BOARD # 211: Parents' Knowledge, Attitude and Behavior on Pre-college Engineering Education Course (Work in Progress)

Xingchen Wei, Vanderbilt University

Xingchen Wei is an Evaluation Coordinator at Vanderbilt University School of Nursing. She earned her M.Ed. in International Education Policy and Management(IEPM) at Vanderbilt University, Peabody College, and also holds a BA. in Psychology and BS. in Education Studies. Her research interests are in Research-Practice Partnerships (RPPs), school-family partnerships, educational evaluation and International Education.

Jialing Wu, The Ohio State University

Jialing Wu is a first-year PhD student in Engineering Education at the Ohio State University. She earned her M.Ed. in International Education Policy and Management at Vanderbilt University, Peabody College, and also holds a bachelor's degree in Mechanical Engineering from China. Her research interests encompass computational social science, international engineering education, pre-college engineering in Engineering Education Research (EER).

Dr. Stacy S Klein-Gardner, Vanderbilt University

Dr. Stacy Klein-Gardner serves as an Adjunct Professor of Biomedical Engineering at Vanderbilt University. She is the co-PI and co-Director of the NSF-funded Engineering For Us All (e4usa) project and now the Executive Director of e4usa, the non-profit company. Dr. Klein-Gardner is a Fellow of ASEE and AIMBE.

Parents' Knowledge, Attitude and Behavior on Pre-college Engineering Education Course (Work in Progress)

Abstract

Pre-college students' Parents' perspectives on education play a crucial role in their children's learning outcomes and future development. While the importance of engineering education has received attention from instructional design and school systems, parent-related factors remain unclear. Engineering for US All (e4usa) aims to provide well-designed engineering courses for high school students who seek to make engineering deeply and meaningfully accessible to the world. Moreover, e4usa encourages partnerships through communities and schools, allowing parents to participate with and better assist their children. This work-in-progress paper attempts to understand parents' knowledge, attitudes, and behaviors (KAB) in engineering and engineering education, exploring potential opportunities to translate parents' positive mindsets into actionable support.

The study conducted three semi-structured interviews with four parents whose children were enrolled in e4usa courses in 2022. After transcribing the interview content, the first two authors conducted qualitative analysis with two rounds of coding. In the first round, we used KAB as the coding category. After discussion, an additional code, "scenario," was added during the second round of coding to help fully capture what parents value.

The preliminary results show that parents have basic ideas about engineering. Some of them have exposure due to their family background and have constructed an image of their child as a diligent and talented student. They also view their children's involvement in engineering education positively, as it benefits their college applications and career choices. However, as engineering courses do not currently count towards Advanced Placement (AP) credits, parents express concerns about balancing the time to take engineering courses and fulfill perceived AP requirements for college admission. Parents' actions are limited by a lack of information and connections with resources, but they still try to enhance their children's engineering education by locating teachers, identifying relevant courses, and promoting family connections. Our next step is to conduct a broader interview among parents and explore potential methods for translating parents' knowledge and attitudes into actions. For example, we could design informational sessions for parents, create engineering activities in which parents can participate, and link local network resources in engineering. This study aims to enhance parental involvement in engineering education by providing actionable insights and recommendations, ultimately supporting schools and policymakers in creating a more welcoming and effective educational environment.

Introduction

As engineering becomes increasingly important with its strong link with scientific and technological advancements, attracting students to this field is essential for talent development and societal progress[1]. Pre-college engineering courses broaden students' pathways to STEM fields by expanding their interest in STEM majors and providing early college experience [2]. Research shows that pre-college engineering courses increase students' self-efficacy and confidence in engineering-related subjects. This, in turn, may encourage greater interest in pursuing careers in the engineering field [3] [4]. Moreover, while most research has focused on curriculum design, course materials, and the influence of teachers[1] [5] [6], studies suggest that parent-related factors could impact students' involve in science activities even more than teacher-related factors [7]. Specifically, parental involvement—both within and outside the home—plays a critical role in shaping students' attitudes toward science, which has direct and indirect effects on their learning outcomes and can influence future career pathways[8] [9]. Research demonstrates that one aspect of parental involvement in children's learning outcomes reflects an increase in school-related learning activities[10]. However, researchers often overlook factors such as attitude measurement, which can adversely affect children's science-related achievements [9]. Therefore, this study aims to explore the role of parents in pre-college engineering education and how they influence students' involvement and pathways in STEM fields [11] [12].

