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Fortitude in frustration, failure: Exploring emotional responses within an at-home elementary engineering program.

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Abstract

Research on social, emotional, and academic development of children often notes the critical role of parents. Yet, how parents perceive and engage with children's reactions to difficulty and perceived failure, to then shape their perspective and engagement with learning remains under-investigated. The current study explored children and parents' perceptions of and reactions to frustration and failure within an out-of-school, home-based engineering program. Specifically, we asked *1) How was failure perceived by participating families?* and *2) What was the subsequent action/reaction to that failure?* Data were derived from post-program interviews with children and parents who participated in a home-based, elementary engineering program involving take-home kits and self-identified engineering projects. Findings derived from descriptive qualitative methods and thematic analysis illustrated development of parent thinking around failure and frustration, both within themselves and their reactions to seeing such emotions in their children. Analysis further revealed how such emotions emerge within their children and impact their experiences. These findings shed light on ways child-parent engagement and the tactics employed by parents may influence a child's perseverance and willingness to work through difficulty. This research represents an entry point for investigating how parents perceive and react to failures and challenges, and how these reactions shape their communication around failure with their children. Such parental reactions and communication may shape children's mindset development, perspectives, and engagement. Implications for family engagement and influence on children's learning through academic emotions in STEM and engineering are discussed.

Introduction

Previous research indicates that the process of learning and acquiring new knowledge or skills can come with a broad range of emotional responses and behaviors [1], [2]. Both positive (e.g., pride, enjoyment) and negative (e.g., frustration, boredom) emotional responses have been associated with learning new things [3]. In turn, these emotional responses can impact student behaviors, motivation, and learning outcomes [4]. Schools and teachers have the task of differentiating instruction and accommodating a wide range of learners and the various responses they might have to learning new things. This differentiation of instruction and response to student emotions can be challenging, particularly when exploring new content or subjects that teachers are less familiar or comfortable with [5], [6], including STEM disciplines such as engineering. Concurrently, previous research indicates that parents can have a significant influence on children's learning and development, particularly in out-of-school environments [7]. Within STEM, parent-child dialogue and interaction often enhance curiosity and interest in STEM disciplines [8] and can elicit behaviors and emotions like question asking and experience sharing [8], [9], [10]. Even though parents and children spend a significant amount of time together, contributing to the unique influence that parents may have, studies focused on parent

experiences with teaching and learning STEM content in the home are only beginning to emerge (e.g., [11], [12]). Very few studies have investigated parent perceptions of children's emotional responses (e.g., feelings of failure, frustration), and reactions to these expressions, in home environments. Far less have investigated frustration or failure and parent responses within out-of-school STEM programs and learning opportunities that may shape their perception or interest in pursuing STEM learning or careers. Because the majority of parent-child time is spent in environments like the home, and many parents may act as supports or barriers to teaching and learning during out-of-school time (OST), parent engagement in learning and reactions to inevitable emotional responses in their children may impact children's interest in and motivation to pursue STEM disciplines [13], [14]. Therefore, the current study contributes key information regarding the ways students experience frustration and failure in engineering learning at home, as well as the way parents react to children's emotional responses. Collectively, this information is essential to the development and implementation of out-of-school STEM and engineering learning opportunities and family-engagement tactics that contribute to the interest of young children in STEM and engineering. We specifically explored child and parent perceptions of and reactions to frustration and failure within an out-of-school, home-based engineering program, and asked *1) How was frustration and/or failure perceived by participating families?* and *2) What was the subsequent action/reaction to those emotional expressions?* Through addressing these questions, we contribute further evidence regarding how adult recognition and reactions to child emotional responses play a significant role in children's learning experiences. Further, we argue that emotional responses and parental reactions should be explored and considered when designing and implementing programs geared toward family engagement and co-learning in informal environments.

