Family Perspectives on Student Summer Opportunities in STEM: Extending the Hoover-Dempsey and Sandler Model in Informal Engineering Education Contexts (Fundamental)

Dr. Araceli Martinez Ortiz, The University of Texas at San Antonio

Araceli Martinez Ortiz, PhD, is the Microsoft President's Endowed Professor of Engineering Education at the University of Texas at San Antonio, with a joint appointment in the Klesse College of Engineering and Integrated Design and the College of Education and Human Development. She is currently Professor and Director of the Engineering Education Graduate Program. She also serves as Executive Director of the Dr. Manuel P. Berriozábal Prefreshman Engineering Program (PREP), advancing STEM engagement and community-integrated research in engineering education. Her research focuses on pre-engineering pathways, skilled technical workforce development, challenge-based learning, STEM educator professional development, and the integration of artificial intelligence in engineering education. She previously served as Executive Director of the LBJ Institute for STEM Education and Research at Texas State, leading major initiatives supported by NASA and NSF. Dr. Martinez Ortiz holds degrees from the University of Michigan, Kettering University, Michigan State University, and Tufts University.

Melisa Ramos Walters MA, The University of Texas at San Antonio

Melisa Ramos Walters, MA, is a Graduate Research Assistant in Engineering Education at the University of Texas at San Antonio, with work spanning the Klesse College of Engineering and Integrated Design and the College of Education and Human Development. She is currently on the thesis track of the M.S. in Engineering Education program, with the intent to continue into the PhD program at UT San Antonio under the mentorship of Araceli Martinez Ortiz, Ph.D. Her graduate research includes serving as the lead research assistant on the BMES program and focuses on the Dr. Manuel P. Berriozabal Prefreshman Engineering Program (PREP) as a mechanism for broadening participation in engineering pathways. She holds a master's degree in Computational and Applied Mathematics from Rice University, where she studied under the tutelage of Dr. Richard A. Tapia.

Her research agenda centers on family engagement in STEM, access to informal engineering education opportunities, and the design of learning environments that support persistence and identity development in underrepresented populations. In addition to her research, she is an exemplary mathematics teacher at CAST STEM High School, where she supports students in developing analytical and problem-solving skills. Raised in San Antonio, her work is informed by a culturally grounded perspective and a commitment to connecting STEM education to real-world and community contexts.

Ana Maria Rabago, The University of Texas at San Antonio

Ana Rabago is currently pursuing a master's degree in Engineering Education at The University of Texas at San Antonio's Klesse College of Engineering and Integrated Design and the College of Education and Human Development. Her work focuses on community-based engineering challenges, STEM instruction for K-12 learners, and family and community engagement in science education. She holds a Bachelor of Science in Biology from the University of Texas at San Antonio and serves as a 6th-grade Science Master Teacher at CAST Network's Advanced Learning Academy in San Antonio, Texas. She collaborates in the Texas Biomedical Research Institute Residency Program to develop curriculum, integrate authentic biotechnology and infectious disease research into middle school classrooms, and manage labs for their Valero Young Scientist Program, where she exposes high school students to biomedical research.

Family Perspectives on Student Summer Opportunities in STEM: Extending the Hoover-Dempsey and Sandler Model in Informal Engineering Education Contexts

[Fundamental]

Abstract

Summer Science, Technology, Engineering, and Mathematics (STEM) programs are widely positioned as mechanisms for broadening participation in engineering, yet the perspectives of families, who authorize participation, navigate access barriers, and interpret program value, remain underexamined. Grounded in the Hoover-Dempsey and Sandler (H-DS) model of parental involvement, this study investigates how parents of students in a large urban city center define the value and effectiveness of STEM summer programs and what program design features they believe support continued educational engagement beyond the summer. Using a mixed-methods design that integrates a parent focus group and a post-focus-group survey (n = 7), the study identifies four interconnected dimensions of family-defined value: confidence and STEM identity, real-world relevance, access and safety, and mentorship/representation. Mapping these dimensions to the five levels of the H-DS model demonstrates that parental involvement in informal engineering education contexts extends beyond the decision to become involved to include opportunity brokering, academic socialization, and reinforcement processes that parents associate with proximal outcomes (confidence, belonging, willingness to persist) and expected distal outcomes (continued participation, pathway exploration, and aspirations). Implications emphasize designing programs that reduce structural barriers, integrate identity-affirming mentorship, communicate transparently with families, and connect engineering activities to community and career relevance.

