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A Case Study of Understanding Family Frustrations in Online Engineering Programs for Children and Caregivers at Rural Libraries (Fundamental)

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Abstract

Online engineering programs offered by public libraries hold great potential for families and children in rural areas, where access to engineering learning resources is often limited. However, these programs can present challenges for librarians in providing support to families needing assistance, as online environments restrict their ability to directly observe and provide just-in-time support. Guided by sociocultural perspectives of learning, we conduct a case study of four caregiver-child groups to examine the type of frustrations families experience in online engineering programs and identify strategies to enhance participation of online engineering programs for children and caregivers. Findings demonstrate that the source of frustration influences the level of participation of the child and caregiver in the engineering design process. This study illustrates four types of frustrations experienced by children—difficulties in solution planning, material handling, achieving desired outcomes, and time constraints—as well as caregivers' frustrations that stemmed from planning and collaborating during the making challenge with the child. Findings highlight different strategies that caregivers used to mitigate their frustrations, such as providing suggestions, assistance, and emotional support, which helped maintain the child's engagement and motivation to complete the engineering challenge. Our findings provide insights on how to effectively design online engineering programs that guide and support rural families to develop positive attitudes toward engineering.

Introduction

STEM programs offered by public libraries hold great potential for families with children, particularly in rural areas where access to engineering learning resources is often limited. Living in rural areas with geographical constraints can make it difficult for families to visit museums or STEM events that could trigger children's STEM interest and participation in their early years [1]. Rural public libraries play a key role in bridging this gap for their communities and families [2], as they are committed to providing informal educational resources, technology, and opportunities to their patrons [3]. An online option to access these sources can allow families to use educational materials at the convenience of their own time and space.

However, online programs in general can present challenges for library staff in giving support to families needing assistance, as online environments restrict their ability to directly observe difficulties and provide just-in-time support [4]. In particular, STEM programs for children attending elementary schools tend to encourage problem-solving by offering hands-on programs that include technical or craft components, which can require assistance and guidance from an adult [5]. The absence of direct observation and in-person support combined with the difficulties during making activities in online spaces can elicit moments of frustration [6]. These

frustrations, which can be seen as "negative" moments, can hinder the learners' motivation and the learning process, but when navigated properly can also become crucial learning moments for both caregivers and children [7]. Thus, this study aims to examine the frustrations that families with elementary-aged children experience in these online environments, with the goal of identifying strategies to enhance the participation of online engineering programs for children and caregivers.

While previous studies have examined in-person maker activities that include children, not many have examined online environments for family-based engineering programs. Broadband has become more accessible for rural areas today and allows families more options to access online informal learning materials [8]. Despite the COVID-19 pandemic showing the usefulness of online learning options, little attempts have been made to utilize and understand the experiences in providing engineering learning, especially in rural areas. Given the lack of facilitation that can be provided in online programs and the high reliance on caregivers' own facilitation, we examine what causes frustrations among families and what strategies caregivers employ to mitigate these moments of frustration that affect children's motivations when participating in engineering programs. This can provide insights in designing online programs in ways that participating families can properly navigate through the program.

Therefore, we aim to investigate the following research questions: (1) What are the types of frustrations families experience during an hour-long online engineering programs at rural libraries?, (2) What are the strategies families use to respond to moments of frustration?, and (3) How do these frustrations and strategies influence families' engagement and interest in the engineering design process?

Literature review

Frustrations during maker activities

Experiencing frustrations and understanding how to address them provides valuable learning opportunities for building motivation and persistence towards success [9]. Such experience allows the child to understand and overcome difficult situations, especially when it comes to areas like engineering. Prior studies have studied the role of frustrations for children when learning during maker activities [6], [9], [10], [11]. Although frustration is a negative emotion, it can help trigger learning moments when navigated appropriately [6], particularly for children. Frustrations are especially unavoidable for young children in preschool to early elementary grades as they are still learning to regulate their emotions [10]. Therefore, frustrations can be understood as part of the learning process. By comprehending the reasons behind children's frustration, adequate strategies can be developed for educational curriculums to help children navigate their situations better. Bers et al. [10] demonstrates an example of this by suggesting designs for a physical makerspace environment where children can be encouraged and scaffolded

to go through the "process of inspiration, creativity, frustration, and breakthrough" [11]. Maltese et al. [9] indicated the necessity of frustration that comes with children's failure during a learning activity. Their study showed that frustrations can promote individuals to embrace challenges and continuously seek out solutions during maker activities.