Relevant Literature

This study is supported by two primary bodies of literature. The first centers on frustration and failure and how both can shape student learning and engagement. Much of the scholarship in this area focuses on curriculum design, traditional school spaces, or curated educational programming (e.g., [15, [16], [17], [18]). Less attention has been paid to non-classroom spaces and programs (such as the home environment) and constraints or affordances for dealing with frustration or failure that such environments might provide. Even fewer studies have focused specifically on engineering content in non-classroom spaces and how the manifestation and management of failure and frustration play a role in student STEM interest or engagement. The second is focused on the role of parents or caregivers in the teaching and learning of children. Parents' perceptions of failure or frustration in their children, as well as their response to it, can shape their interactions and engagement [19], [20]. In turn, the nature of this engagement may impact children's levels of self-efficacy in a task or concept, subsequently influencing their interest or perseverance in learning [13].

Failure, Frustration and Learning

San Juan and Murai [21] note that frustration and failure are not synonymous. Rather, they are related constructs, with failure or perceptions of failure often developing into emotional

responses such as frustration or dissatisfaction [22]. While both frustration and failure are often viewed as negative emotions or responses [23], [24], both can be catalysts for motivation or framed to support more positive cognitive-affective states [25], [26]. Experiences with frustration while learning can shape an individual's level of motivation and determination, both positively or negatively, dependent upon the support or resources made available [27], [28]. Sheridan and colleagues [29] found that with appropriate support and guidance or scaffolding that allows an individual to work through moments of failure or difficulty, frustration can enhance motivation or spur new, creative thinking that contribute to overall learning.

Previous scholarship also notes that learning processes and growth can take place through or because of frustration or failures [30], [31]. This development through adversity often requires learners to assess and analyze the root cause of the frustration and perceived failure, as well as identify solutions or methods for dealing with these emotional responses as they arise [30]. When framed in this manner, frustration and failures are understood as part of an overall process of learning that requires increased effort or perseverance that eventually leads to understanding or mastery [32]. Learning from frustrations or failures can also be shaped by external and contextual factors including environments, as well as social and emotional supports or barriers such as feeling supported in making errors or that they are a natural occurrence [33], [34]. A growing body of research is beginning to examine how frustration and failure can be reframed as expected components to learning in more educational spaces like classrooms or makerspaces [24], [35]. However, limited research has focused on learning in out-of-school contexts and relationships to understand how failure and frustration might manifest to shape motivation and interests, despite children spending most of their waking hours outside of school environments [36].

Parents, Emotional Socialization, and Learning

Alongside educators and typical classroom spaces, families and out-of-school contexts often play an important role in the learning and development of children [37], [38]. Ma and colleagues [39] discuss several domains of learning outcomes for young children (e.g., behavioral involvement, personal involvement, intellectual involvement) all of which include parents or caregivers playing an integral and influential role. The parent-child relationship itself has been found to include several relational domains, which also impact the developmental trajectory and subsequent learning of children through various parental practices [38]. Such practices might include showing warmth and sensitivity, contingent behavior (i.e., adult responses to child behavior), or incorporating routines and decreased turbulence at [40]. Further, parent-child relationships, as well as learning domains, are all implemented under various conditions and circumstances and can require different responses to behaviors and emotions, which can then result in differing outcomes [41].

One way parents have been found to be particularly influential in the learning and development of their children is through their interactions and opportunities to provide instruction. Sometimes referred to as scaffolding, parent-child interactions in learning may look like cognitive support, emotional support, the gradual transferring of agency and ownership of a task, or any

combination therein [13]. Parental support in the form of scaffolding has been found to contribute to positive outcomes for children throughout various stages of development [42], [43], [44]. This often occurs through the simplification of tasks, maintaining attention, and perhaps most germane to the current study, management of emotions such as frustration or disappointment [45], [46]. Like child learning and development, research suggests that parents play a significant role in the emotional development and emotional socialization of children [19], [47]. Often through observing or interacting with their parents, children will learn about various emotions or understand feelings that may arise and appropriate responses [48], [49], [50]. Further, previous scholarship suggests that parent reactions to children's emotional expressions also significantly shape child ability to regulate and manage emotions in various contexts [51], [19], [52]. The association between emotional regulation and academic or learning success is extensive (e.g., [53], [54], [55]). Yet, parental perspectives on emotional socialization and responses to child emotions in out-of-school learning contexts remains understudied.

