Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #45563

BOARD # 204: Enhancing Engineering Education for Homeschool Families Through MAKEngineering Kits (Work in Progress)

Dr. Amber Simpson, State University of New York at Binghamton

Amber Simpson is a Assistant Professor of Mathematics Education in the Teaching, Learning and Educational Leadership Department at Binghamton University. Her research interests include (1) examining individual's identity(ies) in one or more STEM discipline, and (2) investigating family engagement in and interactions around STEM-related activities.

Dr. Adam Maltese, Indiana University-Bloomington

Professor of Science Education

Dr. Kelli Paul, Indiana University-Bloomington

Dr. Kelli Paul is an Assistant Research Scientist at the Center for Research on Learning and Technology at Indiana University where her research focuses on the development of STEM interests, identity, and career aspirations in children and adolescents.

Lauren Penney, Indiana University-Bloomington

Enhancing Engineering Education for Homeschool Families Through MAKEngineering Kits (Work in Progress)

Introduction

According to the United States Census Bureau [1], the average percentage of school-aged children being homeschooled in Fall 2022 was 6%, which was an increase from 3% of school-aged children being homeschooled in 2019 [2]. In addition, a study by Phillips [3] found that homeschooled children are less likely to choose a major in a STEM field as compared to non-homeschooled students. Two reasons parents provide for homeschooling is dissatisfaction with academic instruction (73%) and a desire to provide a nontraditional approach to their child(ren)'s education (54%) [2]. Though homeschool parents play an integral role in supporting their child(ren)'s development as an engineering learner [4], they outsource many opportunities to engage in engineering learning to the local community (e.g., library, museum, cooperatives) or online courses and private tutors [5-6]. This may be explained by parents' misconceptions of the engineering profession [7]; perception of engineering as less accessible and more frightening compared to other science, technology, engineering, and mathematics (STEM) fields [8]; and limited knowledge and skills in engineering education [9].

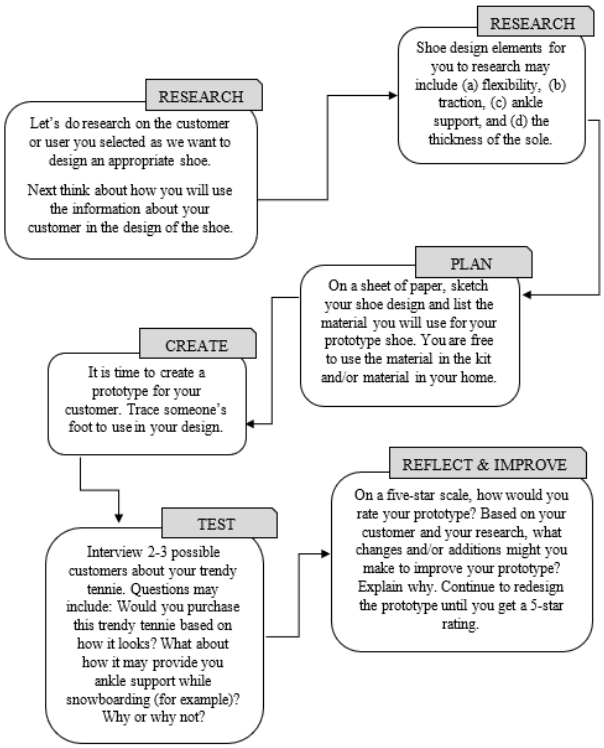
To address the rise of homeschooling and parents' role as an engineering educator, this study explored homeschool families' experiences with using STEM kits designed to support children and families to engage in engineering activities in their homes.

Background

As part of a local National Science Foundation I-Corps program, we engaged in customer discovery to better understand whether and/or how families engage with STEM kits and activities. We interviewed 17 parents, nine parents who homeschooled their children and eight parents whose children attended public or private school. Interviews explored parents' perspective on (a) what they consider in purchasing kits/activities to engage their child(ren) in STEM concepts and practices, (b) likes and dislikes, (c) barriers and/or challenges to engaging in STEM activities, and (d) suggestions on how to improve the typical STEM kit. Parents indicated that their children enjoyed STEM activities that were hands-on (e.g., involved building), allowed for imagination and creativity, could be completed independently, and provided an end product that did something. Additionally, parents mentioned a number of barriers to using such kits, including cost, lack of expertise in STEM concepts, and time (mostly in competition with other interests and extracurricular activities). When looking for STEM kits, parents tended to look for activities that included a re-usable component (e.g., materials), a way to differentiate across age groups, and "activities that 'have life' after the initial activity and don't just sit on a shelf" (Interview 15). We noticed that homeschool parents often mentioned that they used these types of activities to build upon or incorporate into their current curriculum. Specifically, they looked for activities that fostered the development and understanding of concepts and skills grounded in STEM subject areas; included open-ended and exploratory activities; required little preparation time included explicit instructions for parents; and included a balance of instruction and freedom for their children to complete the activity on their own.

