# Designing Workbook Probes for Families: A Smart Home Case Study of Intergenerational Co-Speculation


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## Abstract

Smart home technologies increasingly shape family life, yet research lacks methods helping children and parents jointly articulate experiences and imagine alternatives. We present a family-centered design workbook probe for intergenerational co-speculation about smart home futures, along with a six-step design process model that translates research evidence into narrative scenarios, child-friendly illustrations, and collaborative activities. We deployed the workbook for 2–3 months with nine families (children 6–11), and triangulated our design rationale with families' completed workbook and interviews. We distill five methodological lessons for designing workbooks that sustain shared participation and co-ideation about otherwise invisible domestic technologies: tangible, unplugged materiality; curated-yet-universal scenarios; fictional narratives that create a safe third space; bounded prompts that support perspective-taking; and a relational deployment infrastructure supporting family coordination. We provide transferable guidance for HCI/CCI researchers, framing workbooks as participation scaffolds that balance adult-child dynamics and center family voices in domestic technology research.




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## CCS Concepts

• **Human-centered computing** → **Empirical studies in HCI**; **User studies**; **User centered design**; **Empirical studies in interaction design**; **Empirical studies in ubiquitous and mobile computing**; • **Social and professional topics** → **Children**.

## Keywords

Design methods; workbook; probes; co-speculation; parent-child relationship; home; smart homes; Internet of Things; domestic technology.

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## 1 Introduction

The home has long been an important yet challenging site for HCI and Child-Computer Interaction (CCI) research due to its private and intimate nature, shaped by family relationships. Meanwhile, navigating these challenges to study families' use of technologies situated in the home is valuable to learn about how these technologies affect family dynamics, negotiation, socialization, and relationships [21, 39, 62, 78]. Researching families' technology use to uncover these insights, and particularly capturing children's

voices, presents difficulties arising from ethical requirements, access logistics, and children's developmental communication capabilities [57, 61, 76, 89]. While it is critical to understand children's perspectives, as they are active technology users whose digital experiences are intertwined with family routines [13, 78], common research methods such as surveys or interviews often rely heavily on verbal articulation. These methods can be difficult for young to middle childhood children or result in data that is overshadowed by adult caregivers' perspectives [32, 33, 54, 64]. Consequently, HCI researchers face the ongoing challenge of finding methods that can authentically engage children within the messiness of family life, bridge adult-child power imbalances in the research process, and elicit meaningful, collaborative insights from the family as a whole.

Smart homes represent a complex digital landscape, integrating an array of sensors, interfaces, appliances, that provide enhanced monitoring and control for occupants [19, 80, 83, 95]. As these technologies are increasingly adopted and embedded into family daily life, they promise to deliver increased convenience [82], entertainment [94], security [95], and a greater sense of domestic control [21]. However, research has identified significant issues regarding safety [88], privacy [101], and usability [5] when different family members, especially children, encounter these technologies. While these devices are placed into shared family spaces, their design often fails to consider children's use and participation, creating family relationship tensions that current smart home control mechanisms fail to address [86]. Unlike personal devices (e.g., phones or tablets), smart home technologies are often invisible, environmental, and ubiquitous, making them difficult for families to conceptualize and discuss [26]. Existing smart home research has studied how various user groups envision smart home futures, providing insights into alternative design possibilities [26, 28, 98]. Similarly, HCI research explores how children perceive, understand, and imagine emerging technologies, from smart devices [73, 100] to VR [99] and Generative AI [68], to design more usable, engaging, and inclusive experiences that empower children and foster creativity [11, 50, 59, 77]. Understanding children's visions of technological futures is also important as it fosters their sense of agency and critical thinking while revealing their hopes, fears, and perspectives on societal issues [30, 102], as well as empowering them to become active participants in shaping their own futures [2, 31].

However, capturing how children and parents *jointly* discuss, envision, and negotiate these complex concepts remains a gap. Because smart home technologies impact the entire household, understanding them requires a research approach that goes beyond individual perspectives to capture the collaborative speculation of parents and children together. This context demands a method that is not only participatory but also allows families to externalize and reflect on the "invisible" nature of their connected smart home futures in an accessible and low-stakes environment.

To address these challenges, HCI researchers have turned to design probes, which is a user-centered research method built around "packages of artifacts" and small assignments that invite people to self-document experiences, thoughts, and ideas in their own settings [36, 92]. This shows that design probes are a useful method for domestic research because they allow participants to respond in their own time and space to surface responses [47, 49]. Within this methodological space, *design workbooks* are a particular relevant and useful probe format as they function as curated collections of speculative proposals and scenarios. Workbooks are designed to externalize a design space and to structure early, low-commitment conversations [36, 92]. By using open-ended prompts and physical artifacts, workbooks have been successfully used to elicit values and imagine alternatives in smart home contexts, from Internet of Things (IoT) data collection [27] to monitoring cameras [98].

While design workbooks have proven effective for eliciting individual reflections or adult perspectives, there is limited work and guide on how to adapt them for *collaborative speculation* between children and parents. Current existing workbooks eliciting home technology related topics are focused on adults [14, 27, 71] or view children's input separately from their parents [26, 47]. In this work we explicitly explore this methodological gap by leveraging the smart home context, asking:

- RQ1: What are the core procedural steps and compositional design elements required to create a workbook for intergenerational co-speculation?
- RQ2: What methodological lessons can be drawn about the workbook design elements that facilitate families' shared participation and engagement?

To address these questions, we draw on a larger study of children and families' smart home experiences [85] that combined multiple methods across four stages (e.g., a parent interview, an in-home child-led smart home tour, a design workbook probe, and an exit interview). While the broader study goals and findings are described elsewhere [85], this paper focuses specifically on the design of the workbook, titled *A Smart Home for Us*, as a methodological contribution: we detail our decisions in adapting workbooks for intergenerational co-speculation, and we evaluate this approach through a 2–3 month in-home deployment with nine families [85], which generated concrete lessons about what facilitated shared parent-child participation. Across our design narrative and family evaluation, we show how workbook-making decisions, can help families jointly externalize and discuss otherwise invisible smart home possibilities. Specifically, we discuss: how (1) physical materiality creates touch-points of engagement, (2) curated-yet-universal scenarios provide validation and discovery of more inclusive design, (3) fictional narratives create a safe "third space", (4) bounded collaborative prompts invite perspective-taking, and (5) a relational deployment infrastructure supports family coordination and agency.