Keywords

STEM education; parent engagement; summer programs; informal learning; STEM identity; Hoover-Dempsey and Sandler model; engineering pathways

I. Introduction

Engineering education at the pre-college level increasingly relies on summer STEM programs to broaden participation and strengthen pathways into engineering and technology fields. Such programs can provide hands-on learning, exposure to engineering practices, and mentorship experiences that are difficult to replicate within the constraints of formal schooling. In many urban communities, however, the benefits of summer opportunities are shaped by access conditions, including cost, transportation, scheduling, and perceptions of safety. Even when high-quality programs exist, participation is often contingent on family decisions and capacity, including how families navigate cost, transportation, and scheduling constraints [2]. Parents and caregivers play a central role in informal learning ecosystems. They authorize participation, manage logistics, interpret quality, and connect program experiences to students' longer-term educational goals. Many often help children make sense of STEM as a potential career field as relevant, attainable, and worthwhile. Despite this, the design and evaluation of summer STEM programs frequently prioritize institutional goals, such as enrollment targets or curriculum coverage, while giving less attention to how families define program value and success. When family perspectives are not incorporated, programs risk misalignment with community needs, reduced participation, and diminished sustainability.

This paper centers on family-defined values in the context of designing pre-college STEM programs in a large urban center in Texas. The study is grounded in the Hoover-Dempsey and Sandler (H-DS) model of parental involvement, which conceptualizes parents as active agents whose beliefs and actions influence student motivation, engagement, and educational outcomes [1]. While the H-DS model is often applied in school-centered contexts, informal STEM programs present distinct conditions such as voluntary participation, low-stakes assessment, and identity-oriented goals that warrant explicit theoretical attention [5].

Two research questions guide the study: (RQ1) How do parents define the value and effectiveness of summer STEM programs for their children? and (RQ2) What program design features do parents believe support continued educational engagement beyond the summer experience? By mapping parent-defined values to the five levels of the H-DS model, this work extends parental involvement theory with an informal-learning perspective and offers practical implications for engineering educators and program designers.

II. Background and Related Work

Parental involvement has often been framed in terms of school-based activities, such as attending events or monitoring homework. More recent work suggests that this view is too narrow and misses how families support learning in everyday ways, including shaping expectations, encouraging persistence, and connecting learning to long-term goals [3]. In STEM contexts, this broader view is especially important, since many families support learning even if they do not see themselves as having technical expertise.

Families also play an important role in helping young people access opportunities outside of school. Research on out-of-school STEM programs shows that participation is often influenced by practical considerations such as cost, transportation, and scheduling, as well as how families perceive the value and safety of programs [2]. These factors can shape not only whether students participate, but also how they engage and persist.

Informal STEM learning environments, including summer programs, offer different kinds of learning experiences than formal classrooms. Rather than focusing primarily on grades or standardized outcomes, these settings often emphasize exploration, creativity, and real-world problem solving [5], [12]. This flexibility can make them especially powerful spaces for identity development, where students begin to see themselves as capable participants in STEM. Research on STEM identity highlights the importance of confidence, recognition, and belonging in shaping whether students continue in STEM pathways [6], [11]. Informal programs can support these dimensions by providing hands-on experiences, mentorship, and opportunities for students to engage in meaningful practices. Families often reinforce these experiences by encouraging persistence, connecting learning to everyday life, and helping students interpret and celebrate their successes.