Motivation and self-efficacy are strong factors that impact frustration. For elementary-aged children from grades 3 to 6, Vongkulluksn et al. [12] examined frustration as a factor in providing moments of self-reflection and impacting subsequent activities. Frustration can also impact situational interests and the motivation to continue with children's activities. Knox et al. [7] focused on the influence of caregivers during frustrations that occur in home environments, where interaction is limited to the child and the parent. Their study showed how parents can be role models when tackling frustrations during maker activities which can influence a child's future interests and motivation, as well as providing a method to address it themselves. When it comes to the factors that cause frustrations, Bower et al. [13] found they can come from expectations in materials and technology that were provided for the maker activities. Time limitations, lack of prior knowledge, and personal expectations are also factors that trigger frustration during maker activities [12].

In prior studies of children's engagement in maker activities, frustration has been framed differently by focusing on emotional states, physical moments, or conversations [6]. Guided by previous literature on frustration during making activities [9], [12], [14], this paper defines frustration as verbal and physical negative emotions that occur in moments of experiencing challenges, tensions, limitations, and disappointment. Frustrations during maker activities is inevitable, and it is important that it is navigated with care so that children can maintain interest in STEM topics like engineering.

Challenges in maker online learning spaces

While it is easier for librarians to notice and assist with frustrations directly in face-to-face settings, moving these activities online can bring several challenges. Makerspaces are often provided in physical locations like libraries, schools, or local communities, which brings restrictions when it comes to time, transportation, and space for rural families [15]. During COVID-19, many public libraries had to turn to online options to provide more access to makerspaces for their patrons [16]. This came with challenges for librarians as online options can lead to many barriers, such as having limited social interaction with the patrons which makes it difficult to provide feedback and keep them engaged for active participation [16]. Challenges from the family perspective can also occur from the inability to keep children occupied during long hours or difficulty with technology [17]. To help relieve these difficulties, Kim et al. [18] suggested several design principles for librarians when providing online makerspaces in libraries – for instance, providing active compliments, assuring that mistakes can happen, and exhibiting exciting examples for the patrons.

Existing literature on makerspace and maker activities have focused on in-person situations, where a teacher or instructor is present with the students [6], [9], [10]. While online options have become increasingly accessible and effective in connecting children, particularly those in rural areas [8], there is limited research exploring family-focused online engineering programs at public libraries. The potential of online engineering programs in rural areas remains underexplored, despite their ability to reduce time and travel constraints and allow families to attend from the comfort of their own environments. This becomes more exacerbated in rural areas, where populations are more dispersed and geographically isolated. In addition, much of current research has taken place in classroom settings where the focus of the study was examining relationships between teachers and students or among students [9], [10], [13]. Only a few studies have examined parent-child interactions, despite the critical role of parental participation in providing examples for emotional regulations and guidance when children experience challenges [7].

Caregiver roles during maker activities

Considering the amount of impact parents or caregivers have on a child's overall development and growth, it is important to examine parent/caregiver-child interaction during the moments of frustration, especially in online environments. Peterson et al. [19] observed how different conversational methods in "emotion recognition, action plans and the discussion of collaborative resources" are likely to help children develop a psychological safety net when experiencing mistakes (p.15). In addition, in STEM areas, parents have shown to take on the key role of influencing children in their career motivation, engineering attitudes, and stimulation in academic achievement during various stages of child development [20]. Parents become important learning partners as they bring in their own valuable experiences to provide emotional and practical guidance when needed [21]. Penney et al. [22] observed how parents working on STEM activities at home used prior knowledge to provide physical help or ideas for their children. During this process, they maintained their roles as co-learners, allowing the children to gain agency over their work and build confidence. Thus, parents are important role models and can directly impact their children's attitude and interests towards engineering, especially in online environments where children are not exposed to other peers or adults.

