and they must decide which activities in the Emperor’s laboratory to work with and develop a timetable. You need to consider how students will collect information in the exhibition. Should they use pen and paper, a Dictaphone to confide their discoveries or use the camera in their mobile phones to photograph the things they need to remember?