The background for this research stems from the Enginnering for US All (e4usa) program, an NSF-funded initiative to enhance engineering education across the United States. The program's primary objectives are to deliver a comprehensive pre-college engineering curriculum, provide professional development for teachers, and conduct research to advance engineering education. This study is part of a broader research project designed to understand how parents' knowledge and attitudes influence their behaviors in supporting their children's engineering learning. As a first step, we conducted three semi-structured interviews with four parents to capture their key insights into engineering education, which will inform our next phase of the study, including developing a survey to support students' engineering learning. Thus, our research question is: *What are parents' Knowledge, Attitude, and Behavior (KAB) on pre-college Engineering education?*

Knowledge, Attitude, and Behavior Model

The Knowledge, Attitudes, and Behaviors (KAB) model provides a theoretical framework that explains how individuals' psychological states influence their learning, understanding, and productivity, resulting in a circular flow of interaction [13]. Specifically, Knowledge refers to the information and skills that an individual acquires and understands, which can be enhanced through educational activities; Attitudes encompass feelings and psychological states that can significantly impact one's learning abilities and experiences; Behaviors represent actual actions that can be observed or measured [13]. This model is commonly applied in psychology, education, and healthcare to demonstrate how individuals' learning processes relate to their actions. It has proven particularly effective in increasing positive attitudes towards patients' self-management and in facilitating measurement and intervention in psychological research [14] [15].

By introducing the KAB model, we aim to better understand parents across the three dimensions and explore how the model can support students' engineering education during the pre-college period. We also plan to examine the context to build corresponding dimensions within the model, address any gaps, and provide a foundation for future research. Ultimately, this will offer a more comprehensive understanding of parental influences on engineering education.

Methods

The researchers recruited parent participants through teachers. Participants voluntarily agreed to join the study and gave their informed consent prior to participation. This work-in-progress study draws on data from four parents recruited in the first phase of participant recruitment. Their children attended public high schools in different states, representing both suburban and rural settings. All students were enrolled in a e4usa course during the 2021-2022 academic year and had completed at least one semester of the program.

We conducted three semi-structured interviews with the four parents. The original plan was to conduct two focus groups; however, due to scheduling constraints, two parents participated in separate individual interviews. Ultimately, we conducted two one-on-one interviews and one two-person group interview. All interviews were conducted by the third author via Zoom and were recorded with the parents' consent. Due to IRB restrictions, we did not collect demographic background information about the parents specifically.

The interview investigates parents' understanding of engineering education, perceptions of students' current experiences with the course, and motivation to encourage students to participate in engineering learning. It also explores their reactions to the e4usa curriculum. The following are the specific interview questions: 1) How did you hear about the new introductory engineering course at your child's high school? 2) What was your motivation to enroll your child in the course? 3) What does the word "engineering" mean to you? 4) What is your perception regarding the course as it is being taught so far? 5) Would you recommend this course to other parents?

After transcribing the interview content, the first two authors performed a qualitative analysis using a two-round coding process. The team decided to use team coding to enhance reliability and address gaps in the analysis, thereby providing a more comprehensive evaluation. The researchers applied hypothesis coding during the coding process, and we directly employed "Knowledge," "Attitude," and "Behavior" as the coding categories. This step helped confirm that the application of the KAB model fits well from the parents' perspective [16]. During the coding process, ideas about "community" appeared frequently as a context that intersects with KAB. We believe it would be valuable to investigate this theme further. Therefore, we introduced "Scenario" as an independent code during the second round of coding to capture the aspects expressed by parents, and "community" appears as the common theme in this study. When two rounds of coding were finished, the two authors compared and discussed their coding results and reached a consensus on the outcomes. Appendix A presents the final definitions of the codes with examples from the original interview. After the research team confirmed the main codes and definitions and reached a consensus on the analysis, hypotheses emerged under each of the four main codes. The following analysis illustrates how parents' knowledge, attitudes, behaviors, and the context of engineering education interact. We then verify these results against the original interview text and, finally, attempt to generalize the findings.

Results

The data reveal that in terms of knowledge, parents demonstrate a strong understanding of the importance of engineering education. While acknowledging the limitations in their access to engineering-related courses during their school years, they have developed an understanding of engineering studies, shaped by their personal experiences. Moreover, they show a positive attitude towards their children's involvement with engineering, attributing this to various factors such as their

children's interests, effective teaching, and local network resources. However, though they recognize the broader benefits of pre-college engineering education for their children's academic and personal growth, they are concerned about the challenges posed by existing high school policies and the cost of higher education. Additionally, parents' behavior shows that they actively support their children's engineering interests through encouragement, connecting their interests with family experiences, and advocating for more resources. Their desire to provide their children with the opportunities that were unavailable to them in their educational journeys drives their actions. They recommend engineering courses and take steps to ensure their children have access to the necessary resources to explore their potential paths in engineering.