Theoretical Grounding

This study is broadly informed by the control-value theory of achievement emotions. As noted by Pekrun [3], achievement emotions can range a wide spectrum from enjoyment in learning, to boredom or disinterest in content, to frustration or anger when learning tasks do not go as planned. The control-value theory of achievement emotions posits that student emotional responses to learning activities can be positively shaped or influenced. Such influence occurs when their feelings of self-efficacy, competence, as well as level of control or agency are supported and fostered [3]. This theoretical perspective argues that various factors might influence the fostering of student perceptions of control, including learning contexts or environments and both direct and subliminal messaging a student receives from peers, parents, or teachers [56], [4], [57]. The current study centers both learning context and engagement, specifically with parents, and represents one component of a larger grant-funded project. An overarching aim of this larger project is to engage families in opportunities to explore STEM concepts and skills, while expanding access and accessibility to STEM disciplines. Because they have more knowledge and experience, parents often support their children's learning in various ways and in so doing transmit values and expectations around learning and problem solving [58]. Thus, guided by Pekrun's control-value theory, we focus on parental understanding of and reactions to frustration and feelings of failure that may arise in their children while working together on collaborative engineering kits in home environments.

Methods

This exploratory study investigated the perceptions and responses to failure by children and parents who participated in a STEM engineering program in the home or out-of-school contexts. Using a descriptive qualitative method and thematic analysis, post-program interview data were analyzed via a process of reducing information into significant statements or quotes and combining those into emerging themes [59]. The inclusion of parent and child perspectives from over 20 families provides diverse data for the interpretation of narrow units of analysis (i.e., statements, phrases) and aggregation into broader units (i.e., themes, meanings) [60].

Context

This study is part of a larger grant project working in partnership with families and community members to develop, implement, and refine an out-of-school elementary engineering program. An overarching goal in this effort is to uncover what roles and methods parents, mentors, parents, and other community members might play in developing student awareness, interest, and preparation for engineering careers. Families were recruited for participation through informational fliers, social media posts, and partnerships with local community organizations (e.g., Boys & Girls Clubs, local schools, public libraries). Programs occurred between January and June of each year (2019-2022). While aspects of the program evolved to meet the specific needs and circumstances of participating families, the general program, materials, and project formats remained consistent each year.

Participating families engaged in two elements of an at-home engineering program. The first involved use of researcher-developed take-home engineering kits consisting of two guides – child-oriented instructions and an adult facilitation guide – as well as basic materials and equipment (e.g., popsicle sticks, small motors, hot glue guns, etc.). Each kit was designed to expose families to the complete engineering design cycle, starting with problem identification, to brainstorming/solution ideation, prototyping, testing, redesigning, and communicating results. The second element involved the use of the engineering design cycle learned through the take-home kits to engage in an individual engineering problem or challenge in their home or community, the ideation of an engineering solution, and designing, prototyping, and testing their proposed solutions. Building from the exposure and practice provided through the take-home kits, parents and children worked together to implement the engineering design cycle using readily found recyclable materials from around their homes or community.

Participants

Participants in this study are over 20 families who lived in either a mid-sized city in the Midwest US (Years 1-2) or a small city in the Northeast US (Years 2-4). Participants were racially and socioeconomically diverse, with parents self-identifying as Asian, Black, White, and multi-racial and with incomes ranging from less than $25,000/year to more than $75,000/year. Ten participating parents had professional experience with STEM or currently worked within a STEM discipline (e.g., engineering or mathematics Ph.D.; software engineer; systems engineer). The remaining parents self-described little to no experience with STEM. Participating children were also racially diverse and ranged in grade from kindergarten to 7th grade and ages six to twelve. Familial and individual pseudonyms have been utilized when presenting the results of the study.