Based on these findings, we revised four previously developed MAKEngineering kits [10] by the research team to target the needs of homeschool families. In general, the kits were designed to follow an engineering design process – research, plan, create, test, improve, and reflect – similar to that of Teach Engineering [11]. See Figure 1 for an example. In this kit, children were tasked with the following: *You have been asked by a popular shoe company to design a new trendy tennis shoe for unique needs of their four customers. Pick one of the customers and design a tennis shoe to meet their needs. You decide to use everyday products to construct the tennis shoe prototype*.

Figure 1. *Engineering design cycle for Trendy Tennies kit.*



Changes to this iteration of the kits included making more explicit connections between the activity and STEM concepts and careers, highlighting content standards, extending opportunities to learn and engage in STEM concepts through additional problem-solving activities and challenges, and including a variety of questions and suggestions that encouraged parents to push and build upon their children's thinking. Examples will be provided in the presentation.

Methods

Twenty-six homeschool families were recruited through Facebook. They each received two kits and were asked to provide feedback via a survey and optional follow-up interview. To date, ten homeschool parents completed the survey, seven of which were also interviewed. Nine families identified as White and one preferred not to respond. Only one of the ten parents had been employed in a STEM field. Three parents held a master's degree, four held a bachelor's degree, one an Associate's Degree, and two a high school degree. Fifteen children between the ages of 5-

14 engaged in the kits. Seven children identified as she/her/hers, six as he/his/him, and two did not respond.

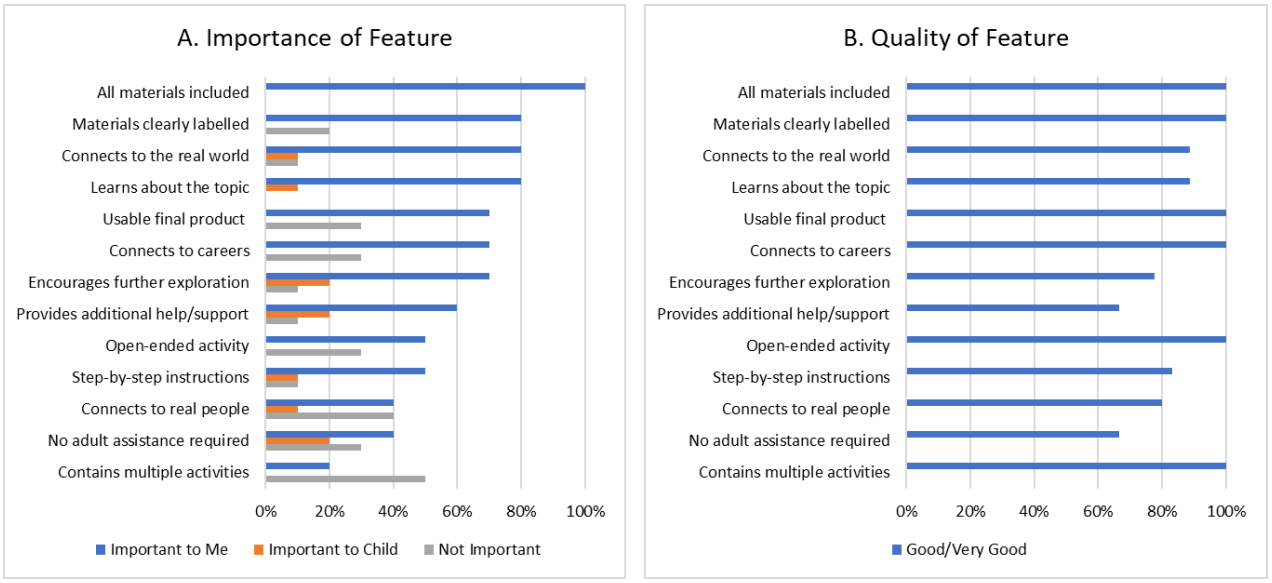
The research team developed the survey to explore how well the kits supported homeschool parents and children as engineers within their home environment. Parents completed the survey after both kits were completed. Questions included the following: (a) Which of the following features are important to you and your child when choosing to do a STEM kit/activity? (e.g., all materials included, open-ended activity); (b) Please rate the quality of each of these features in the two kits that you completed.; (c) What did you like MOST about the kits?; (d) What did you like the LEAST about the kits?; and (e) How do you or your child think we can improve the kits? The data from closed-ended items was compiled into frequency tables, which detail the number of participants selecting each response option.

