Using narratives to evoke empathy in museum-based engineering activities

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Abstract

In this design-based research project, researchers and activity developers across four institutions are investigating how narratives can evoke empathy and influence girls' participation and engagement in museum-based engineering design activities. The project involves the development and testing of six pairs of engineering activities. Through iterative development of these activity pairs, we have refined a conceptual model defining how engineering activities can incorporate a variety of narrative elements to support empathy and engagement. In addition, each pair includes one version of the activity with narrative elements, and one without — for example, children design a vehicle that can move over different textured surfaces (non-narrative) or that can help someone travel around the world across different landscapes (narrative), allowing us to examine how narrative elements influence girls' ideation and persistence in iterating their designs. We analyzed the number of children who participated in each version of the activities, average hold times, and detailed observations and follow-up interviews with girls between ages 7-14 who tried the activities with their families. Results showed that narrative versions invited greater participation among both girls and boys, and that different narrative elements (such as characters and settings) evoked different aspects of empathy (such as affective responses and cognitive perspective-taking). We discuss the implications of the results for the design and facilitation of inclusive engineering design experiences in informal learning settings.

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Purpose

In this design-based research project, researchers and activity developers across four institutions (New York Hall of Science, Scott Family Amazeum, The Tech Museum of Innovation, and Creativity Labs at UC Irvine) are investigating how narratives can influence girls' participation and engagement in museum-based engineering design activities. By developing and testing activities that incorporate narratives in a variety of ways, the project aims to help museums create equitable and effective STEM learning experiences that engage all children in the core concepts and practices of engineering.

Theoretical framework

Research in engineering education and policy has shown that women remain underrepresented in engineering (National Science Foundation, 2017), in part because girls are less likely to engage with decontextualized or competitive engineering challenges (Ceci & Williams, 2010; Rusk, Resnick, Bern, & Pezalla-Granlund, 2008). Using real-world problems as the basis for engineering and design activities can increase girls' engagement by linking to personally- and socially-relevant issues (Bennett, Monahan, & Honey, 2016; Peppler & Glosson, 2013; Seehra, Verma, Peppler, & Ramani, 2015). In addition, recent approaches to engineering education have emphasized the importance of emotional and interpersonal skills like empathy and perspective-taking as part of the design process, allowing engineers to understand the experiences of their clients and design solutions that meet their needs (Walther, 2017; Hess & Fila, 2016). Together, these lines of work point to the need to create new and more inclusive engineering experiences that are grounded in human-centered stories and that encourage learners to consider others' perspectives. Researchers and activity developers in museums have found that adding narratives to otherwise abstract engineering activities is a promising strategy for evoking empathy and engaging girls (Bennett, 2000; Monahan & Bennett, 2013). However, there is little systematic evidence that defines what kinds of narrative elements are most effective in eliciting empathic responses and supporting engineering practices like ideation and iteration.

Methods and data sources

In this project, museum practitioners and researchers are collaborating to develop and test six pairs of engineering activities. Through iterative development of these activity pairs, we are building a conceptual model defining how engineering activities can incorporate a variety of narrative elements to support empathy and engagement. Each pair includes one version of the activity with narrative elements, and one without — for example, designing a vehicle that can move over different textured surfaces (non--narrative) or that can help someone travel around the world across different landscapes (narrative). By comparing narrative and non-narrative versions of each activity, we are examining how narrative elements influence girls' overall engagement and persistence in the engineering process. Each activity was developed in a roughly 10-week cycle: In the first four weeks of the cycle, the narrative and non-narrative versions were rapidly prototyped and iterated to establish that the engineering concepts and materials were comparable, and that narrative elements were engaging for museum visitors. In the final six weeks, the two conditions were alternated such that the narrative and non-narrative versions were each tested on the museum floor for three full days (generally on weekends when museum visitation was high).

Data have been collected for five activity pairs to date. Data include: 1) Documentation of materials and facilitation strategies used in each activity, including the iterative revisions made based on initial prototyping; 2) The total number of children participating (and their ages and genders), and the amount of time family groups spent engaged with each version of the activities (a total of 1290 family groups tracked); and 3) Detailed observations and interviews with a subset of 207 girls (ages 7-14) who participated in either narrative or non-narrative versions of the activities with their families.

Development of Activity Pairs

Through iterative activity development of five activity pairs, we identified several aspects of narratives that can shape how visitors engage with engineering problems: 1) where the narrative is located — in characters, settings, and/or problem frames; 2) point of view — whether visitors are imagining someone else's perspective, or imagining themselves in a novel situation; and 3) how the narrative is communicated — through a combination of materials, facilitation, surrounding environment, the name of the activity, and visitors' own work. Table 1 describes how these elements have been combined in the five activities developed to date.

Table 1. Narrative elements in five engineering activities

Activity	Narrative location	Point of View	Communicated via
Dowel Structures	Problem	Self in imagined situation	Facilitation, Signage
Chain Reaction	Character, problem	Realistic other	Materials, Facilitation
Invention Challenge / Help Grandma	Character, problem	Realistic other	Activity name, Facilitation, Signage, Visitors' work
Dropped Calls / Safe Landing	Character, problem, setting	Imaginary other	Activity name, Materials, Facilitation
Air Powered Vehicles	Setting, problem	Self in imagined situation	Materials, Facilitation

Narrative and non-narrative versions involve similar engineering concepts and use comparable materials, but differ in how the activity is framed:

1. *Dowel Structures:* Children build a structure that is stable and fits everyone in their group (non-narrative), or that can protect their group from an earthquake (narrative).