Data Source

The data utilized in this study are post-program interviews with the primary participating parent in the program and their child(ren). Interviews were conducted by researchers located at each research site and conducted in person, via phone, or virtually using Zoom and ranged from 30 to 90 minutes in length. Interviews consisted of open-ended questions posed to the caregiver, followed by occasional impromptu probing questions seeking clarification or further detail. Examples of parent interview questions include '*What was your approach when your child experienced a failure or became frustrated or discouraged?', 'How did you acknowledge and*

attend to other emotions such as excitement, anger, boredom, sadness, etc. through the engineering design process?' Children were also asked questions pertaining to feelings of frustration or failure, such as *'What was your favorite kit? Why? Which one was your least favorite? Why?*' and *'How comfortable are you with failure/when things don't go right?'.* All interviews were recorded via phone, voice recorder, or the Zoom recording feature. Interview transcription was conducted using available software (e.g., Scribbie, Ottr.ai) and services. Transcriptions were reviewed and cleaned by researchers to ensure accuracy and completion.

Data Analysis

Qualitative thematic analysis was conducted beginning with examining phrases and sentences that applied to study research questions from interviews transcribed verbatim. Significant statements and perspectives were grouped into broader themes or units of information to provide a foundation for interpretation [59]. In this case, themes refer to specific patterns of meaning or constructs and are drawn from directly observable, caregiver perspectives and dialogue [62]. From these themes, textural and structural descriptions of perceptions of failure and reactions to failure in themselves and their children were developed to illuminate 'what' they experienced and 'how' those experiences occurred. Researchers aggregated and synthesized descriptions of participants' experiences to generalize across our sample where possible [61].

Positionality Statement

The first author identifies as a White, middle class, male, early-career academic. His areas of research involve family engagement and family-school-community partnerships; however, the program and experiences explored in the current study was his first out-of-school experience focused specifically on engineering content. He entered this study with an understanding of and strong interest in social influences on learning and development in children, and ways that parental/familial interactions are shaped by context and environment. However, he was not a parent during this study and cannot recall participating in similar STEM-focused programs as a child. Thus, his perception and analysis of parent and child expressions of frustration and failure, as well as their reactions to these emotions, is based on his previous research and first-hand observations of others' experiences.

The second author identifies as a White, middle class female. She has been researching failure in STEM learning environments for approximately five years. Failure is an emotional and embodied experience. Her personal and professional relationship with failure is one of reflection. But it is also a relationship built on "it just is," particularly in academia where the norms and expectations are constructed as to experience different forms of failure (e.g., grants, journal submissions, collaboration). As a researcher, her lens of failure is grounded in iteration. It is not always the case that a failure is a learning opportunity. However, it is the second author's belief that it is through the accumulation of failure experiences (i.e., iteration within and across experiences) that inform what can be learned through failure moments. Specific to this study, these experiences are also being shaped by parents, the material and engineering tasks, and the home environment.

The last author identifies as a Caucasian, middle class, male who is a senior academic and a parent of two. His research focuses on how youth develop and maintain interest in STEM education across formal and informal learning contexts. As a parent, educator, and researcher he

has experienced multiple moments of failure in all of those roles and tried to make sense of the intersection of theories around learning through failure, experiences in supporting learners through failure and seeing his children and other kids and parents experience failure, particularly in STEM. These experiences and extensive self-reflection influenced his input on the design of this intervention and the interpretation of data produced.

Results

Guided by our research questions '*How was failure perceived by participating families?'* and *'What was the subsequent action/reaction to that failure?'* data analysis revealed several ways in which failure and frustration manifested in the at-home STEM engineering program. Parental perspectives, observations, and developing understanding of these frustrations and perceived failures emerged in a significant way. We present the most prevalent themes and provide examples from several participating families. The first theme revolved around parents' recognition of frustration or failure moments and their own reactions or reflections regarding how to use those occurrences as moments for instruction. The second theme centered around parents' own observations of their children, their frustrations or failures, and reflections on their children's approach to such moments.