Methodologically, we contribute a reproducible six-step design process model (Section 4) for researchers creating workbook probes for children and families. While smart homes serve as our case study, this systematic roadmap, moving from evidence-based scenarios to collaborative activities, is transferable to other domestic technologies. Empirically, we present how families respond to specific design decisions to triangulate our key lessons (Section 5). Theoretically, we extend HCI/CCI understandings of probes and participatory methods by positioning workbooks as participation scaffolds that balance adult-child dynamics and support intergenerational co-speculation in domestic technology research.

## 2 Background and Related Work

We review related work that situates our study within research on family technology use, design probes and workbook-based methods,

and the use of probes researching smart home contexts. Together, this literature motivates our method choice to employ a family-centered design workbook to study children's and parents' shared experiences with domestic technologies.

## 2.1 Collaborative Views in Family Technology Design

Families, such as children and their parents, are important stakeholders when designing technology for domestic contexts, as they are frequent and diverse technology users [13, 43, 62]. Children's digital experiences in young to middle childhood are often intertwined with family routines, with parents typically introducing, managing, and gatekeeping access to technologies [63, 78, 88]. Although parents and children may each have dedicated personal devices (e.g., smartphones and tablets), households also rely on shared technologies such as game consoles, smart speakers, and family computers; consequently, much technology use unfolds as a social, co-located, and negotiated practice in the home [39, 62].

Studying family technology use therefore requires approaches that surface both children's needs, amid developing cognition, communication, and digital literacy, and parents' perspectives as observers, mediators, and co-users [64]. In particular, parents' reflections on children's technology practices, alongside accounts of their own habits, help complete a more holistic picture of family digital life that motivates participatory and reflective design methods [22, 66]. These collaborative dynamics form the foundation for understanding families' interactions with increasingly embedded domestic infrastructures such as smart home technologies, where questions of shared control, visibility, and accountability become even more pronounced.

## 2.2 Design Probes and Workbook-Based Methods in Family Technology Research

Design probes are a user-centered research method built around "packages of artifacts" and small assignments that invite people to self-document experiences, thoughts, and ideas in their own settings [36]. Probes cultivate dialogue and interpretation, making participants active contributors who produce rich, multi-layered material over time [92]. In this sense, probes are crafted, question-bearing objects whose material form is tuned to a context and posed gently and provocatively to elicit creative, personally meaningful responses [92].

In *Making Design Probes Work*, Wallace et al. [92] identify four properties that shape *"how and how far a participant involves herself in the process"*: *openness vs. boundedness*, which determines how specific prompts are; *materiality*, which frames the invitation to respond through aesthetics and tactility; *pace*, which addresses the time and duration; and *challenge*, which refers to the effort required. These properties support sustained engagement across multiple probe activities and are often complemented by interviews or dialogical review sessions to support interpretation and reflection [92].

Design probes encompass diverse forms, including artifact kits (e.g., postcards, cameras, prompt cards), structured or semi-structured diaries, and workbook-style tools that support longitudinal self-reporting in everyday contexts [52, 53, 69]. These formats draw on diary study traditions in HCI and Computer-Supported Cooperative Work (CSCW), where participants record activities, emotions, or reflections over time to capture situated, first-person accounts of lived experience [8, 46]. These diary and workbook-based probes typically support slower reflection and narrative sense-making, allowing participants to revisit past events and articulate interpretations [6, 75, 81].

As a probe format, design workbooks combine interpretive openness with temporal and cumulative structure [7, 37]. Their bound form enables the ordering of prompts, gradual introduction of activities, and accumulation of responses over longer periods, while also affording creative expression through sketching, writing, and storytelling [7, 37, 53]. Prior work shows that workbook formats can lower barriers to participation, support engagement in domestic settings, and help participants integrate reflection into everyday routines [37, 53, 55]. While most workbooks are paper-based, digital and hybrid forms have also been explored, particularly where sharing or remote participation is required.

This probe approach has been widely adopted to study families' technology use, where privacy, routine, and relational dynamics make direct observation difficult [15, 20, 47–49, 51, 78, 91]. For example, Hutchinson et al. used technology probes, i.e., digital messaging and video applications for family communication, as deployed prototypes placed in family homes that logged usage while also supporting open-ended interaction and reflection [47]. Browne et al. similarly deployed prototype communication devices to surface how technologies become woven into emotional and relational practices across distributed families [10]. Other work has employed cultural probe kits composed of evocative materials such as disposable cameras, diaries, maps, and postcards to capture intimate moments of care, conflict, and coordination [20]. Vezzoli et al. combined probe activities with contextual interviews to document shared parent–child reading practices and identify how digital devices reshape co-reading routines [91]. Derix and Leong developed paper-based worksheets such as *My Digital Family Tree* and *Device Journal* to foreground parents' perspectives and elicit detailed accounts of everyday technology use [15, 23, 24].

Across these examples, probes function not only as data collection tools but also as *provocations* that prompt participants to notice mundane behaviors, articulate values, and reflect on tensions around control, privacy, and responsibility. Their extended duration captures rhythms of family life, while their material form supports participation by children and adults with varying literacy levels.