These processes are also reflected in the concept of science capital, which describes how access to STEM-related knowledge, experiences, and social networks influences participation over time [9]. From this perspective, families act as important partners in building that capital by helping students navigate opportunities and make sense of them. Although there is growing research on STEM programs and participation, systematic reviews continue to point to gaps in understanding how families define program value and make decisions about engagement, particularly in large, urban-centered settings and among low- to middle-income communities [4], [7]. This study addresses that gap by centering on parent perspectives and by examining how families interpret the value and effectiveness of informal STEM experiences.

III. Theoretical Framework: Hoover-Dempsey and Sandler in Informal STEM Contexts

The Hoover-Dempsey and Sandler model conceptualizes parental involvement as a multilevel process linking parents' motivations and actions to student outcomes [1]. The model specifies five levels: (1) parents' decision to become involved, (2) parents' choice of involvement forms, (3) mechanisms of involvement (modeling, reinforcement, and academic socialization), (4) proximal student outcomes (such as motivation, engagement, and self-efficacy), and (5) student outcomes (such as achievement and persistence).

In many applications, the H-DS model is examined primarily through formal schooling behaviors. In informal STEM contexts, however, each level can take a distinct form. At Level 1, the decision to become involved includes enrolling a child in a voluntary program and investing time, trust, and resources despite structural barriers. At Level 2, parents may engage through opportunity brokering, such as researching options, arranging transportation, and encouraging participation, rather than volunteering in a classroom. At Level 3, parents influence children through reinforcement and academic socialization by framing STEM experiences as meaningful, connecting them to daily life, and normalizing struggle. Level 4 outcomes in informal STEM settings often include increased confidence, interest, and belonging; these are outcomes closely aligned with STEM identity research [6]. Although Level 5 outcomes were not directly measured longitudinally in this study, parents frequently articulated expectations that summer experiences would influence future course choices, career exploration, and postsecondary aspirations. In line with Hill's inclusive view of parental role construction [3], this paper treats family engagement in informal STEM as a legitimate and consequential form of educational involvement that can be theorized within the H-DS framework.

This study uses the H-DS levels as an analytic lens to interpret parent-defined value and to show how families describe involvement processes that extend beyond initial enrollment decisions.

IV. Methods

A convergent mixed-methods approach was used to triangulate qualitative and quantitative evidence. This design was selected because of the small sample size, n=7, and to balance the qualitative survey responses that help identify patterns of agreement across participants, with a deeper focus group discussion to understand parental beliefs and meanings. The participants involved were seven parents or caregivers of middle school students living in a large urban community. The participants reported low- and middle-income backgrounds, identified primarily as Latino, and had varied educational and professional experiences. The focus on one metropolitan region and a small, self-selected group limits generalizability but supports in-depth exploration.

Data was collected by inviting the participants to a semi-structured focus group, followed by an individual survey administered immediately after the discussion. The focus group lasted approximately two hours and was guided by protocol questions addressing children's STEM interests, access to opportunities, perceptions of program quality, and anticipated impacts. The follow-up survey included demographic questions and Likert-style items aligned with constructs commonly measured in STEM attitudes and perceptions instruments.

Qualitative data were analyzed through thematic coding. Initial codes were derived from the H-DS framework (e.g., decision factors, involvement forms, mechanisms, proximal outcomes), with inductive refinement to capture emergent themes (e.g., emotional safety, representation, and value). Survey responses were summarized descriptively to identify areas of convergence and used to support triangulation rather than statistical inference. This was done by organizing results by research question and mapping themes to H-DS levels.

V. Findings

RQ1: How do parents define the value and effectiveness of summer STEM programs?

Parents defined the value of a generalized program, noting four closely related dimensions: confidence and identity development, real-world relevance, access and safety, and mentorship/representation. Survey responses indicated strong agreement that STEM programs outside of school increase interest, support teamwork and communication, strengthen problem-solving, and improve confidence. Focus group narratives provided explanatory depth and illustrated how these dimensions unfolded in practice.