Knowledge

Parents' personal experiences and perceptions of their children's growth shape their comprehension of engineering education.

They believe that pre-college engineering education resources were insufficient in their own learning experience in the past, and today's children also lack an understanding of engineering. For example, one parent mentioned, "when I was in school, I didn't really know what engineering was... I wasn't exposed... I think a lot of the students view engineering as … making something…" However, this parent continued to mention that the background of other family members may compensate for this gap: "[my child's] dad is an Airborne veteran…a mechanical engineer... [the child] grew up doing mechanic work just like their dad did."

Parents expanded the definition of engineering with their children, moving from viewing that engineering knowledge is confined to the field to the idea that it can be applied to other areas. They may perceive engineering as an isolated field, separate from other disciplines originally. For example, one parent saw that engineering knowledge may not relate to their child who was very science-focused at the beginning: "She was not ever really looking at engineering. She's very much like a science person and she's very science-oriented." Then, they come to see that engineering knowledge is everywhere, as one parent mentioned: "he didn't realize all of the pieces that go into engineering, like project management and…working with the community." Parents also possess some understanding of the practical application of engineering knowledge in the real world, as they also view engineering as a form of service: "...it's almost like you're doing engineering, but you're working with the community... it's a service…"

When discussing their children's choice to pursue an engineering course at the high school level, parents commonly highlighted their children's strengths in mathematics and science, as well as qualities such as intelligence and a strong work ethic, before referring to other influencing factors. For example, one parent said: "he loves science and math. He works really hard. I wouldn't say he's the smartest kid in his grade, but he is a really hard worker." Another parent described their child as "a truly gifted child." This description could be related to parents' general perception of engineers, as they seek to connect their perception with their children's performance.

Attitude

Parents exhibit a positive attitude towards their children's exposure to engineering education. However, they also worry about a lack of additional engineering education for their children. The reasons for a positive attitude included their children's involvement, good teachers, rich local network resources, and the development of comprehensive engineering skills. For instance, one

parent mentioned the child's excitement: "Because [the child] had so much fun, because he learned so much." Great teachers and sufficient local network resources also contributed: "[The teacher is] fantastic... and uses community resources... experts in the community." Parents also believed that engineering education would benefit their children in various ways. Coding and management skills, which are usually not emphasized in engineering knowledge, were also mentioned: "Working with software that is technically computer science... there's project management... community relations." Moreover, parents believe that benefits for their children's personal and academic development exist. One parent mentioned the impact on children's career plans: "Exposure to engineering at that young, early stage in his high school career really solidified in his mind that that was what he wanted to do with his future." They also expressed the benefit of pre-college engineering experience for college applications: "And I really think it makes a huge difference in how... higher education looks at students, potential candidates."

Parents also expressed concerns regarding school-provided resources and the potential to transfer high school-level engineering courses to college. One concern involves how the development of their child's interests aligned with existing high school policies and academic requirements, given the limited time available to students: "The high school has so many requirements, and I'm not sure how this affects her choices [of taking additional engineering courses]. And there are a lot of options, but it's hard to fit the extra step in." Since the engineering courses were not counted as Advanced Placement (AP) credits, parents questioned whether the time investment was worthwhile: "My son did mention a couple of times, he's like, I don't understand why this is a pre-AP class." Given the high cost of college credits, the possibility of transferring high school course credits to college became another important consideration for parents, but the current engineering course did not meet this need: "College is expensive, and parents and students are looking to transfer [engineering course credits]... if it is a college-level class in high school."

Behavior

Parents take various actions to support engineering education, ranging from encouraging their children to explore engineering, promoting engineering education, and seeking additional resources. For example, parents encouraged their children to explore different interests: "So I encouraged him to do that because, like I said, he maxed out the engineering electives, and I knew he wanted more." Parents also helped their children connect their interests with existing engineering aspects in the family. One parent mentioned how they helped their child study bridges by asking their grandfather for assistance: "And she was identifying every bridge we crossed… We ended up at my dad's house, and I was telling my dad about that. So then he was sending some emails about stuff, and they were making connections. So I had to keep him updated on that project, which was a nice family connection and gave her a different opportunity to share that."