Increased Awareness of Parent Reactions to Child Emotions

One primary theme that emerged amongst participating parents was an awareness of themselves and their methods of handling frustration or set-back. This recognition often occurred through observing their children's frustration or failure and reflecting on their approach or acknowledgement of it. Children's frustration was often readily perceived by parents and subsequently understood or supported as a natural or even beneficial component to learning. In acknowledging their children's frustrations and moments when things did not go according to original plans (i.e., failures), many parents chose to model tactics for working through it or suggested ways that children might move beyond frustration.

One example of this comes from a dyad that participated in the second year of the program. Mary and her son, Jack, worked together on several take-home engineering kits of varying levels of difficulty and complexity. Jack' dad would sometimes join in on these kit projects, however it was predominantly Mary working with Jack and observing his reactions and emotional responses to challenge and failure as it arose. In reflecting on their working relationship, Mary noted that moments of frustration happened during which she was purposefully conscious of her own reactions and made efforts to curb her typical response. She said,

I think when I do this, like when I become more controlling than I need to, I don't think they actually learn the concept. And they probably lose interest in completing the activity, as opposed if I say, "Okay, that's a great idea. Let's keep going with it." And if he finds that he has challenges, he thinks of his own way to change it. Or he'll just simply ask me, if he really wants help from me, how he can best change it so he can solve the issue or problem at hand.

Through these opportunities to work closely with Jack, Mary seemed to gain greater understanding of how she might interact and engage with him in learning processes. She also noted the great benefit and agency that might come from Jack working through failures on his own terms. Mary said,

He has to fail to really understand how to solve it. You can't really invent anything without having any failure. And he has to experience the failure with it himself, not me. Sometimes it was taking a step back and really, really not taking over the project. Allowing him to learn, and allowing him to guide, even if it's something that I don't think was best, allowing his idea to come into fruition, whether it succeeded or failed, even though I may have had an idea of what would've been better. And so to really be calm, and patient, and let him have control.

Another example of this parental reflection and influence came from a mother-daughter dyad in year three of the program. Angela and her daughter Annie worked through numerous take-home engineering kits, as well as their own independent engineering project which they identified together. When asked to think about her experience, Annie noted,

Sometimes I did get a little frustrated, 'cause I thought it would work, and it didn't... So that was a little frustrating.

Responding to this and reflecting on how she saw her role and strengths that she might have brought to this learning experience, Angela identified her response as a teaching moment and an opportunity to reframe failure or frustration. Angela said,

… I think just letting her not feel so defeatist about things, like trying to be positive, even when like thing... Like the grabber, that was so frustrating to her, and just letting her, telling her and coaching her like, "Okay, let's just put it aside for right now, and then we'll come back to it tomorrow and maybe you'll have a fresh look at it", so I think the fact that I don't get flustered with that stuff is helpful.

Other parents acknowledged frustration or project failures as a natural part of the learning process that was facilitated by the program's self-paced take-home kits and overall independent structure of the learning experience. One parent, Lynn, who participated with her two children in year four of the program discussed her approach toward the failures she and her children experienced. Much of her description and modeling seemed derived from her own perspective and ways of thinking through barriers and trying various options or resources. Lynn said,

I mean, sometimes, we would just go back and maybe like, watch one of the videos, or just… I think just kind of just like playing with it to see like, maybe what's not, you know, do a little experimenting. Like, is it that it's not connected correctly? Or, you know, just kind of giving that opportunity for like, the hands on…

Through her reflection, she also recognized that this was an opportunity to learn from failure and frustration by focusing on the various steps or the overall process. Lynn worked to reframe

failure as teaching moments and opportunities to look for ways that progress was made. Noting this, she said,

I mean, I think we just kind of always say, like, you know, I'm sure there's something we can take away from this or learn from it. So let's just, you know, try to work through it and, you know, we'll, we'll do the best that we can, because some of the kits could be a little bit frustrating. So we're just going to do our best. And, you know, if it doesn't work, then you know what, that's okay, too. It's not, it's not a failure. If it doesn't work, like if we didn't get the like to turn on or whatever, like, that's okay. Like, no, we tested and, you know, we tried and in the end if it didn't, you know, okay, so I think just kind of also teaching like, it's okay, if you fail, right?