Theoretical Framework

To explore how families navigate the moments of frustration, we draw on Vygotsky's sociocultural theory, which emphasizes that children's learning and development are shaped through social interaction with more knowledgeable others [23] who can provide appropriate scaffolds for children to accomplish tasks they cannot yet accomplish independently [24]. The role of guidance and scaffolds are particularly important to help children progress in STEM learning [24]. According to Vygotsky [23], social interactions and dialogues are crucial for learning and development of children. Therefore, caregiver roles [25] and problem-solving

strategies used during parent-child conversations [26] play a critical role in how children develop strategies for managing frustrations during maker activities [10].

In fact, parents are widely recognized as important figures in influencing a child's exposure and interest in STEM career paths. Parents' responses to frustration/failure can influence how children develop their own attitudes in similar situations [19] and can also impact how children continue their motivation and pursue further interests in engineering [7]. In this study, we examine family interactions occurring at home during online sessions by looking at the authentic, naturally occurring parent-child conversations. By adopting sociocultural perspectives of learning, we aim to deeply understand how family dynamics and cultural contexts influence each child's experience during moments of frustration and engagement in engineering learning.

Methods

Study Context

This case study is part of a larger design-based research project that developed an online engineering program for rural libraries. With seven rural libraries across seven different states in the U.S., we co-designed and developed six 1.5-hour synchronous Zoom sessions. These online sessions were delivered to elementary-aged children and their caregivers. These sessions, facilitated by rural library staff, introduced making challenges related to engineering. The sessions were intended to be child-led, and each session consisted of introducing the engineering design process of ask-imagine-plan-create-improve with an activity that focused on each stage of the process. Materials needed to participate in each session were distributed to families via researcher-assembled kits. The program was initiated between March to April of 2024 over six weekly sessions. Each library location schedule was different based on the preferences of participating families and librarians.

Participants

The families were recruited with the support of seven library partners by disseminating recruitment flyers across the library's social media, library sites, and active community outreach. While our online engineering program served multiple families, participants included in this case study were four family groups. The four groups who demonstrated substantial dialogue related to moments of frustration were chosen, and these groups consisted of two child-caregiver dyads and two larger groups involving two caregivers and multiple siblings. One librarian from each library facilitated the online sessions. Our data comes from two libraries located in two different states. The details of the families that were chosen for this study can be found in Table 1 with pseudonyms for the names of the children and the library.

Table 1

Family Demographics

Rural library pseudonym	Child pseudonym	Child age (2024)	Child ethnicity/gender	Family members shown in video recordings
Poppyfield	Larry	9	White/male	Mother, child
Poppyfield	Nancy	5	White/female	Mother, child
Lilybrook	Lisa	10	White/female	Mother, child, younger sibling 1 & 2, father
Lilybrook	Norma	11	White/female	Mother, child, younger sibling, father

Data Sources

Data sources included video recordings of child-caregiver interactions during online engineering sessions. Participants were instructed to self-record their engagement using personal devices (e.g., smartphones and tablets) while they logged into Zoom with a separate device for the sessions. The purpose of the self-recording was to capture child-caregiver discourses and interactions that cannot be heard when families are muted in a Zoom recording. After several rounds of reviewing the self-recorded videos, we decided to focus our analysis on two sessions as they showed the most occurrences of frustrations. The focus of these two sessions were to: (1) design circuits with copper tape, LEDs, and batteries and (2) build rock-carrying mechanisms using levers, wheels, and axles (see Table 2). As such, we analyzed approximately 2.5 hours of video data from Larry, Nancy, Norma, and 2 hours from Lisa.

Table 2

Session information

Session number	Session challenge	Duration (minutes)	Materials
2	Use a light component to communicate the solution you designed to solve your user's problem or need.	75	5 LED diode lights (red, blue, green, yellow, white), 10 ft copper conductive tape1 coin cell batteries (3V), 1 binder clip, 3 pieces of colored craft paper (letter size), 1 printed Chibitronics template, 1 masking tape, 1 scissors

3	Imagine that your user found cool rocks that they want to share with their friends. But they are too heavy to carry. Can you build a structure to carry them for at least 5 inches and unload the rocks?	75	1 box, 2 plastic cups, 4 wooden wheels, 4 CD, 10 popsicle sticks, 5 pipe cleaners, 2 pairs of chopsticks, 4 wooden dowel rods, 2 large rocks, 1 masking tape, 1 scissors

Other data sources included exit interviews that lasted approximately 30 minutes to 1 hour for each family. Interviews were conducted in Zoom when participants completed six online sessions. Questions were asked to the children first and then to the caregivers about their experiences during the six sessions and their understanding of engineering before/after the program.