Parents strongly promoted the engineering courses or expressed a preference for them: "I would highly recommend enrolling, even if your child does not necessarily think that engineering might be a fit for them…"" Another parent mentioned: "I would [recommend it to others], of course…my wife has done the same thing."

Parents hoped for more engineering resources and took action to secure them: "When my son went in to look at some of those schools, they really were lacking in what his interests were as far as electives. And being a school counselor, a high school counselor, I'm a big fan of trying out the electives to see if that is really what you think your path is." One reason parents took these actions was related to their own experiences with the lack of engineering education during their time: "So we

have been pushing and pushing to guide him in that direction just because we—I mean, every parent says this—we just wanted better for him than what we had. And these courses and camps and classes were not offered for us growing up, at least not for my husband and me."

Scenario - community

Parents expected children to apply what they had learned in the community and make contributions in certain scenarios. In this study, researchers found that "community" was a common context, and parents defined what community meant to them in different ways. Some described it as the place where they lived and the people they met. One parent mentioned: "There were some great people in our community working to connect kids with internships and all kinds of opportunities." Among these, the benefits of connections with local resources and people were particularly valued by parents. One parent mentioned: "…it was a unique community…which was a really great thing." Parents also considered broad ideas about the scenario and hoped that their children could apply what they had learned in practical contexts or within their community. As one parent said: "'It was almost like you were doing engineering, but you were working with the community and giving back…"

Discussion and Future Plan

Our findings underscore parents' critical role in encouraging their children's interest in engineering education. The data indicate that in terms of knowledge, parents demonstrate a strong understanding of the importance of engineering education, yet they often hold abstract knowledge about the field, which may influence their attitudes and expectations toward their children's involvement in engineering-related learning. However, the idea that parents connect engineering education closely with their personal experiences can significantly impact students' self-efficacy and future career expectations [2] [3] [7]. Creating a positive and fair learning environment will help students build self-confidence and determination, which are important for their continued success in engineering education[17]. Future research could examine how parental stereotypes in engineering affect their attitudes toward children's learning and explore ways parents can support learning at home or collaborate with schools to create a more positive environment.

At this stage, we are limited to drawing broad conclusions from the results of this pilot study. Future research with a larger sample size from a greater range of educational settings could offer additional insights. While parents generally have positive attitudes and knowledge about engineering education, the relationship between their knowledge, attitudes, and behaviors in this field remains unclear. More research is needed to design focus group questions that can better explore this relationship.

Acknowledgments

This work has been primarily supported by the National Science Foundation (NSF) through NSF Award Number [EEC-1849430 & EEC-2120746]. The opinions, findings, conclusions, and recommendations expressed in this material are those of the author(s) alone and may not reflect the views or official position of the NSF. The authors would like to acknowledge and extend their sincere thanks to the entire team of the e4usa project for their valuable contributions, collaboration, and support throughout the course of this work, without which this project would not have been possible.

References

[1] M. A. Fox and Government-University-Industry Research Roundtable, Eds., *Pan-Organizational Summit on the U.S. Science and Engineering Workforce: meeting summary*. Washington, D.C: National Academies Press, 2003.

[2] K. A. Miller, G. Sonnert, and P. M. Sadler, "The Influence of Student Enrollment in Pre-College Engineering Courses on Their Interest in Engineering Careers," *J. Pre-Coll. Eng. Educ. Res. J-PEER*, vol. 10, no. 1, May 2020, doi: 10.7771/2157-9288.1235.

[3] T. Luo, W. W. M. So, Z. H. Wan, and W. C. Li, "STEM stereotypes predict students' STEM career interest via self-efficacy and outcome expectations," *Int. J. STEM Educ.*, vol. 8, no. 1, p. 36, Dec. 2021, doi: 10.1186/s40594-021-00295-y.

[4] L. A. Phelps, E. M. Camburn, and S. Min, "Choosing STEM College Majors: Exploring the Role of Pre-College Engineering Courses," *J. Pre-Coll. Eng. Educ. Res. J-PEER*, vol. 8, no. 1, Feb. 2018, doi: 10.7771/2157-9288.1146.

[5] V. C. McGowan and P. Bell, "Engineering Education as the Development of Critical Sociotechnical Literacy," *Sci. Educ.*, vol. 29, no. 4, pp. 981–1005, Aug. 2020, doi: 10.1007/s11191-020-00151-5.