## 2.3 Design Workbook Probes for Children and Families in Smart Home Contexts

Probes serve to elicit values and envision alternatives within smart home research [27, 28, 41, 98]. Within this space, design workbooks have been employed as curated collections of speculative proposals and visual scenarios that externalize a design space, invite reflection and storytelling, and structure early, low-commitment conversations among stakeholders [27, 28, 98]. For instance, Pierce et al. used scenarios and collages to explore emerging concerns around privacy, trust, and accountability in smart homes [71]. Chen et al. created a design workbook to examine expectations surrounding personal and family digital data after death [14]. Desjardins et al. developed the *Bespoke* booklet to support situated speculation

and collaborative ideation around IoT futures [27]. Wong et al. employed visually rich workbooks to elicit participants' values and imaginaries around smart home cameras [98].

While this body of work shows the usefulness of workbooks for value elicitation and speculative exploration, these studies primarily focuses on adult participants and assumes familiarity with abstract reasoning, technical vocabulary, and individual reflection. Children experience smart home technologies in different ways: they often interact with these systems indirectly through household routines [82, 86], possess limited understanding of underlying mechanisms [87], and face limited flexibility and autonomy over smart home control configuration and data practices [88]. As a result, children's perspectives on topics such as privacy, autonomy, and surveillance risk being filtered through parental prospective or being left out completely.

Workbook-based probes offer particular promise for addressing these challenges. Their tangible and structured format can integrate drawing, storytelling, and playful activities with guided prompts, enabling children to express experiences and concerns that might be difficult to articulate. Workbooks can support shared parent–child engagement, creating opportunities for joint discussion and negotiation while creating space for children's independent ideation. This dual intent aligns with the collaborative nature of family technology use and the asymmetric power relations that shape children's interactions with domestic technologies.

Taken together, prior work on family technology use, design probes, and smart home workbooks motivates our method choice to adapt a family-centered design workbook probe. By combining visualized smart home scenarios with age-appropriate activities and reflective prompts, we seek to scaffold family discussion and co-ideation around everyday technologies while centering children's lived and imagined experiences. In doing so, we extend workbook-as-probe practices beyond adult-centered value elicitation toward a collaborative and participatory method that supports children and families' meaningful involvement in the design and evaluation of complex domestic technologies.

## 3 Situating the Research

*3.0.1 Study Background.* Our *A Smart Home for Us* Design Workbook was developed as a part of a study examining children and families' smart home experiences and design ideas [85]. The overall goal of that study was to capture children's and parents' joint and separate smart home needs, and ideate with them on how to design smart home technologies that are more child- and family-centered. The study employed an adapted Mosaic approach [16], which is a multi-method framework developed based on the premises that by piecing together children's ideas captured via different approaches (e.g., child-led home tours, photographs, and children's drawings), researchers could *"make sense of the whole"* [16]. Our Mosaic approach consisted of four steps, each with unique goals (see Figure 1).

In **Step 1**, we conducted a parent interview to gather background information on the family's current smart home usage and parent-child relationships and interactions related to smart home technologies. In **Step 2**, we conducted an in-person home visit where the participating child took us on a smart home tour, allowing researchers to observe and interview the child in their natural home environment. We always started the home visit with a dedicated child-friendly assent process, explaining study goals using age-appropriate language to ensure children understood their participation was voluntary. To rebalance researcher-child power dynamics, children were positioned as experts of their homes and encouraged to only share what they felt comfortable sharing.

At the end of the home visit, we introduced **Step 3**, the *A Smart Home for Us* Design Workbook,[1] as a creative probe to provoke shared family reflections and designs. Each family was given 2–3 months to complete the workbook; the research team sent weekly emails with tips and check-ins, while reminding families that children could skip activities or complete them partially. Finally, in **Step 4**, we scheduled an in-home exit interview to learn about the experiences children and parents had with the workbook and gather collective input on their ideas. In each step involving children, we obtained assent at the beginning, encouraged breaks, and emphasized that there were no 'right or wrong' answers. Children could pause or stop the study at any time. This study was approved by the University of Michigan's Institutional Review Board (IRB).

### 3.1 Overall Research Recruitment and Participation

Our study had the following inclusion criteria. First, a participating family had to own smart home devices such as smart speakers/displays, monitoring cameras, smart locks, so that we could study how children navigate interconnected smart home systems. Second, the family had to have at least one child aged 6–11 years who has access to and uses these technologies; we intentionally limited participation to one child per household to ensure balanced data representation across families. Third, at least one parent had to be available to participate with the child, sharing the parental perspectives of the child's smart home experiences. And fourth, the family lived in a geographic area that the research team could access within driving distance.

In spring 2024, we started recruitment with the explicit goal to recruit a diverse sample by using multiple channels through postings on social media platforms (e.g., local city subreddit and facebook groups), institutional mailing lists, personal networks, as well as distributing flyers at local children's hospitals, libraries, and public school events to promote the study.

In total, after months of recruitment efforts, we recruited nine families (10 parents and 9 children, including both parents in family 7), in the same geographic area, with young children (ages 6-11) in their core primary school years (see Table 1). All the study steps were explained during the recruitment process. Our participating families generally had above-average household incomes for the area and were highly educated (2 Bachelor's, 5 Master's, and 2 PhDs). All owned or were buying their homes; eight lived in detached houses and one in an apartment. Four families had members working in technology-related occupations, four in non-technical fields, and one identified as being in a tech-adjacent role. Each family was paid $20 for each of the four steps (parental interview, child tour, design workbook, and exit interview), and received an additional $40 for completing all four steps, for a total of $120.