Table 1. Parent-Defined Value Dimensions with Supporting Evidence

Dimension	Survey Pattern	Focus Group Evidence	H-DS Level
Confidence & Identity	High agreement	“She finally believes she can do it.”	3–4
Real-World Relevance	High agreement	“It connects to careers.”	2–3
Access & Safety	Frequently discussed	“Cost is the first barrier.”	1
Mentorship	High agreement	“Representation matters.”	3–4

Confidence and STEM identity: Parents consistently described how they valued a STEM program's effectiveness in terms of its influence on students' perceived development in confidence, persistence, and willingness to take on challenging tasks. One parent emphasized the importance of seeing STEM thinking show up in everyday routines: “My son calculates how he is progressing in his training by wearing a Fitbit.” Another described valuing take-home artifacts that extended learning into the home: “We love that our son came home with a kit where he could extend the learning with those at home.” These examples illustrate how parents interpreted hands-on and technical engineering activities as mastery experiences that made competence visible and reinforced students’ developing STEM identities and confidence, which are closely tied to persistence in STEM pathways [6], [10], [11].

Parents also connected informal interests to identity development and future possibilities. For example, one parent noted, “My son loves streaming on YouTube. They create 3D animation with their videos, and now he wants to have a STEM career using all the math.” Such comments reflect parents’ academic socialization practices (H-DS Level 3), in which families frame STEM activities as meaningful and connected to a child’s interests and future selves. Parents frequently contrasted these outcomes with school-centered measures, summarizing that success was not only about performance but about belief: “It’s not about grades, it’s about believing they can do it.”

Real-world relevance: Parents valued programs that connected engineering activities to authentic problems, community needs, and visible career pathways. Survey responses converged on the importance of helping students understand how STEM connects to real life. In the focus group, parents described relevance as a source of motivation that sustains engagement after the program ends. One parent described a progression from building models to more advanced making: “Learning to work with building models has now grown into 3D printing in a makerspace.” Parents described these experiences as helping students recognize engineering as a real practice rather than an abstract school subject, aligning with H-DS Level 2 involvement forms (program selection) and Level 3 mechanisms (meaning-making and academic socialization).

Access and safety: Parents emphasized that program quality cannot be separated from feasibility. Cost, transportation, scheduling, and age restrictions were discussed as practical filters that determine who can participate. Parents framed safety broadly to include both physical safety and emotional safety(environments where students can take risks, make mistakes, and persist without stigma). This expanded safety framing was especially salient in the discussion of gender and representation. One parent stated, “I believe that this stigma does exist, but women can excel just as well as males in this field,” while another added, “Extracurricular activities are critical to engage young girls and to promote their place in STEM.” These reflections show how parents evaluate programs through an equity lens and how structural conditions shape their decisions to become involved in H-DS Level 1. These barriers are consistent with prior work showing that access conditions often shape whether families can engage with out-of-school STEM opportunities at all [2].

Mentorship and representation: Parents highlighted mentorship as both practical and identity-affirming. Parents described representation as central to students’ comfort in asking questions and imagining themselves in engineering roles. Rather than treating mentorship as a motivational add-on, parents framed it as a mechanism (H-DS Level 3) that strengthens belonging and recognition (H-DS Level 4), which are key predictors of persistence [6].

RQ2: What program design features do parents believe support continued educational engagement beyond the summer experience?

When asked what sustains engagement beyond the program itself, parents described a reinforcing set of design features rather than a single factor. First, parents emphasized hands-on, design-based activities that allow students to build, test, and iterate. Tangible products were described as catalysts for continued exploration at home and as evidence that students can "do" engineering. Second, parents valued low-stakes environments in which struggle is normalized, and students can persist without fear of embarrassment. Parents described these conditions as especially important for students who have not previously experienced themselves as "engineering types."

Third, parents emphasized mentorship structures that extend beyond brief guest appearances. They valued consistent interaction with near-peer mentors and professionals who can translate program experiences into understandable narratives about pathways and careers. Fourth, parents requested transparent communication with families regarding goals, schedules, safety procedures, and how to extend learning at home. Finally, parents reiterated that scholarships, transportation supports, and scheduling flexibility are not peripheral logistics but core program design features that determine participation. Together, these features reflect the involvement forms and mechanisms of H-DS Levels 2–3, which parents associate with confidence and belonging (Level 4) and with continued engagement and pathway exploration (Level 5).