Parental Perspective on Child Emotional Response

A second theme related to failure and frustration emerged from parents' perspective on their children and greater insight into ways their children approach challenge and frustration. Parents' experience in working on take-home kits and self-identified projects afforded many families an opportunity to work together in a flexible way that allowed for and encouraged multiple approaches to problem solving and working through frustration. Still other parents observed their children's approach to challenges and setbacks and gained greater insight into how their children approach learning.

An example of this parental perspective came from, Rachel, who participated in year three of the program with her daughters. Rachel recalled positively the flexible and open-ended approach that the engineering kits afforded. These moments were seen as allowing her daughters' various strengths in overcoming challenge or methods of employing creative thinking to emerge. Rachel noted,

I like step by step stuff. I like directions, I like to be like, "Okay, let's figure it out," and all that stuff. But this not only gives you that, it gives you room to explore, right? Sometimes I tend to box things in, I'm like, "Okay, let's do this, and this is what we're supposed to do…" But this gives the kids an opportunity to be creative…They get to explore their different strengths and so forth and discover things…

It was this child-led creativity and exploration experience that began to show Rachel how her daughters approached difficulty or frustration, which in turn shaped her own perspective. Rachel's daughter, Joy, talked about the ability to try various ideas out and see what may work (or not), saying,

I enjoy doing hands-on activity, 'cause you study like reading books and stuff like that is a good part of learning, but I like more of the hands-on feel. Because there's small things that you can put together and you don't have to just think that you can do it… You can actually put it into action and when you think of something and you can see how different things go, and then you can go into it...

It was through reflections and observations such as these that Rachel began to understand how her daughters approached flexible, open-ended projects and challenges that naturally arise within them. Rachel said,

I guess that's the creativity part where it's giving people room, 'cause like I said, this is like, "Let's just do this, this certain way and get it done and get it over with." … 'Cause when we just started, I was like, "this is how it's gonna be, and this is what we're gonna do". But now I'm like, "Okay, you know, what do you think?". I was like, "Okay, fine, go do your thing", and we did mess up a few times, but it was okay we were able to fix it. So it's like "It's okay, it's okay, it's gonna be okay". So maybe that aspect where I'm like, okay, an error could be an area for discovery.

Yet another family who participated in year four of the program reflected on new insights into ways they worked through frustration. Melanie observed how the ability of her daughters to persevere through frustration or failure and come back to a project, supported their own self-confidence and motivation to carry on in the program. She noted,

They're really self-confident. They already have quite a bit of self-confidence. I think a lot more of, they got frustrated, but then once they got it to work and then calmed down and figured it out and thought it through better, there's that sense of I did it. Which I guess would help their self-confidence.

Melanie's daughters reflected on the same frustrating or failure experiences observed by their mother. Both girls would tackle challenges by employing a tactic of taking a break or coming back with a fresh perspective. They said,

Most of the time we would stop and think about a different prototype. We got angry sometimes. We got angry, we were like, "I'm done with this." We were like, "We're done with is," and then the next day we would come back to it, work on it, and then we're like, "Well, this is the best we've got," and we started recording.

Still other participating parents gained other insights into their children's learning and methods for approaching challenge. One example comes from a participating family in year three of the program. Mari observed her daughter's experience working with several of the take-home kits, noting the moments that spurred frustration and other emotional responses and learning more about her daughter's approach to them. She said,

She got frustrated, for sure. And most of the project kits were kind of failure-proof, kind of it turns out to be okay, like the shoes…there's no right or wrong, right? And the robot things, I think as long as it's moving, I guess it's okay. She knew what was wrong, but I don't think she knew how to correct that problem at that age maybe, I'm not sure. I could see the problem, but I asked her why she thinks it's not happening the way she expected and she's like, "Well, this is supposed to be this, but I cannot, I don't know how to make it this way," and so there was certainly frustrations and it kinda slowed her down when she got frustrated. She didn't really try to solve it vigorously.

