Designing for Empathy in Engineering Exhibits

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Women are persistently underrepresented in science and engineering fields (Bix, 2014). However, when engineering problems are posed as personally meaningful and connected to people and communities, girls are more likely to express interest in solving them (Bennett, 2000). Personally meaningful problems can tap into learners' capacities for empathizing with those for whom they are designing, and can help learners develop positive conceptions of engineering (Cunningham & Lachapelle 2014). While some research has attended to this relationship between empathy and engineering, such empathic engineering engagement remains understudied in education. Constructionism helps to further explain that empathy and relationships between both people and material are central to the learning and design process. For example, Harel and Papert (1991) argued for engagement with carefully selected materials to support the development of personal relationships in which affect can blend with and inform formal domain learning. This can create moments of empathy in what we might call a human-centered design experience, a design process that takes a deep appreciation of the needs of others into consideration (Nelson & Stolterman, 2003).

While human-centered design elements are promising starting points for evoking empathy within engineering learning activities, it remains unclear how to design engineering activities to support empathy and how empathic design relates to engagement with engineering. Our research focuses on the design of engineering activities within museum contexts because informal STEM learning environments are inherently social, have the potential to reach diverse audiences, and can contribute to more inclusive and contextualized experiences with engineering. This research asked: *How do design elements of science museum-based engineering activities support empathy development and influence engagement with engineering for girls (ages 7-14)?* We conducted observational studies of three activities at an urban science museum on the East Coast of the United States. Exhibits included: 1) *Help Grandma*, in which visitors read activity cards with characters requesting help with everyday tasks, and designed inventions to help them; 2) *Chain Reactions*, in which visitors created contraptions to take care of pets; and 3) *Air Powered Vehicles*, in which visitors constructed vehicles to help someone travel over different landscapes (e.g., sandy deserts or forest floors).

We observed a total of 117 girls (ages 7-14; 38-40 observations per exhibit) using an observation protocol we co-developed to track engagement in engineering practices and evidence of demonstrating empathy within the design process. Our protocol included overall dwell time, empathy markers (i.e., desire to help, user-centered design, affective empathy toward designing, affective empathy toward user, perspective-taking, familiarity, societal issue), and engineering practices (i.e., imagining new possibilities, iteration, persistence, problem scoping, solution finding,

testing, and tinkering). We photographed visitors' projects and conducted semi-structured interviews that asked visitors about their design process.

We conducted an analysis of variance (ANOVA) to compare dwell time, empathy markers, and engineering practices across activities. For all exhibits we found that the average dwell time within exhibits was well above average of science in museum exhibits (typically 1 minute) at an average of 17 minutes per observed visitor. This suggested that the designs presented opportunities for investigating engineering practices and their relationship to empathy. Of the engineering practices we observed, frequencies clustered around persistence, testing, and tinkering across exhibits perhaps also because observed visitors often started out tinkering with materials and went on to solve problems with the materials. Of the empathy practices we observed, frequencies clustered around perspective-taking and familiarity. Perspective-taking refers to acting out a use or explaining how someone would use the design, for example, a visitor who created an invention to help a grandma carry a heavy item stating "If it was real, the person would push it up" while acting out how the design would be used.

Of all exhibits, *Help Grandma* produced the highest frequencies across all empathy markers. Help Grandma included the design element of creating an innovation for a familiar person and we consider that it was this design element that supported empathy. Taking a deeper look at empathy, we recognized that empathy markers explained both engineering as well as dwell time. Those visitors who showed at least one empathy marker stayed with the exhibit over 30 minutes and performed at least five different engineering practices. Small design changes had an impact on empathy markers. For half of the observations, the animal characters of the Chain Reactions activity wore collars that read "I want to play" or "I am hungry". For the other half of the observations the collars were omitted. When the collars were there, visitors stayed with the activity significantly longer with more empathy practices compared to engagement without collars. The collars provided opportunities to attribute needs and desires to the characters, which, similarly to the Help Grandma activity, supported the possibility to design for characters. The findings that empathy markers are compelling predictors for engineering and dwell time and that empathy markers can be evoked through specific design elements has implications for the design of engaging engineering activities that appeal to girls and museum visitors more broadly.

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