VI. Discussion

This study demonstrates that parents' perspectives map to all five levels of the H-DS model, not only to the decision to become involved. Parents' accounts indicate that informal STEM programs operate as identity-supporting ecosystems whose value is defined by family criteria.

At Level 1, parents' decisions to enroll their children were shaped by role construction and efficacy beliefs, as well as structural opportunity conditions, including cost, transportation, scheduling, and safety. Parents' repeated emphasis on cost as a primary barrier highlights how access constraints can override program quality. This extends the H-DS decision-making process by highlighting the importance of equity conditions as determinants of involvement in informal settings, aligning with calls for a broader understanding of parental role construction that accounts for everyday family realities [3].

At Level 2, parents described how STEM programs helped open doors, how they handled logistics, and chose programs that fit their kids' goals and who they're becoming. These considerations and forms of involvement are often invisible in school-centered accounts, yet parents framed them as substantial investments of time, planning, and trust. Recognizing these forms of involvement has practical consequences: if program designers assume families can simply "opt in," they may unintentionally reproduce inequities in who can participate.

At Level 3, parents highlighted how they reinforce learning at home and help connect what kids do in summer programs to their everyday lives and interests. Quotes such as "My son calculates how he is progressing…by wearing a Fitbit" and "now he wants to have a STEM career using all the math" show how parents translate program experiences into everyday meaning. These mechanisms match H-DS pathways in which modeling, reinforcement, and meaning-making influence how children interpret learning experiences [1].

At Level 4, parents described programs as effective when kids seemed to build confidence, felt like they belonged, and persisted when challenged. They valued this even more than just improving grades or test scores. The statement "It's not about grades—it's about believing they can do it" reflects an identity-centered definition of success. This aligns with STEM identity research showing that confidence, recognition, and belonging are key predictors of persistence, and closely reflect how students develop a sense of themselves in STEM [6], [10], [11].

At Level 5, although long-term outcomes were not measured in this study, parents connected summer experiences to anticipated future engagement, including continued participation, comfort interacting with engineers, and broader career exploration. Notably, parents emphasized readiness factors such as confidence, curiosity, and openness to STEM possibilities, rather than immediate commitment to a specific engineering career. This framing suggests that program evaluations that focus solely on near-term pipeline metrics may miss what families perceive as the pathway's primary benefit.

Science Capital Connection

Overall, the findings indicate that designing summer STEM and engineering programs requires attention to both the family experience and the student experience. When access supports are in place, emotional safety, representation, and mentorship are treated as core features rather than extras; families interpret programs as trustworthy and worthwhile. These are conditions that likely increase participation and sustain engagement. These findings also align with the idea of science capital, in which access to STEM experiences, relationships, and knowledge builds over time and shapes participation. Parents in this study were not just supporting logistics; they were actively helping their children recognize opportunities, interpret experiences, and imagine future pathways. In this way, family involvement contributes directly to how students build and use science capital [9].

VII. Implications for Engineering Education and Program Design

Several implications follow for engineering educators and summer program designers. Access supports, such as program scholarships, transportation assistance, and scheduling flexibility, should be integrated as intentional design elements. Safety should include emotional safety and promote a sense of belonging, especially for students who may experience stereotype-based doubt. Programs should prioritize hands-on, design-based experiences that yield tangible artifacts and mastery experiences, and mentorship structures should be designed for consistency, representation, and near-peer relatability.

Finally, friendly, transparent communication with families should be built into program operations so parents can reinforce learning and connect experiences to longer-term goals through academic socialization.

VIII. Limitations and Future Research

The small, self-selected sample limits generalizability and is likely to overrepresent families already inclined toward STEM opportunities. The study focused on one urban region and one program ecosystem. Future work should recruit larger, more diverse samples, compare program types (school-based vs. community-based; single summer vs. multiyear), and use longitudinal designs to examine how family-defined values relate to later course-taking, persistence, and career exploration. Additional research could also examine how families with limited prior STEM engagement interpret the program's value and which supports are most effective for building trust and access.