Mari found these moments to be enlightening and reflected on how this might be a challenge within her daughter's learning, noting,

I have to say, yeah, she needed a lot of help, like hands-on help. She needed the answer, right away. And I don't think it changed so much for the other projects, she certainly enjoyed it, enjoyed the project, but I really think it's the personality. I don't think she has the personality to kind of face severe frustration. I think it really has to do with patience. Ability to be... Work patiently, not get frustrated at all. Maybe at school she's okay and she's okay to accept the failure part too, but at home she just wants to be successful and don't take any advice.

Discussion

Despite a growing body of knowledge around the impact of failure and frustration on learning [21], [22], few studies have specifically examined the experience of parents and their perspectives on failure and frustration through participation in out-of-school learning opportunities with their children. As such, the purpose of this exploratory study is to highlight and better understand parent perspectives on their children's failure or frustration while working with them in a home-based elementary engineering program. Specifically, we sought to answer the following research questions, *1) How was frustration and/or failure perceived by participating children and parents?* and *2) What was the subsequent action/reaction to those emotional expressions?* The current thematic analysis of transcribed interviews reveals distinct patterns across participating caregivers, revealing ways in which they changed and developed, as well as changes they saw within their children.

Parents As Emotional Socializers

Findings from the current study provide unique insights into the ways that parents perceive and engage with their children while participating in an out-of-school engineering program in their homes. Through reflecting together about their experiences working with take-home kits and independently identified projects, parents and children were provided an opportunity to think about moments of frustration and times where they felt their project had failed. While these emotional responses were discussed with both participating children and their parents, key insights into ways that context, emotional socialization and response methods, and overall impact that natural feelings like frustration can have on the learning process in informal environments emerged predominantly from parents. These findings align with the control-value theory of achievement emotions and are relevant to the furthering of this perspective and ways it might manifest in informal learning environments and relationships [3]. The distinct ways in which parental perspectives and reactions to children's emotional responses within informal, familiar spaces represent a distinct blending of multiple, foundational aspects of Pekrun's [3] control-value theory - learning contexts or environments and direct or subliminal messaging students receive – shaping student self-efficacy and learning outcomes. Overall, through reflections on their interactions with their children during moments of difficulty, awareness of parents' growing understanding of how they engage with and support their children in learning emerged. Parents became active socializers and demonstrated increased awareness of how their responses to frustration and failure shaped the experience and understanding of their children [63]. To primary themes were identified in relation to emotional responses of failure or frustration in children and parents' reactions to them. While other elements of interest emerged, both themes

discussed were observed across most participating families and provided the greatest understanding into the impact that this form of engagement may have.

Reflections on Parent Reactions

Family engagement in STEM learning that centers parents and children working together in their home provides opportunity for connection and observation that may otherwise not typically occur. In our review and analysis of participant interviews and reflections, frustration and feelings of project failure were common and accepted across all participating families. Yet, what emerged was a clear indication of the real benefits that might be derived from parental viewpoints regarding their own perspectives and approach to their children and their learning processes. Participating parents made note of moments in which they observed their child(ren) getting frustrated by steps in kit projects or their own identified engineering project not going according to original plans. It was parents acting in the moment and their noticing of the emotional response that often triggered more intentional parent reactions. Parents also suggested that the collaborative nature of the program and the purposeful positioning of child and parent as coworkers on these projects allowed them to bring their own strengths forward and model measured responses to unsatisfying situations. These interactions and parent perspectives of their own reactions or responses to child emotions align with previous scholarship noting the power that is derived from parent-child interactions in learning domains [41], [38]. Context, too, may play a role in these interactions, as both children and parents may feel freer to respond to frustration or failure in authentic ways as they are in a safe, familiar environment in which they can be themselves. The context in which this program occurred, participant homes, may provide the foundation for these authentic reactions and responses. Analysis illuminated parents' own, individual methods of responding or supporting their children and seeing moments of frustration or failure as opportunities to learn or model prosocial responses [13]. In this way, parents are afforded an opportunity to truly think about and reflect on their experiences with child emotional responses to difficulty and how that might impact their child's learning [42]. Through this work, many parents reflected on their reactions to child failure and were inclined to use those moments to instruct or demonstrate their own values and comprehension of the benefit of frustration and perseverance through difficulty. Opportunities such as this may have been aided by the low-stakes nature and flexibility purposefully built into the program and the take-home kits. As a self-selected program and individual projects based on interests and personal contexts, emotional responses and parent reactions may be further supported and given an opportunity to arise and worked through, without added pressure of formal assessment or curriculum [47].