Data Analysis

We conducted a case study [27] to examine how four families responded to and coped with moments of frustration during an online engineering program. To address our research questions, we analyzed the video data in three phases. First, two researchers developed content logs [28] to identify moments of frustration that occurred verbally and physically. In this study, we define frustration as moments in which participants displayed verbal and non-verbal expressions of discomfort or challenge (e.g. sighing, throwing things, groaning, or placing head in hands). Then, these moments of frustration were transcribed line-by-line to analyze the strategies employed and their effect on participant engagement and interest. The transcripts were open coded by one researcher and examined by another researcher. Five types of codes were developed: “expression of frustration”, “frustration from child”, “frustration from parent”, “parent response/strategy to frustration” and “orientation of frustration”. The first category determined whether the frustration from the child was verbal or non-verbal. The second and the third categories were used to identify the types of frustrations that occurred either from the child or the caregiver. The fourth one was used to code the types of strategies used by the caregivers to mitigate the child’s frustrations. The last category was used to examine if the frustrations came during the making process (internal) or from other external factors. The exit interviews were also transcribed line-by-line. To understand how the interactions impacted engagement and interests, we focused on interview questions that asked what participants liked and disliked about the sessions and what they took away from participating in the program.

Results

We present our findings with the themes that were identified from each family’s interactions during moments of frustration. All four families had different sources of frustrations and strategies that were observed throughout the two sessions.

(1) What are the types of frustrations families experience during online engineering program sessions at rural libraries?

Our analysis found that frustrations came from both caregivers and children during the two sessions. While most frustrations came from the making activity, they also came from the home environment. The following are summaries of the findings from both sessions.

Frequency of frustrations

Frustrations from either the child or the caregiver were brief, only lasting for a few seconds. They occurred more frequently in session 3 (building rock-carrying mechanisms using levers, wheels, and axles) than session 2 (designing circuits with copper tape, LEDs, and batteries). The number of frustrations that arose for each participant is shown in Table 3.

Table 3

Frequency of frustrations

Child name (pseudonym)	Number of frustrations during session 2	Number of frustrations during session 3
Lisa	3	9
Lisa's mother	1	4
Larry	3	7
Larry's mother	1	1
Nancy	5	2
Nancy's mother	8	8
Norma	2	1
Norma's mother	2	1

Frustrations from the child during the engineering design process

Most of the frustrations primarily originated from the children during the engineering design process as they experienced difficulties in solution planning, material handling, and achieving desired outcomes. Frustrations related to planning and making with the materials were mostly observed in session 3 where children had to make a structure with levers, axles, and wheels. For the first family, Larry was often unsatisfied with how the materials he chose did not work together as intended. Nancy, who was the youngest among the four families, expressed frustrations when she could not cut the paper the way she wanted. Lisa became frustrated with trying to come up with ideas on what to make with the materials.

Children were also frustrated when plans did not meet their expectations. Larry often showed irritation about how the results were different from his original plan. During session 2, he became visibly annoyed with the copper tape not working properly to make the LED lights turn on. Norma showed annoyance when her structure did not perform well during testing in session 3

or when the process took a long time with the materials during session 2. Similarly, Lisa expressed disappointment when her creation failed to dump the rocks as she planned. This was intensified when the librarian mentioned time was up.

Some children also expressed how time constraints seemed to trigger frustration. This was shown during the sessions where Lisa and Larry got agitated when the librarians mentioned how much time they had left. This was also expressed in the exit interviews. Families mentioned it could have been helpful to know the activity a little ahead of time to prepare and brainstorm solutions so that they did not run out of time. Norma even expressed during session 3 that they had done some planning ahead so they would have enough time to complete their artifact.