2. *Chain Reaction:* Children use a sequence of simple machines to accomplish a goal, like ringing a bell or landing a ball in a cup (non-narrative), or to take care of a pet, for example feeding or playing with a dog or cat (narrative).
3. *Invention Challenge/Help Grandma:* Children design and build models of novel inventions to solve abstract physical challenges, like lifting a heavy object (non-narrative), or to solve problems that grandparents face in everyday life, like carrying groceries or climbing stairs (narrative). Persona cards provide information about "clients" and their lives.
4. *Dropped Calls/Safe Landing:* Children design something to protect a cell phone from a 20-foot drop (non-narrative), or to protect an alien landing on the surface of a planet (narrative). Children choose and personalize a character in the narrative version.
5. *Air-Powered Vehicles:* Children design a vehicle that can move across different textured surfaces (non-narrative), or that can help them travel around the world across different landscapes.

Results

Observations throughout iterative activity development revealed how specific materials and facilitation strategies communicated narratives and supported the engineering design process. In particular, the materials used in many activities suggested a relatable context or provided physical reminders of the users of a design. For example, *Chain Reaction* included lifelike and interactive models of animals that visitors could incorporate into their contraptions, designing inventions to play with or feed them, and *Air-Powered Vehicles* included realistic backdrops and terrains from different kinds of landscapes. In other cases, knowable materials provided a starting point and inspired visitors to imagine solutions to the problem. In *Help Grandma,* children's inventions were inspired by examples left behind by other visitors (with labels describing their work) as well as the constraints and affordances of the repurposed building materials that were available (nuts, bolts, pegboard, rubber bands, recyclables, etc). Similarly, facilitators used the narrative framings to provide an accessible introduction to design problems, and prompted visitors to think about the end users of a design. Feedback from museum staff indicated that the narrative versions were easier to facilitate because they provided easily understandable starting points for problem scoping, as well as open-ended and imaginative avenues for helping visitors decide what to change about their designs.

Although hold times were comparable for the narrative and non-narrative conditions, we saw a significant difference by condition in the number of groups participating in the five activities, $\chi^2 = (4, N = 1290) = 13.786$, $p = .008$. Specifically, more family groups participated in the narrative than the non-narrative conditions. For groups with at least one girl, we observed significant differences between conditions in the number of groups participating in *Dowel Structures* (χ^2 (1, $N = 192$) = 8.33, $p = 0.004$) and *Air-Powered Vehicles* (χ^2 (1, $N = 137$) = 6.139, $p = 0.013$), and marginally for *Chain Reaction* (χ^2 (1, $N = 187$) = 2.829, $p = 0.09$) and *Dropped Calls* (χ^2 (1, $N = 95$) = 3.042, $p = 0.08$). For groups with boys, we observed significant differences in participation between conditions for *Air-Powered Vehicles* (χ^2 (1, $N = 147$) = 11.435, $p = 0.001$) and *Dropped Calls* (χ^2 (1, $N = 116$) = 6.759, $p = 0.009$), and marginally for *Chain Reaction* (χ^2 (1, $N = 240$) = 2.817, $p = 0.09$). These results indicate that the narrative conditions were more appealing to children overall, and that when more girls participated in these activities, it was not at the expense of boys' participation. Finally, we found that visitors themselves frequently engaged in their own storytelling, extending the narratives that we provided. For example, children personalized their own characters in *Safe Landing* (choosing aliens or astronauts, naming them, and decorating them), and this occasionally prompted further storytelling about where the character was traveling to and why. This type of engagement with the narratives was especially prevalent in younger children (under age 10), who were more likely to engage in pretend play than were older children. Building on these findings, the sixth activity currently under development is exploring how narratives created by children themselves can motivate engineering and design (using special effects with light and shadow to encourage visitors to create their own stories or light displays).

Through observations and interviews during the development of the first three activities, we identified several indicators of empathy in narrative activities: 1) *Affective responses:* including emotional connections with the end user (e.g., sympathy, compassion), or describing how one would feel in a given situation; 2) *Identification:* making a connection to one's own prior experiences or familiar situations; 3) *Perspective-taking:* imagining another point of view, such as thinking about what it would be like to experience a design problem or use a design solution; and 4) *Expressing a motivation to help:* wanting to offer assistance or protection. When these behaviors were included in a structured observation protocol for the final two activities, we found that the majority of children (64%) in the narrative condition showed at least one of these indicators of empathy, and a large percentage (47%) showed two or more. Further, empathy behaviors were more prevalent in an activity that used characters (*Safe Landing;* 80% showing at least one indicator) compared to one that relied on setting (*Air-Powered Vehicles;* 52%). However, each activity supported distinct aspects of empathy: characters evoked affective responses and motivation to help, while settings were more likely to evoke perspective-taking, in which children imagined what it would be like to be in a place. This suggests that relatable characters may be a particularly powerful strategy for evoking emotional aspects of empathy in this age group, but that settings might be useful for certain kinds of design problems.

Significance

Through the iterative development of these activities, this project has shown how elements of narrative can be incorporated into engineering activities to support the core engineering content, as well as related skills like empathy and user-centered design thinking. The project advances theoretical knowledge about how a relatively subtle narrative framing can provide novel ways into engineering problems. In particular, we found that different narrative elements fostered different aspects of empathy (with characters evoking emotional responses and settings supporting perspective-taking to a lesser extent), and that narrative framings benefitted both girls and boys. These findings suggest the potential value of using of narrative elements (especially relatable characters/clients with familiar problems) to engage children in engineering. In addition, by exploring how materials and facilitation strategies work together to reinforce both the narratives and the design process within each of these activities, this work provides practical strategies for designing more equitable experiences that infuse engineering problems with real-world contexts and stories.

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