[1]The workbook is available in full in our OSF repository: https://osf.io/z9k5p/overview?view_only=3351a53418e64083af05821630b6da19


**Figure 1: An overview of the four study steps: Step 1: Parental interview is to inquire about children's smart home use and parent-child relationships. Step 2: Home visit includes a child-led tour to observe and interview children to understand their smart home experiences and needs. Step 3: We use a design workbook as a probe to facilitate the creative process for generating ideas and concepts with families. Step 4: An exit interview with both the parent and the child to learn about their experiences and input on the design workbook.**

| ID | Child Age | Gender | Speaker | Display | Thermo. | Light | Lock | Vacuum | Monitoring Cam | Others |
|---|---|---|---|---|---|---|---|---|---|---|
| F1 | 10 | F | • | | | | | • | • | |
| F2 | 9 | F | • | • | • | | • | | • | |
| F3 | 8 | F | • | • | • | • | • | | • | Pet Care |
| F4 | 6 | F | • | • | • | • | • | • | • | |
| F5 | 9 | M | • | • | • | | • | | • | Blinds |
| F6 | 7 | F | | | • | | • | • | • | |
| F7 | 9 | F | • | • | | • | • | • | • | |
| F8 | 10 | F | • | • | • | • | • | • | • | |
| F9 | 11 | F | • | | • | • | • | • | • | Pet feeder |

**Table 1: Participant Demographics with Smart Home Devices (•: smart home device used by children. F[number] representing the participating family number, F1 is family 1.**

## 3.2 Data Analysis

The larger project generated two corpora of data: (1) researcher documentation, comprising design notes and documentation generated over the eight-month iterative workbook creation process; and (2) field evaluation data from participants, including audio transcripts from home visits, photographs, completed workbook pages (sketches and answers), email exchanges, and researcher field notes. The analysis of the method creation process was conducted concurrently with the creation process, following a Research through Design (RtD) approach. We employed a process of iterative reflection and critical discussion, where insights from each development step were synthesized to inform the subsequent iteration. We focused on presenting the rationale behind key design processes to articulate the method's iterative evolution. Key insights regarding the process and design decisions are detailed in Section 4.

For the analysis of the participant data, the lead author first reviewed all transcripts to build familiarity with the data while conducting analytical memoing [44] focused on workbook related content. Subsequently, the first two authors used an inductive thematic analysis approach [9] to identify themes regarding the research questions (e.g., children's responses to the workbook, parents' suggestions of the workbook).

While the workbook's content was structured around five design principles synthesized from literature (see Section 4.1), our analysis of the participants' data remained inductive. We intentionally separated the thematic content of the families' discussions on their lived smart home experiences (e.g., monitoring, tensions) from the their feedback on the workbook as a research tool. To manage potential prestructuring and ensure reflexivity, the research team held weekly meetings to review and discuss emerging codes and themes and ensure they were grounded in the participants' actual responses. To analyze the workbook artifacts, we located specific mentions of workbook pages (writings and drawings) within the audio transcripts to understand the participants' perspectives. We also triangulated perspectives where parents and children discussed the same prompt to identify points of alignment or tension. The research team held weekly meetings to iteratively refine the codebook until it achieved theoretical saturation. The families' responses to the workbook are presented in Section 5 including five lessons highlighted success (what worked out well) and opportunities (what can be improved) for the workbook efficacy.


**Figure 2: Sample design workbook pages. A: The packet of materials we provide each family, including a workbook, colored papers and pens, a portable drawing board/bag that holds everything for the child to easily organize and carry around. B: Introduction of the workbook leading character, Smarty, introducing families the workbook rules. C: Smarty's techie town neighborhood lives seven families, each has unique stories about their favorite smart home device. The families include: the Camerons, the Lockettes, the Thermans, the Brights, the Sweepers, the Chillers, and the Sounders. D: An example prompt asking the parent and the child to reflect on monitoring cameras use benefits and issues, by each completing a table to compare and discuss reflections.**

We situate this design workbook within a larger research context; while the comprehensive study and its findings are reported in a separate publication [85], this paper focuses specifically on the workbook's design. We first present an iterative design narrative (Section 4) detailing the six procedural steps and key decisions that shaped the final workbook design. We then report lessons learned (Section 5), triangulating our design reflections with feedback from a 2–3 month family deployment to illustrate how participants engaged with specific workbook elements.

# 4 Design Narrative: Workbook Design Process and Decisions

## 4.1 Step 1: Scoping the Workbook Format and Content

*4.1.1 Deciding the workbook physical format.* Our design process began by establishing constraints and requirements for the workbook. First, to elicit both shared and individual perspectives—and to enable comparison across family members—the workbook needed to support a *shared experience* between parents and children. Second, we opted for a physical booklet to encourage children to engage in direct, hands-on manipulation of the material. Third, while prior smart home workbooks have proven successful, we observed that

they were primarily designed for adults. We therefore drew on childhood studies literature, which highlights how books, worksheets, and drawing-based activities can support children's expression, sustain motivation, and reduce adult–child power imbalances in research settings [34, 65]. Based on these considerations, we selected a physical, paper-based workbook as our medium.

*4.1.2 Analyzing close examples.* To scope the workbook content, we examined two influential examples from smart home research. Desjardins et al. created the *Bespoke* workbook, in which participants reacted to 10–12 pages of photographs of their own home devices overlaid with imagined, situated drawings [27]. Wong et al. generated dozens of text-based scenarios spanning themes such as safety and social tensions, then selected monitoring camera-focused scenarios and illustrated them as comic-style conflicts between stakeholders (e.g., renters and owners, children and parents) in a digital workbook [98].

While these workbooks provided inspiration for content and structure, both were designed for adult participants and did not include activities tailored to children's understanding and interests. In addition, they primarily supported *individual reflection* rather than functioning as shared artifacts intended to spark intergenerational discussion and collaboration.

*4.1.3 Deriving content from existing literature.* When deciding how to source our workbook content, we weighed the feasibility and relevance of these example approaches against our design constraints. We ruled out a bespoke approach tailored to each family's specific devices, as it would require rapid turnaround and more demanding design resources. We also avoided relying overly on our research team's personal experiences to generate scenarios, since doing so risked producing narratives that might not resonate with children's lived experiences of smart homes.

To ensure that the workbook content was both relevant and empirically grounded, we turned to academic literature to identify evidence-based themes and patterns in family technology use. We reviewed work on topics including digital parenting [66], designing technologies that support parent-child relationships [78], family-centered approaches to technology design [18], definitions of family [25], and the role of children's involvement in daily household tasks as socialization and informal learning [1, 45]. Our goal was not to conduct an exhaustive systematic review, but rather to derive research-informed inspiration for scenario development.

