Expanding the 'Personally Meaningful': Engaging in Sound Making to Support Engineering Practices

Santiago Hurtado, Technical University of Munich, s.hurtado@tum.de
Anna Keune, Technical University of Munich, anna.keune@tum.de

Abstract: Personally meaningful design activities, such as sound making, can provide contexts for engineering education. Sound is personally meaningful because it connects to histories of a person's experiences and represents them. Building on constructionist perspectives, this qualitative study investigated engineering practices while youth created sound with conductive materials inspired by personally meaningful objects. Findings suggest that personally meaningful design activities should include materials with personal histories.

Introduction

The STEM field faces dropout issues internationally (e.g., Chen et al., 2018). Alternative approaches to STEM (Science, Technology, Engineering, and Mathematics) education are needed to counteract this trend. We focused on engineering education, which can be a path toward STEM education (Simmaro & Couso, 2021). Engineering education in K-12 is still not widely implemented, but early exposure could provide youth with positive experiences to inform their decisions to choose to stick with STEM. A promising approach toward early engineering education is through personally meaningful projects (Papert, 1980). Personal projects provide meaning beyond intended use, they evoke experiences that tie domain learning and interests (Turkle, 2007). One meaningful context in this area is sound making. Sound can have personally meaningful properties because we experience sound in everyday life and attribute meaning to sound through memories and emotions (Cambrón, 2005). Sound can become an object-to-think-with that provides a link between abstract and sensory knowledge at the intersection of cultural presence, embedded knowledge, and the potential for personal identification (Papert, 1980, p. 11). Despite these promises, we know little about the utility of sound making for engineering learning. Thus, we asked: *How does sound making tie personally meaningful objects and engineering practices in middle school students, and what electronic kits can support this better?* This qualitative study investigated the engineering design practices as youth engaged in sound making with electronic maker kits and conductive and non-conductive materials inspired by personally meaningful objects. We understand sound as vibrations transported through waves that can carry meaning. We found that sound making can evoke engineering design practices especially when it is possible to combine several conductive materials and build on personally meaningful objects. We close with implications for designing for engineering learning through sound making.

Methods

To address the research question, we used a qualitative approach with two groups of ten-year-olds in two 75-minute-long sessions for each group at a makerspace in Bavaria. The first group consisted of five girls and five boys and the second of seven girls and four boys. Every participant brought a personally meaningful object to the workshop (e.g., toy car, plant, house keys). Participants used the Playtronica Playtron, MIDI controllers that can be connected through smartphone or computer to play an instrument, and Squishy Circuits kits, which included battery packs, buzzers, motors with propellers, and switches, usually connected through conductive playdough. All participants had access to additional materials, including graphite pencils, copper tape, conductive thread and paint as well as other non-conductive craft materials. The participants had to produce sound with their personally meaningful object, electronic kits, and crafting materials. The data sources were: (1) Videos captured with three cameras (280 minutes) to show the interactions of all participants and (2) semi-structured interviews (123 minutes) that asked about their experiences with sound making, engineering, and crafting throughout the sessions. To answer the research question, we analyzed the video data and interviews following an iterative thematic approach to understand the engineering design practices (see National Research Council, 2013) that participants performed while creating personally meaningful sound. Additionally, the engineering design practices were coded as instances to compare how students engaged with the kits.

Findings

We found that engineering design practices through personally meaningful sound making were supported differently. Due to space constraints, we focus on Squishy Circuits. We identified two themes with Squishy Circuits: (1) Physical sound tinkering as conducive of engineering practices, which involved creating sound with movable objects powered with Squishy Circuits, and (2) filtering sounds as conducive of engineering practices, which involved using the buzzer as a main sound maker, but tinkering through filtering it with materials on top of it to modify its sound (e.g., foam, paper, dough, fabric). Squishy Circuits allowed youth to experiment with materials and to approach their sound creating task in different ways. They were able to design, iterate their designs, come up with new designs, and showed understanding of how materials worked and were connected.

Barney, a boy in the first group, brought a fidget spinner to the course as his personal object. He aimed to recreate its plopping sound. He tried replicating the sound of removing the lid of a metallic container remotely by using the Squishy Circuits propellers to create air pressure from inside. Barney iterated by adding propellers, battery packs, and adjusting the placement of the materials. When this did not work, he tried alternatives and understood that his design would not allow for his desired result due to not being airtight, the lid being too heavy, and the propellers not having enough force. Barney finished his project tapping the side of the can with the propeller and added the possibility of putting an ear inside the can for extra detail on the sound (see Figure 1). He showed engineering design principles through planning of his design, developing possible solutions, iterating multiple times on these solutions, and constructing explanations of the materials and their interactions. Barney used his personal object to guide his design and engage him to stay with it until the end.

Figure 1
Barney's four material explorations for his artifact representation: (1) Squishy Circuits buzzers with playdough, (2) xylophone being hit by the propeller, (3) propeller inside a plastic bottle, and (4) metallic can.

Discussion

This study points to the possibility of sound making with construction kits that connect to a range of materials as for engineering engagement. Also, providing a spectrum of materials for playing with resistance and conductivity as well as including physical materials enables experimentation with a range of sounds (e.g., tapping, sliding). This study suggests considering personal histories when designing personally meaningful activities. Beyond design activities being personally meaningful because people can choose what they want to design, bringing material objects (e.g., a plant, house keys, a toy car) from a persons' past and designing with them as an inspirational source can expand the personally meaningful toward including personal histories in activity designs. Such sound making can provide opportunities for early engineering education.

References

Cambrón, M. A. (2005). Sonido y sociabilidad: consistencia bioacústica en espacios públicos. *Quaderns-e de l'Institut Català d'Antropologia*.

Chen, Y., Johri, A., & Rangwala, H. (2018). Running out of STEM. In *Proceedings of the 8th International Conference on Learning Analytics and Knowledge. LAK '18: International Conference on Learning Analytics and Knowledge*. ACM. DOI: 10.1145/3170358.3170410

National Research Council. (2013). *Next Generation Science Standards: For States, by States.* National Academies Press.

Papert, S. A. (1980). *Mindstorms: Children, Computers, and Powerful Ideas.* Basic Books.

Simarro, C., & Couso, D. (2021). Engineering practices as a framework for STEM education: a proposal based on epistemic nuances. *International Journal of STEM Education*, *8*(1). DOI: 10.1186/s40594-021-00310-2

Turkle, S. (Ed.). (2011). *Evocative objects: Things we think with*. MIT Press.