IX. Conclusion

The parents of students in a large urban city center involved in this study valued summer STEM programs most when they functioned as identity-supporting environments: accessible, safe, hands-on, culturally affirming, and connected to real-world relevance. Mapping parent-defined value across the H-DS model shows that parental involvement in informal engineering education contexts extends beyond enrollment decisions. Parents engage as opportunity brokers and meaning-makers, using reinforcement and academic socialization to support confidence and belonging as proximal outcomes that parents believe sustain long-term engagement. Centering family-defined values can also strengthen the trust and sustainability of engineering pathway programs.

References

[1] M. C. Whitaker, “The Hoover-Dempsey and Sandler model of the parent involvement process,” in *The Wiley Handbook of Family, School, and Community Relationships in Education*, S. B. Sheldon and T. A. Turner-Vorbeck, Eds. Hoboken, NJ, USA: Wiley, 2019, pp. 421–433, doi: 10.1002/9781119083054.ch20.

[2] B. Ju, O. Ravenscroft, E. Flores, D. C. Nacu, S. Erete, and N. Pinkard, “Understanding parents’ perceived barriers to engaging their children in out-of-school STEM programs,” in *2020 Research on Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT)*, 2020, pp. 1–4.

[3] N. E. Hill, “Parental involvement in education: Toward a more inclusive understanding of parents’ role construction,” *Educational Psychologist*, vol. 57, no. 4, pp. 309–314, 2022, doi: 10.1080/00461520.2022.2129652.

[4] F. Gülhan, “Parental involvement in STEM education: A systematic literature review,” *European Journal of STEM Education*, vol. 8, no. 1, Art. no. 05, 2023, doi: 10.20897/ejsteme/13506.

[5] M. D. Burghardt and D. Hecht, “Designing informal vs. formal education activities—What we’ve learned,” *International Journal of Designs for Learning*, vol. 11, no. 2, pp. 39–45, 2020, doi: 10.14434/ijdl.v11i2.27321.

[6] R. Dou and H. Cian, “Constructing STEM identity: An expanded structural model for STEM identity research,” *Journal of Research in Science Teaching*, vol. 59, no. 3, pp. 458–490, 2022, doi: 10.1002/tea.21734.

[7] F. Kayan-Fadlelmula, A. Sellami, N. Abdelkader, and S. Umer, “A systematic review of STEM education research in the GCC countries: Trends, gaps and barriers,” *International Journal of STEM Education*, vol. 9, Art. no. 2, 2022, doi: 10.1186/s40594-021-00319-7.

[8] K. Holmes, E. Mackenzie, N. Berger, and M. Walker, “Linking K–12 STEM pedagogy to local contexts: A scoping review of benefits and limitations,” *Frontiers in Education*, vol. 6, Art. no. 693808, 2021, doi: 10.3389/feduc.2021.693808.

[9] L. Archer, E. Dawson, J. DeWitt, A. Seakins, and B. Wong, “‘Science capital’: A conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the arts,” *Journal of Research in Science Teaching*, vol. 52, no. 7, pp. 922–948, 2015, doi: 10.1002/tea.21227.

[10] A. Bandura, *Self-Efficacy: The Exercise of Control*. New York, NY, USA: W. H. Freeman, 1997.

[11] H. B. Carlone and A. Johnson, “Understanding the science experiences of successful women of color: Science identity as an analytic lens,” Journal of Research in Science Teaching, vol. 44, no. 8, pp. 1187–1218, 2007, doi: 10.1002/tea.20237.

[12] National Research Council, Learning Science in Informal Environments: People, Places, and Pursuits. Washington, DC, USA: National Academies Press, 2009, doi: 10.17226/12190.

[13] M. S. Barron, K. K. Martin, L. Takeuchi, and R. Fithian, “Parents as learning partners in informal STEM learning,” Phi Delta Kappan, vol. 96, no. 6, pp. 33–37, 2015.