Frustrations from the caregivers

For caregivers, frustrations stemmed from planning the making challenge and collaborating with the children during the making process. In Larry's family, his mother became frustrated with Larry's progress when he struggled to advance to the next step in making. Nancy's mother was anxious when she could not come up with a solution: "*Well, this is not going to work, and I don't know how to make it work. Tried two different things now, that are obviously not going to work."*

In some cases, moments of frustration happened between the child and the caregiver. In Nancy's family, visible frustrations came from the mother when Nancy shared a lack of attention and response. For Norma's family, the mother's frustrations during both sessions came from disagreements about ideas and when Norma showed a lack of seriousness during the activity. The excerpt below shows a moment when Norma's mother tried to share her opinion on the design of the structure but was interrupted by Norma who seemingly wanted to stick to her idea:

> *Mother: Does this have to be... I'm just asking. Why does this have to, why does this stick have to be this far over.*
> *Norma: Mom! I'm just trying to make my own thing.*
> *Mother: If you make it...I...*
> *Norma: It doesn't matter. (inaudible) I want to do it the way I want to.*

Lisa and her mother also expressed frustrations with their communication. Lisa's mother became frustrated when Lisa would not share her thoughts or refuse help, when the younger sibling would interfere with Lisa's progress, and when she had to take care of her youngest child who would sometimes cry or climb on the table.

Frustrations from external factors in the home surroundings

Besides those that occurred from the maker activity, frustrations were also caused by external factors within the home environment. Norma and Lisa's families were different in terms of their surroundings than the first and second families since they had other family members in the

background. For Norma, the presence of her younger brother and father did not affect the interactions between her and her mother. It also did not become a distraction for them during the making process. However, Lisa's experience was different from the other families. During her participation, her mother had to take care of two other younger siblings in the house while assisting Lisa during the sessions. The second sibling, Ruby aged four years old, was not signed up for the program but was seemingly interested and wanted to partake in the making activities. The other sibling, being only a year old, could be heard crying multiple times throughout the sessions which sometimes limited the mother's availability to center her attention on Lisa. Because of this, Lisa was often left to deal with her frustrations alone. Thus, Lisa's frustrations came from both the making activities and her sibling's curiosity. In fact, Ruby would keep asking Lisa about what she could do herself or to help what Lisa was doing. This often led to irritations from Lisa.

While Larry and Nancy did not have other family members intervening or interacting in the background, they both had cats which would often cause mild distractions. This would evoke frustration for the caregivers, who then had to call out to their children to stop interacting with the cat and concentrate on the making.

(2) What are the strategies families use to respond to moments of frustration?

To address these frustrations, caregivers showed several types of strategies, such as cognitive, emotional, and different communicative measures to respond to their children.

Step-by-step guidance, suggestions, and reframing

One of the most observed strategies was caregivers providing guidance, suggestions, and attempts to shift the point of frustration. For Larry, his mother responded to his frustrations with the materials by giving suggestions on what other actions could be taken to fix the problem. When Larry could not get his creation to work, his mother helped deconstruct his concerns and locate the reason for that thought. Then, instead of continuing to reassure him, she provided an action plan for notetaking to address his thoughts about failure. An excerpt shows a moment when Larry was discussing the materials he planned to use for Session 3 and expressed a fear of failure that his ideas might not lead to a successful solution. The session's challenge was to create a structure with levers, wheels, and axles to carry and dump rocks. The following portion is when he was at the planning stage before diving into the making stage of the engineering design process:

> *Larry: The other ideas might be a failure.*
> *Mother: But, you don't know unless you try. What's the idea you think would be a failure?*
> *Larry: The, the back wheels are not connected.*
> *Mother: Right.*

Larry: ... but the front wheels are...
Mother: Right.
Larry: ... and when it tips the, the front wheels goes, holds up, but the back wheels are on the back.
Mother: Right.
Larry: But...
Mother: What, what would be a failure about that?
Larry: It could... Because the one failure thing that I think that's going to happen is the, like, it's, so when it bends like, it's gonna be like, rocks... So it's gonna be heavy, so when it bends so much I think it's, just go snap. I don't know what, that's going to happen.
Mother: Okay, why don't you write that down as a risk?