We conducted follow-up interviews with parents who expressed interest in sharing additional information about their experience with the kits. The interviews were conducted via telephone and lasted approximately 10 minutes. Notes were taken of the parent's responses during the interviews. We asked parents to describe how the kits supported their child as a STEM learner, how they used the additional resources and parental supports (e.g., Links/QR codes) included in the kites, and how (if at all) the kits fit within their homeschool curriculum? For each response, we identified common patterns and unique insights, and then looked across these to uncover three big ideas.

Results

Results from the survey indicated that the various features of our kits were not only important to most parents and/or their children (see Figure 2A), but also generally rated as "good" or "very good" quality (see Figure 2B).

Figure 2. *Survey results.*



Note. Sample size for each feature in 2A is 10. Sample size for each feature in 2B was based on the number of parents who indicated the feature was important to them (e.g., Open-ended activity $n = 5$).

Parents' open-ended responses identified what they liked about the kits, many of which aligned with their ratings of the importance and quality of the features. The following quotes provide examples (italics identify kit features when mentioned):

- I liked that kids could *complete it on their own*, that all *materials were provided*, and that they practiced designing something themselves with a goal in mind.
- It truly gave my child the opportunity to think outside the box to create the stem projects.
- [My child] could make multiple versions... after the first, there were *plenty of materials* to make another version if adjustments were wanted.
- I liked how the shoe one was kind of like a *real-world simulation of a project*.

Each family also took advantage of at least one of the additional facilitation supports (e.g., links) included in the kits as a way to engage in engineering concepts, practices, and processes. As stated by a parent, "The pamphlet guides with extra info and support were fantastic!"

Interview results underscored three big ideas that expand our understanding of how the kits enhanced the learning process for children. We note each big idea below and include direct or paraphrased quotes as support (italics connect the included quotes to the big ideas).

First, kits provided children with opportunities to think critically, be creative, experience failures, and learn about engineers and the design process.

> "This project has given Emily the *opportunity to think critically, be creative, develop math, science, art and technology skills*. She doesn't learn very well doing worksheets or listening to lectures. This kind of learning is perfect for her and has really filled a gap for her.
>
> My son did the light up card and expressed excitement when lit up. He is now *curious about circuitry*, which has extended beyond [the kit] as we are *continuing to explore these ideas*. This kit *sparked an interest*.
>
> *Frustration led to creativity* for my son, who prefers step-by-step instructions.
>
> "The kits were fun because they were something different." *We have never used a kit that used the engineering design process; the design-create-revise process was new to my kids*. "I valued that for them."

Second, parents used the kits in their homeschool curriculum as "fun" project-based activities to support and enhance connections to science and math concepts.

> "Sometimes the regular activities in the curriculum can get dry or tedious. *We used the kits during the holidays when we were doing light schooling and wanted something different.* The "art factor" in the kits changed things up and worked well."

> We are huge believers in providing our children with raw materials and ideas. We have zones in our basement where our kids each have their own space. We encourage them to pick something they want to learn about and explore it. *These kits fit with that approach. They like to fuel creativity in their kids ---these kits are great for that.*
>
> There often is a disconnect to science in such kits, but these resources *allowed me to make the connection to science*. "That is what made it allowable for me to use it as science."

Third, parents adapted the kits to meet the learning needs and abilities of their children.

> *We adapted the kit to focus on writing with my daughter.* Writing sentences out of context is not of interest to my daughter. We made sure to write things out.
>
> *I allowed my daughter to make the thing her own. There were no rules. It was open-ended.* This would not have worked with my other child who wants more step-by-step instructions and being compliant.

Discussion

STEM kits grounded in the engineering design process may be an avenue to support homeschool children as engineering learners, especially as the number of school-aged children being homeschooled continues to grow [1-2], as well as the need for diverse perspectives in STEM [12]. The initial results of this study highlight multiple features of STEM kits that are important to parents and children, which are generally well attended to in our kit designs, including supports for parents who may be uncomfortable as engineering educators [8-9] and who tend to outsource their children's opportunities to engage in engineering learning [5-6]. Additionally, preliminary results illustrate the potential of the kits to support homeschool children not only in engineering concepts, practices, and processes, but interdisciplinary concepts, skills, and dispositions (e.g., writing, interest, creativity) using engineering as a foundation [13]. These are also skills and dispositions that have been shown to support children's developing identities as engineers [14-15] and their potential in pursuing a STEM degree and career [16]. The results also point to parents' ability to diversify the kits to target their children's learning needs and make connections to other disciplines in support of their curriculum. This supports our prior scholarship that underscored parents are skilled and knowledgeable practitioners that are capable of engaging, supporting, challenging, and enhancing their child(ren) as STEM learners [17-18].