[6] C. Carrico, H. Matusovich, and S. Bhaduri, "Board 164: Engineering Interventions in My Science Classroom: What's My Role?," in *2023 ASEE Annual Conference & Exposition Proceedings*, Baltimore , Maryland: ASEE Conferences, Jun. 2023, p. 42516. doi: 10.18260/1-2--42516.

[7] R. George and D. Kaplan, "A structural model of parent and teacher influences on science attitudes of eighth graders: Evidence from NELS: 88," *Sci. Educ.*, vol. 82, no. 1, pp. 93–109, Jan. 1998, doi: 10.1002/(SICI)1098-237X(199801)82:1<93::AID-SCE5>3.0.CO;2-W.

[8] J. Sherman, "The Millennial Trail: Parental Involvement In Their Children's Engineering Education," in *2005 Annual Conference Proceedings*, Portland, Oregon: ASEE Conferences, Jun. 2005, p. 10.1309.1-10.1309.14. doi: 10.18260/1-2--15138.

[9] R. George and D. Kaplan, "A structural model of parent and teacher influences on science attitudes of eighth graders: Evidence from NELS: 88," *Sci. Educ.*, vol. 82, no. 1, pp. 93–109, Jan. 1998, doi: 10.1002/(SICI)1098-237X(199801)82:1<93::AID-SCE5>3.0.CO;2-W.

[10] K. V. Hoover-Dempsey and H. M. Sandler, "Parental Involvement in Children's Education: Why Does it Make a Difference?," *Teach. Coll. Rec. Voice Scholarsh. Educ.*, vol. 97, no. 2, pp. 310–331, Dec. 1995, doi: 10.1177/016146819509700202.

[11] F. Gülhan, "Parental Involvement in STEM Education: A Systematic Literature Review," *Eur. J. STEM Educ.*, vol. 8, no. 1, p. 05, Jul. 2023, doi: 10.20897/ejsteme/13506.

[12] "Final_Report-Priya_Desai.pdf."

[13] P. G. Schrader and K. A. Lawless, "The knowledge, attitudes, & behaviors approach how to evaluate performance and learning in complex environments," *Perform. Improv.*, vol. 43, no. 9, pp. 8–15, Sep. 2004, doi: 10.1002/pfi.4140430905.

[14] W. Xu *et al.*, "Knowledge, attitude, and behavior in patients with atrial fibrillation undergoing radiofrequency catheter ablation," *J. Interv. Card. Electrophysiol.*, vol. 28, no. 3, pp. 199–207, Sep. 2010, doi: 10.1007/s10840-010-9496-2.

[15] Q. Chen, J. Bao, and Y. Zang, "The knowledge, attitude, and intention to use internet-based mental health services: A serial mediation model," *Internet Interv.*, vol. 37, p. 100755, Sep. 2024, doi: 10.1016/j.invent.2024.100755.

[16] M. B. Miles, A. M. Huberman, and J. M. Saldana "Qualitative Data Analysis".

[17]E. A. Eschenbach, M. Virnoche, E. M. Cashman, S. M. Lord, and M. M. Camacho, “Proven practices that can reduce stereotype threat in engineering education: A literature review,” in *2014 IEEE Frontiers in Education Conference (FIE) Proceedings*, Madrid, Spain: IEEE, Oct. 2014, pp. 1–9. doi: 10.1109/FIE.2014.7044011.

Appendix A

The Codebook of the Paper

Code	Definition	Examples
Knowledge	Parent's background knowledge about engineering/ learning engineering. This could include vague impressions and stereotypes about engineering learning.	"when I was in school, I didn't really know what engineering was... I wasn't exposed... I think a lot of the students view engineering as … making something…" "I wouldn't say he's the smartest kid in his grade, but he is a really hard worker."
Attitude	Parent's attitude towards children's early exposure to engineering/ learning engineering.	Positive: "Because [the child] had so much fun, because he learned so much." Concern: "The high school has so many requirements, and I'm not sure how this affects her choices…. And there are a lot of options, but it's hard to fit the extra step in."
Behavior	Current or potential actions taken by parents in terms of their children's learning engineering.	"But I encouraged him to push the physics to senior year and do like biology, chemistry, …. So I encourage him to do that because like I said, he…likes the engineering electives and I know he wanted more."
Scenario (community)	The anticipated scenario for applying and implementing engineering knowledge and skills. This could refer to a specific context or a more abstract situation. *Note: "Community" appears as the main theme in this study.*	"And it's like, it's almost like you're doing engineering, but you're working with the community and you're giving back your, …, which is what my children are doing with their lives."