In Norma's case, Norma's mother would similarly provide her own ideas and suggestions for what could be done to resolve frustrations. In response to the child's inability to concentrate which caused frustration, Nancy's mother directly called for Nancy's attention or provided continuous questions to get her back on track. Lisa's mother provided small step suggestions, such as prompting her to look in the bag for other materials or turning the circuit sheet around to see if it would give a new perspective. These strategies helped the children progress to the next steps of their making and maintain their participation in the sessions

Emotional support

In some cases, caregivers provided emotional support through encouragement and waited for the child to ask for help. For instance, Larry's mother indicated several times that she was available if he needed anything. Nancy's mother also expressed reassurances such as, *"So, it doesn't have to be perfect"* or *"It's ok"* to the child's distress and encouraged her to try again. In Lisa's family, her mother would often try to offer support whenever Lisa would sigh or express frustration by asking *"What can I do to help you?*" or *"Is there anything I can do at all?"* while taking care of the other two siblings. She did not persist in providing help and waited until Lisa gave a specific response. She also offered moments of comfort and would sometimes guide Lisa by asking what she might be able to do for the next step if she was stuck and providing suggestions on what she could do. The father also provided indirect assistance across the room. The excerpt below shows Ruby (younger sister) asking questions to Lisa while she was already having frustrations on finishing her structure for unloading rocks, and the father intervening to help Lisa during her progress:

Lisa: Well, yes. Well, no, I don't know right now!
Mother: Relax, it's ok.
Lisa: It's really stressful right now.
Mother: Well, what can I do to help?

Lisa: Well. I'm just trying to focus on this and Ruby keeps asking me a lot of questions and it's really stressing me out.
Mother: Uh huh
Ruby: Will the thing that stays together, Lisa?
Father: Ruby. You need to hush for a minute and let Lisa work.

Ignoring or stepping back

While caregivers provided positive methods to address frustration, there were also several instances where children were ignored, quietly responded to, or disciplined. For example, Nancy's mother responded to the child's frustrations with limited encouragement and direction. In both sessions, the mother took over while Nancy suggested ideas on the side. Although Nancy expressed mild frustrations regarding her mother's reactions to her building attempts or planning efforts, it was often simply ignored. In one case, Norma continued to experience frustration despite her mother' help. In response, the mother stopped expressing her ideas and quietly allowed Norma to continue with her idea until she became stuck again. The mother would then ask if she could provide suggestions or ideas about what to do as a next step. This was similar to an instance between Lisa and her mother who responded with quiet anger *"I don't know Lisa (quietly) Stop. Just stop. Put it down."* The frustration was not further addressed, and the child progressed awhile without further dialogue.

(3) How do these frustrations and strategies influence families' engagement and interest in the engineering design process?

Despite encountering challenges, all families did not give up during the process and were able to complete something to present during the "show and tell" portion of the sessions. Our analysis of the videos and exit interviews demonstrated that children were not heavily impacted by the frustrations that occurred. Instead, they emphasized that the enjoyment of success from other portions of the program seemed to outweigh moments of frustration. Caregivers considered frustrations not as setbacks, but as valuable opportunities for learning. Caregivers mentioned during the exit interviews that these moments of frustration helped them understand their children better and recognize the importance of their role during frustrating situations. For instance, Norma's mother expressed: *"I learned that I have to kind of let her make her own mistakes...I kind of saw that it was not going to work. But I just kind of let it go because... sometimes how you have to learn is by making mistakes...."*. Frustration with materials was also mentioned during the interviews, but families shared that these frustrations did not impact the overall experience or hinder their engagement in engineering learning. For example, Nancy's mother mentioned *"I think our problem with that one was the wheels, the rest of it worked okay"*. In our case study, four families used moments of frustration as valuable learning opportunities to foster resilience as caregivers and children worked through challenges together.

Discussion

This case study examined family families' interactions around moments of frustration to understand the types of frustrations during online engineering programs, the strategies families used to mitigate them, and how these strategies influenced families' engagement in the engineering design process. Our findings demonstrate that the source of frustration, whether from the making activity or the home environments, can influence the level of participation and interaction of the children and caregivers during the engineering design process. However, when children's frustrations were appropriately addressed, they fostered interest and sustained participation in engineering design process rather than leading to disengagement or disruption .

Our findings showed that frustrations primarily originated from the children, who experienced difficulties in planning solutions, material handling, and achieving desired outcomes. Other occurrences of frustration came from the interference of other family members. Similar to previous studies, time limitation was also a factor for panic and frustration near the end of the making session [12]. Although it was not a substantial amount, some children would often feel agitated when they did not have enough time to complete their creations and share them with the librarian and other families. This finding suggests that providing enough time and letting families understand that failure is a part of the learning process during maker activities is important. Having librarians explicitly communicating this to families and leveraging the pressure of needing to be perfect can help children feel less intimidated about engineering.