In addition, homeschool families often allow student interest and agency to determine the content of the activities [5]. Therefore, we will continue to explore how homeschool parents utilize and adapt the kits to support their children as STEM learners and shape their identity as an engineer, whether as part of their formal curriculum or as fun, supplemental activities or "light schooling." Each family provided suggestions for how to improve the kits, and while these were rather unique to each family, future work will investigate ways to improve the kits through continued distribution of the kits, expanding to diverse populations, and hosting of STEM nights for homeschool families.

References

[1] United States Census Bureau, "Household pulse survey: Measuring emergent social and economic matters facing U.S. households," 2024. Available: https://www.census.gov/programs-surveys/household-pulse-survey.html. [Accessed September 1, 2024].

[2] National Center for Education Statistics, "Homeschooled children and reasons for homeschooling," 2022. Available: https://nces.ed.gov/programs/coe/indicator/tgk/homeschooled-children [Accessed September 1, 2024].

[3] L. Phillips, "Homeschooling is an art, not a science: The impact of homeschooling on choice of college major," *Sociological Viewpoints*, vol. 26, no. 2, pp. 19-25, 2010.

[4] H. Ehsan, A. P. Rehmat, H. Osman, C. Ohland, M. E. Cardella, and I. H. Yeter, "Examining the role of parents in promoting computational thinking in children: A case study on one homeschool family (Fundamental)," in *Proceedings of the 2019 ASEE Annual Conference & Exposition*, June 16-19, 2019, Tampa, FL: ASEE, 2019.

[5] C. Gann and D. Carpenter, "STEM educational activities and the role of the parent in the home education of high school students," *Educational Review*, vol. 71, no. 2, pp. 166-181, 2019.

[6] T. R. Jones and M. E. Cardella, "Informal pathways to engineering: Middle-school-aged homeschool students' experiences with engineering (fundamental)," in *Proceedings of the 2015 ASEE Annual Conference & Exposition*, June 14-17, 2015, Seattle, WA: ASEE, 2015.

[7] M. Ge, J. Li, A. Berry, and J. Lamborn, "An investigation of children's, parents' and teachers' perceptions of engineers and engineering," In *REES AAEE 2021 conference: Engineering Education Research Capability Development: Engineering Education Research Capability Development*, Perth, WA: Engineers Australia, 2021, 215-224.

[8] A. K. Stone-MacDonald, K. Wendell, A. Douglass, and M. L. Love, *Engaging young engineers: Teaching problem-solving skills through STEM*. Baltimore, MD: Brookes Publishing, 2015.

[9] A. Ata-Aktürk and H. Ö. Demircan, ""My child might be thinking about something beneficial to humanity": Enhancing parental perspectives on engineering education in early childhood," *Journal of Research in Childhood Education*, pp. 1-20, 2024.

[10] A. Simpson, J. Ying, and A. V. Maltese, "MAKEngineering kits: Design principles for family engineering engagement and awareness," *Journal of Pre-College Engineering Education Research (JPEER)*, vol. 14, Article 3, 2024.

[11] University of Colorado Boulder and ncwit.org, "Teach engineering: Engineering design process," n.d. Available: https://www.teachengineering.org/populartopics/designprocess [Accessed February 18, 2025].

[12] A. E. Martin and T. R. Fisher-Air, ""If we don't have diversity, there's no future to see": High-school students' perceptions of race and gender representation in STEM," *Science Education*, vol. 105, 1076-1099, 2019.

[13] T. R. Kelley and J. G. Knowles, “A conceptual framework for integrated STEM education,” *International Journal of STEM Education*, vol. 3, 1-11, 2016.

[14] A. Simpson and P. Knox, “Children’s engineering identity development within an at-home engineering program during COVID-19,” *Journal of Pre-College Engineering Education Research (J-PEER)*, vol. 12, Article 2, 2022.

[15] G. J. Kelly, C. M. Cunningham, and A. Ricketts, "Engaging in identity work through engineering practices in elementary classrooms," *Linguistics and Education*, vol. 39, pp. 48-59, 2017.

[16] A. V. Maltese, C. S. Melki, and H. L. Wiebke, “The nature of experiences responsible for the generation and maintenance of interest in STEM,” *Science Education*, vol. 98, 937-962, 2014.

[17] A. Simpson, Q. Zhong, and A. V. Maltese, “Spontaneous mathematical moments between caregiver and child during an engineering design project,” *Early Childhood Education Journal*, vol. 51, 211-222, 2022.

[18] S. Kim and A. Simpson, “Parents’ epistemic supports during home-based engineering design tasks: opportunities and tensions through the use of technology,” *Educational Technology Research and Development*, vol. 72, 209-238, 2023.