New Parental Perspectives on Their Children

A second distinct theme to emerge from analysis revolved around parent perspective and understanding of their children, specifically, and their innate responses to frustration, failure, or difficulty. Again, through their reflections on their experience in the program and the barriers and supports that were afforded, parents consistently noted that they learned and observed more reactions in their children than they otherwise might have through their typical engagement at home. This informal dialogue with children also allowed for children's own perspective on frustrating moments or elements of failure that stuck with them to emerge [49], [50]. In hearing and speaking about such moments with their children and researchers, parents were provided with greater insight into how their children perceive their emotions, including feelings of failure [51]. Parents often reflected on other emotions or benefits, such as increased self-confidence or

interest, that may be attributed to their perseverance in failure or working through their frustration to reach a result. Further, through working in close proximity with their children and engaging in more equal roles or dynamics as co-engineers, parents were provided opportunities to consider their perspectives or understanding of their children. While some parents found that children's characteristics or aptitude aligned with STEM disciplines or STEM-oriented work, others found that it gave them a clearer idea of barriers to disciplines like engineering might be for their child (e.g., Mari). Collectively, however, findings indicate that parents gained greater insight into their children, how they move through the world, and how their natural inclinations and emotional responses might impact their learning and interests. In line with child learning and development scholarship, findings support the unique role parents play in the emotional development and socialization of children [14]. Further, current study findings suggest that just as children will learn about various emotions, understand feelings, and appropriate responses from parents, parents too may learn about their child(ren)'s emotional responses and ways to best react and engage that supports their child's growth and determination through adversity.

Conclusion and Implications for Practice

With the understanding that parents play a critical role in the learning experiences of children, alongside their social and emotional development and socialization, we explored parent and child perceptions of their experience with frustration and failure while participating in an engineering-oriented STEM program in out-of-school contexts. The current investigation highlighted two prominent themes, specifically oriented around parent perceptions of both their own and their child(ren)'s interactions with frustration and failure. Through a descriptive qualitative and thematic analysis, two primary themes emerged:

1. Parents gained greater introspective insight into ways that they observe and subsequently react to feelings of frustration and failure within their children, further informing future interactions and learning opportunities; and,
2. Parents observed their child(ren) in atypical contexts that allowed them to see what and when feelings of frustration or failure might arise within their child(ren) in ways they otherwise may not have been able to identify.

Our exploratory study contributes further evidence to the unique role that parents can play in the learning and development of their children, particularly when it comes to academic emotional responses and engagement with new or challenging content. This study also serves as an entry point into further conversation around familiar, informal environments such as the home and ways that such contexts might impact emotional responses and reactions of both parents and children as they learn and interact with one another.

As educators or PK-12 STEM programming practitioners consider working with parents and families in different ways, the current study may inform various approaches to designing and implementing curriculum or content that consider the emotional component and socialization process that occurs. Looking deeper into approachable and familiar contexts, such as home environments, may also lead to new insights into ways of making STEM and engineering learning more accessible to more diverse individuals. Further, centering the growth in

understanding of parental perspectives of their children's emotions and what triggers them, along side their own reactions to them, may contribute to enhanced interest in and benefit derived from such out-of-school, family-engaged learning opportunities. Contributing simultaneously to both the STEM/engineering-focused content exposure and the social-emotional experience of children while participating can positively impact the overall experiences with and perspective children have of STEM disciplines. Subsequently, this may support their increased interest and engagement with careers or educational programming in these areas in the future.

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