This process produced a set of key takeaways about how families engage with domestic technologies. To synthesize these takeaways, two authors conducted affinity diagramming [44], grouping the findings into five overarching design principles (see Table 2). These principles were then refined through iterative discussions with the entire research team, including experts in Child-Computer Interaction and a developmental pediatrician.

## 4.2 Step 2: Translate Design Principles Into Scenarios Through Storytelling

With five design principles established, we next translated them into concrete scenarios that illustrate how these principles can be supported or undermined in everyday smart home contexts. We used storytelling as our primary mechanism, drawing on prior work suggesting that narrative structures can improve children's engagement and comprehension [60, 67, 74]. Our goal in this step was to embed abstract principles into relatable situations and to create a shared reference point that families could discuss together.

*4.2.1 Smart home device selection.* Drawing on prior research on children and families' smart home use [4, 21, 35, 78, 82, 86, 88], we identified seven smart home technologies frequently adopted by families (see Table 3). These devices were selected because they are common in domestic environments and play varied roles in shaping family practices such as safety, comfort, communication, and play [40, 82, 88, 90, 94]. Methodologically, we adopted a "buffet-style" selection strategy: by including a diverse set of device types, we increased the likelihood that at least some devices and scenarios would feel familiar to each participating family, regardless of their specific home configuration. This approach helped balance broad relevance with the diversity of smart home setups across households.

*4.2.2 Constructing device narrative scenarios depicting family dynamics.* After identifying relevant devices and grounding them in empirical accounts of use, our next challenge was to present these insights in a format that would appeal to children and still remain meaningful for parents. We therefore constructed narrative scenarios: story outlines that specify events, characters, and settings to create an immersive, discussable situation. Scenarios are commonly used in design to explore possibilities and evoke responses by providing context, tension, and opportunities for change [60, 70].

For each device, we developed a set of scenarios situated in realistic family settings to illustrate how the five design principles could be supported or hindered in practice. Informed by our literature synthesis (see Section 4.1), these stories were intentionally designed to reflect diverse household dynamics, including shared use, negotiation, and conflict. This approach allowed us to surface tensions, such as families' competing needs around privacy, safety, and autonomy, and to depict those tensions as prompts for discussion and design ideation.

*4.2.3 Creating device family characters.* To make the scenarios more engaging and accessible, we explored ways to make the storytelling playful without trivializing the topic. Rather than depicting device use only through realistic human households, we anthropomorphized each device type as its own "family" of characters. Each device chapter thus features a distinct set of characters, family composition, and interpersonal dynamics, allowing us to represent different relationship configurations and recurring forms of negotiation across chapters. For example, the monitoring camera chapter features the *Cameron* family. This chapter includes three scenarios inspired by research on parental monitoring and children's agency [41, 87, 90, 98]. The scenarios were created to foreground relational tensions between parents' desire for safety and children's desire for privacy. By presenting these tensions through characters, families could reflect on the protagonists' needs rather than immediately critiquing their own behavior. This created a neutral "third space" for discussion, which we then built upon through the prompts and activities described in Step 4.

| Theme | Definition |
|---|---|
| Safety, Privacy, and Protection | Focuses on creating smart home environments that prioritize safety, privacy, and risk prevention through design features that protect family members and educate them on safe practices. |
| Learning and Empowered Participation | Emphasizes fostering children's learning and encouraging active family participation, supporting designs that facilitate educational opportunities, self-esteem, and skill development. |
| Inclusive, Accessible, and Customizable Interaction Design | Centers on smart home designs that accommodate both individual preferences and shared family use, ensuring inclusivity and accessibility for all users through granular control management and customization. |
| Connected and Collective/Collaborative Family Experiences | Focuses on enhancing communication, trust, and shared experiences among family members through designs that facilitate meaningful interactions and collective activities. |
| Adaptive and Predictable Systems | Highlights the importance of designing smart home systems that are contextually aware and adapt to evolving family needs without causing unpredictability or surprises, ensuring seamless support. |

**Table 2: Five design principles that technologies designed for families should consider (synthesized from literature review).**

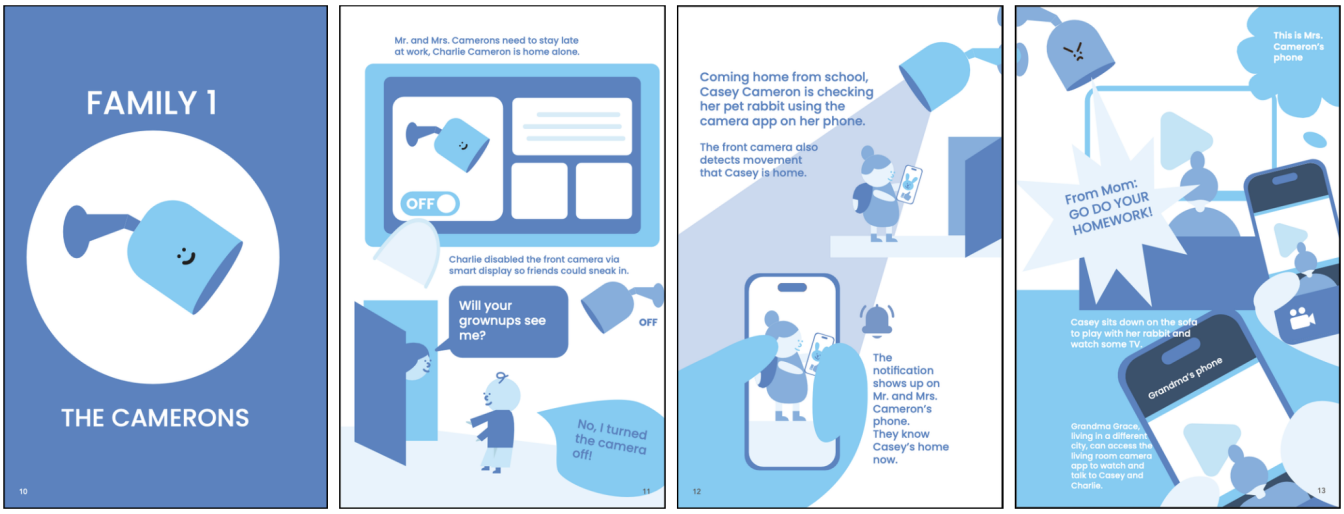


**Figure 3: An example of the illustrated scenarios featuring the Cameron family.**

By systematically constructing these scenario sets, we were able to visualize how the design principles might operate within domestic smart home contexts. The complete set of seven devices (mini-chapters), corresponding scenarios, and mapped principles are presented in Appendix A.