Caregivers made several strategic moves to mitigate the frustrations during the maker activities. They provided timely suggestions, assistance, and emotional support, which helped maintain children's engagement and motivation to complete the engineering challenge during the online program. This is similar to the suggestion of "normalizing" failure and promoting productivity through frustrations [9]. In some cases, the caregiver's responses to the child's frustrations were limited in terms of encouragement and direction. When caregiver frustrations emerged, they limited the child's engagement and interest; however, when children's frustrations were appropriately addressed, they fostered collaboration and sustained participation. These interactions show that parents can recognize when their child is experiencing frustration and can provide appropriate guidance, especially when they are the only adult present [7]. In addition, caregivers in our study did not try to take control of the children's creations. This is similar to the study by Penney et al. [22], which explains parents attempting to co-learn with children and allowing them to have agency over their making helped enhance confidence. This allows children to navigate their frustrations in a positive direction during the learning process.

The caregivers' strategies towards frustrations also play a crucial role in scaffolding children's attitudes and motivation in engineering [25]. How parents engage in conversations about frustrations with their children can influence their attitudes in similar situations, help scaffold their own problem-solving strategies, and lessen their fear of failure or disappointment [19].

There was an instance where Nancy echoed her mother's phrase "*Third time's the charm, right?"* when her mother was frustrated with trying to make their structure stand upright, which was similar to what she experienced herself. In addition, children were able to calm down or find alternative solutions to continue their work with the appropriate support from their caregivers. This demonstrates how adequate guidance and scaffolding during maker activities can help children develop their own strategies when encountering similar situations by themselves [24].

As for engagement and interest, all four families managed to complete their structures despite the frustrations they encountered. Caregivers emphasized that the outcome did not need to be perfect and that their children's creations were valuable regardless of frustrations encountered during the process. Since there was no formal assessment or survey examining children's making experiences, our study has limitations in determining how parent-child interactions during moments of frustration influenced their motivation or self-efficacy during each engineering session. However, during the exit interviews, the children and the caregivers expressed positive views about their progress. Importantly, the caregivers recognized moments of frustration as opportunities for learning, both about themselves and their children. They mentioned that it led them to understand more about how to tackle frustrations and challenges during future maker activities. Thus, similar to previous studies, frustration during making activities provided positive learning moments and further interest in engineering for both caregivers and children [7]. We suggest future research to explore further into understanding the impact of frustration and caregiver strategies on specific outcomes through more specific measures of assessment.

We also observed frustrations that arose due to the online nature of the program. As the sessions were held at home, pets and sibling interference became a distraction for the families. This does not usually happen during in-person or drop-in events at public libraries. On the other hand, the families did not express frustration with technology itself, such as with internet connection issues, inability to communicate with the instructor, or Zoom fatigue, unlike other studies on online learning [16]. In addition, while the families did not actively seek help from the librarians despite their offers of assistance before or during the making sessions. In most cases, frustration moments were not too severe, and caregivers were able to handle them. Even if families do not reach out for help, we recommend librarians to observe families' interactions online and reach out to offer any help or check in to see how they are doing when needed.

There are some limitations in this study. First, our study focused exclusively on groups in which all participating caregivers were mothers. In addition, the study cannot be generalized to represent all rural circumstances as we only focused on four families and lacked diversity in socio-economic and cultural aspects. We suggest future research to include various family structures to better understand the range of frustration and family dynamics that can occur during online maker activities and their impact on engineering learning. Another limitation was the video/audio quality. Since participants recorded their own videos using their personal devices in different spaces, sometimes the families' interactions or facial expressions were not captured

clearly on screen, and conversations sometimes overlapped with the Zoom sessions being done on another device.

Conclusion

Our study of four families' interactions in an online engineering program provide deeper insights on the complexities of frustrations and its multifaceted role in family-based engineering programs at rural libraries. The findings highlight different types of frustrations that families face in online engineering programs and emphasize the importance of appropriate support to overcome frustrations. The study findings further inform future educational strategies for rural librarians to better foster children's motivation and resilience in family-based programs, particularly in online contexts. By incorporating strategies that guide and support caregivers and children, future online engineering programs at public libraries can be strengthened to enhance families' overall engineering learning experience.

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