## 4.3 Step 3: Turning Narrative Scenarios Into Visual Illustrations

*4.3.1 Defining the visual strategy.* To translate the text scenarios into visual artifacts, we evaluated the visual strategies used in prior smart home workbooks. Desjardins et al. employed photographs of participants' actual homes [27]. While effective for adult audiences, we opted for an illustrated, stylized approach as high-fidelity imagery can signal a 'finished' or 'factual' state, which may constrain children to propose only practical, realistic solutions rather than engaging in speculation [17, 42]. Wong et al. used black-and-white comic sketches [98]. Although this abstraction can support open interpretation, we were concerned that an uncolored aesthetic might feel serious or less appealing to children. Based on these considerations, we adopted a colorful hybrid style drawing from comics and graphic novels. This approach aimed to preserve narrative richness and a playful tone while remaining sufficiently sophisticated for parents. The stylized yet vibrant aesthetic also signaled that the workbook was an invitation to imagination and exploration, not a test of their technical knowledge.

| Device | Explanation |
|---|---|
| Monitoring Cameras | Including indoor and outdoor monitoring cameras, optionally integrated as part of smart displays, doorbells, or standalone devices. Families often use monitoring cameras for safety, communication, fun, and convenience [40, 41]. |
| Smart Locks | Mostly entryway door locks used for convenience, safety, and security [90]. |
| Smart Thermostats | Used for temperature control, monitoring, and energy efficiency. Families use them to keep home temperatures comfortable [82]. |
| Smart Lights | Used for convenience, energy efficiency, and pleasure. Families use them for indoor and outdoor lighting needs [82, 94]. |
| Robot Vacuums | Used for convenience and cleanliness. Families use them for automated cleaning tasks [88]. |
| Smart Fridges | Used for convenience, energy efficiency, and entertainment [86]. |
| Smart Speakers / Displays | Families use them for all kinds of things, from seeking information and calendar management to entertainment and managing other smart home devices [4, 35]. |

**Table 3: Seven types of smart home technologies related to children and families that we included in the workbook to construct stories and scenarios for.**

*4.3.2 Iterative illustration and design refinement.* For each scenario, we translated the narrative into detailed visual sketches (see Figure 4) in collaboration with a graphic design student. Across iterative design meetings in spring and summer 2024, we refined layout, composition, typography, and color palette (see Figure 5). This refinement process was guided by three design goals:

(1) **Visual consistency:** We established a consistent graphic structure across all seven device mini-chapters so families could quickly learn the workbook's flow and structure, and distinguish story content from interactive prompt sections.
(2) **Color assignment:** We assigned each device chapter a unique color palette, enabling families to associate devices with colors and reducing cognitive load when navigating the workbook.
(3) **Text for clarity:** To reduce ambiguity in interpretation, we balanced illustration with accompanying text so that the intended principle and tension remained legible even if visual readings differed between the parent and the child.

## 4.4 Step 4: Scoping Interactive Prompts and Activities

After finalizing the illustrated scenarios, we integrated reflective prompts and participatory activities into each device chapter. This step transformed the workbook from a primarily narrative artifact into an interactive design tool. While the stories aim to provoke reflection, the activities help families articulate those reflections, compare viewpoints, and build shared ideas, bridging the fictional scenarios with participants' lived experiences.

*4.4.1 Initial approach and pilot evaluation.* We began prompt design by examining how earlier workbooks structured participation. Desjardins et al. used broad, open-ended prompts (e.g., asking for general reactions or identifying the most surprising or least relevant elements) [27], while Wong et al. relied more on interviewer-facilitated discussion than embedded prompts [98]. Following the former approach, our first prompt iteration asked general questions such as *"What do you think of this story?"* and *"How would you solve this problem?"* We initially hypothesized that minimizing constraints would maximize creative freedom for children.

To evaluate this approach, we conducted pilot sessions with children who were 6–10 years old, recruited from our personal networks. Feedback revealed a mismatch between our intent and children's experience: broad prompts were often too abstract for young children, and participants struggled to generate ideas without concrete guidance. In practice, this shifted the burden of facilitation onto parents, who had to invent follow-up questions to maintain the conversation.

*4.4.2 Refining prompts through child-centered methods.* In response to pilot feedback, we pivoted toward more structured, child-centered prompts. We drew on established CCI techniques including "Would You Rather" [79], "Likes and Dislikes" [93], and "Shared Elaboration" [103]. This new strategy balanced personal reflection with collaborative ideation.

Across device chapters, activities were structured to first elicit individual viewpoints (e.g., *"Child, how would you feel if you were this character?"* or *"Parent, if you were a child being monitored, what would you do?"*), and then transition to prompts that required comparison and discussion. This sequencing helped shift participation from individual critique to shared design work. The rationale and structure of the prompts across device chapters are summarized in Table 4.

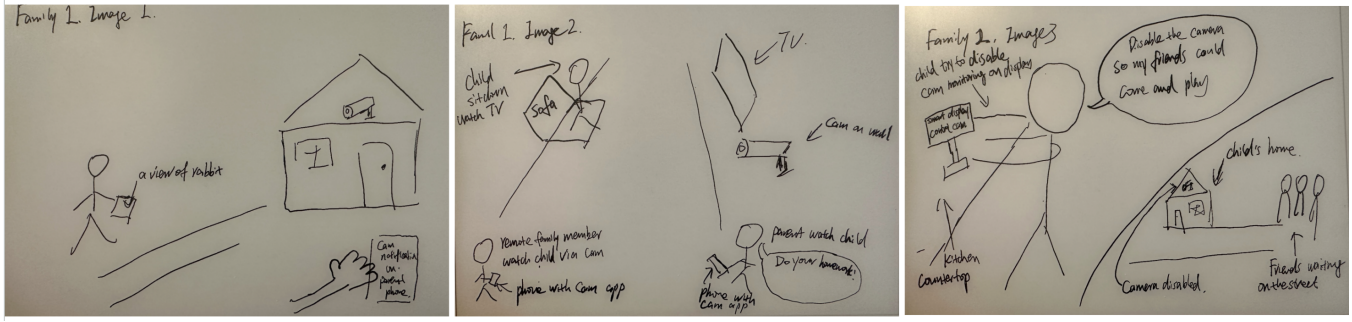


**Figure 4: Example sketches from the author to visualize the scenarios related to the monitoring cameras.**

| Device Type | Description of Prompts |
|---|---|
| Monitoring Cameras | The prompts asked children and parents to imagine they switch roles, and reflect on feelings regarding being monitored. Considering the versatile nature of cameras, prompts asked parents and children to share lived experiences where cameras were helpful, caused problems, or made families feel closer. |
| Smart Locks | We designed child-friendly smart lock interfaces based on real-life use cases. The prompts explored children's likes and dislikes regarding the smart lock app features (e.g., safety tips, parental control). Families discussed the use case of parents monitoring children's entry through smart lock logs. Additionally, inclusive design prompts asked families to design smart lock supporting diverse needs, such as features for elders with poor vision or younger cousins who might treat the lock as a toy. |
| Smart Thermostats | To address family members' different preferences of the home temperature based on real-world use cases, we asked children to interview family members to learn about their individual preferences. Our prompts also included energy consumption topic that includes visualizing household energy consumption data, encouraging families to discuss and reflect on the importance of energy consciousness. |
| Smart Lights | Smart light has versatile use for purposes such as work, convenience, and pleasure [82, 86]. We asked families to design light features to support their specific needs. At the same time, controlling lights can be a playful activity for children [86], so we illustrated a sibling prank scenario and asked families to share their perspectives on how to handle technology-mediated pranks. The goal was to understand how families would respond to conflicting moments. |
| Robot Vacuums | In contrast to marketing claims promoting quiet operation, robot vacuums are often quite loud. To address this, we used an illustration of a child annoyed and scared by the device as a conversation starter. We then asked families to think about how to turn annoying experiences into pleasant ones by applying qualities from things they enjoy to a new robot vacuum design. |
| Smart Fridges | Positioning the fridge as a central hub for food related activities, our prompts asked child participants to learn about family meal planning from parents through interviews. Families then designed smart fridge features to support meal planning, preparation, cooking, and family communication. |
| Smart Speakers & Displays | Recognizing these devices as shared command centers, our prompts asked families to design a mode that ensures fairness when multiple family members attempt to issue commands simultaneously. |

**Table 4: Design Prompts and Rationales for Each Device Type.**

## 4.5 Step 5: Integrating a Unifying Storyline and Characters

Once the device-based mini-chapters were complete, we faced a structural challenge: prior smart home workbooks presented content as a collection of independent worksheets or loosely connected scenarios [14, 27, 97]. In our early draft, the workbook felt like seven mini-chapters stapled together. Recognizing that a workbook is still a *book*, a medium that benefits from narrative continuity, we sought to create a connecting thread across chapters. Drawing on literature suggesting that children build rapport and empathy


**Figure 5: Example sketches by the graphic design student designer that shows the workbook draft storyline and layout.**

with recurring characters through narrative arcs [29, 56], we developed an overarching storyline and a main character to enhance engagement and continuity.

*4.5.1 Smarty and Techie Town.* At the center of this narrative is *Smarty*, a friendly anthropomorphic house character who lives in *Techie Town*, a fictional neighborhood where resident families actively use smart home technologies (Figure 2 B and C). Smarty served two methodological functions:

(1) **Narrative anchor:** Smarty guides readers across chapters, providing a consistent voice that transitions families between device contexts (see examples in Figure 6).

(2) **Interactive facilitator:** Rather than using an anonymous "researcher voice," Smarty invites children to reflect, imagine, and respond, lowering barriers to participation and helping the workbook feel conversational.

To strengthen the relationship between story world and design concepts, the families in Techie Town were named and characterized according to the devices they use (e.g., the Camerons use cameras; see Figure 2C). This book-level narrative provided a social-emotional bridge that supported empathy with the characters' experiences and helped families engage more meaningfully with the design activities.

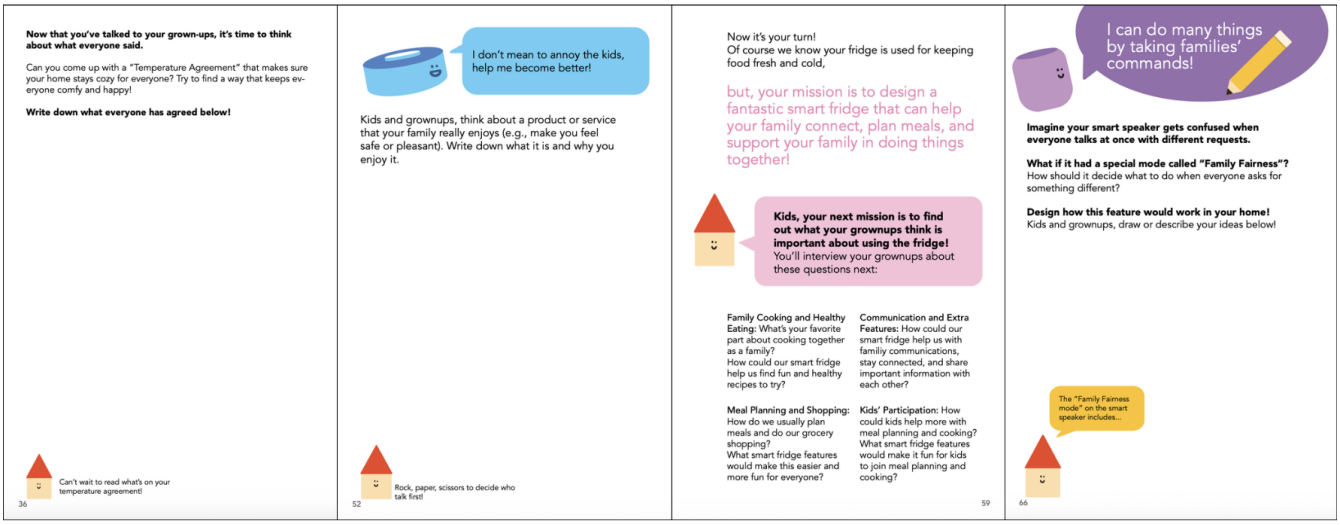


**Figure 6: Examples of how we use the main character Smarty to guide readers across chapters.**

Overall, by integrating storytelling, illustration, and participatory prompts, the workbook functioned as both an exploratory and confirmatory research tool. Grounded in prior work on family technology use and digital parenting, scenarios allowed families to validate which smart home principles resonated with their lived experiences, while also generating new ideas through reflection and co-ideation.[2]

## 4.6 Step 6: Scoping the Deployment and Support Structure

Beyond designing workbook content, we also designed the *workbook participation experience*. We recognized that for a probe to succeed in a busy family setting, the logistics of engagement must be designed as carefully as the scenarios and prompts themselves. Accordingly, we focused on reducing barriers to participation and building a relational support structure that could help families sustain engagement over time.

*4.6.1 Comprehensive materiality: an "all-in-one" packet.* While the workbook delivered the core content, we anticipated potential physical friction in getting started. If a child needed to search for supplies or find a workable surface, these small hurdles might be barriers to participation. We also wanted children to be able to carry materials as they moved through their home, rather than feeling constrained to a single location.

We therefore created an "all-in-one" deployment packet (see Figure 2A): a bright-red zip-packet containing the workbook, a set of colored pencils, loose drawing paper, and a portable drawing board. Our intent was to make participation feel easy and accessible, families could "open and go," and to signal that the research team had attended to logistical details so participants could focus on discussion and creativity.

[2]Detailed content and layout of the full workbook are available in our OSF repository: https://osf.io/z9k5p/overview?view_only=3351a53418e64083af05821630b6da19.

*4.6.2 Designing for longitudinal engagement and relational support.* Prior work suggests that research with families benefits from time, since living with technology is an evolving process and insights often unfold gradually rather than through a single moment of recall [27, 58, 72]. We therefore structured the deployment to give families sustained time for reflection and idea generation.

We distributed the workbook packets at the end of the home visit (Figure 1), after the child-led tour. We explained the workbook structure to both the child and the parent, encouraging them to establish their own "rules" for completion, either following the chapter order or selecting topics based on interest. We suggested a pace of roughly one chapter per week, resulting in an 8–12 week timeline. This duration accounted for seven device chapters plus introductory and concluding activities, while also leaving room for delays due to family schedules.

To support this pace without adding pressure, we designed a Weekly Email Reminder System. Each week, researchers sent brief, personalized "tips and tricks" emails. These messages served two purposes: (1) offering a gentle prompt to keep the study salient amid families' busy life, and (2) signaling reciprocity, showing that the research team was present, available, and invested in the family's experience.

During deployment, we encouraged families to write and sketch directly in the workbook. Sketching can help participants externalize ideas [12], visualize abstract concepts [38], and communicate in ways that support collaboration [84]. We suggested that families set aside a dedicated weekly time to work together, while also emphasizing flexibility: if scheduling conflicts arose, families were encouraged to proceed at their own pace without guilt.

Taken together, these steps reflect the care invested in both the workbook artifact and the deployment experience. By attending to aesthetic quality, narrative coherence, and material completeness, we aimed to signal that families' participation was welcomed, supported, and valued. This design process culminated in an act of trust: after crafting the probe with our best intentions, we handed

it over to families, trusting their agency to adapt the method to their routines, appropriate the materials in ways that worked for them, and respond to the invitation to co-speculate in their own authentic ways.

## 5 Lessons Learned: Triangulating Design Intentions with Family Realities

In this section, we present five methodological lessons drawn from the six design steps described in Section 4. We validate these lessons by triangulating our design intentions and decisions with families' actual responses to the workbook during the deployment. These lessons include family responses where they highlighted engagements (what worked out well) and pointed out friction points (what can be improved) for the workbook efficacy.

### 5.1 Physicality Creates Touch-points of Engagement

Our decision to create a physical, paper-based workbook (Step 1) and distribute it as part of an "all-in-one" drawing packet (Step 6) was intended to encourage children to physically handle, carry, and manipulate the materials. Our participant data suggest that physicality, in practice, created concrete touchpoints for engagement: children incorporated the packet into their daily lives (e.g., C7 brought it to a nearby coffee shop), and families began to associate the workbook with particular places, routines, and shared moments. In this way, the physical artifact operated as a tangible anchor that helped designate specific times and spaces for family discussion.

For some families, the workbook's "unplugged" nature was a functional necessity. For example, C5 emphasized the importance of the workbook *"not being on a screen"*, which enabled him to *"gather them [personal thoughts] all together into one place and draw it out."* P3 appreciated that the workbook allowed C3 to *"practice reading and writing."*

However, we identified a tension where the 'unplugged' nature of the medium might limited expression, as C3 sometimes found the workbook:*"kind of hard to explain that [her answers] on a piece of paper"* when asked how to make things better. This suggests that while a physical base is essential, paper-based probes may lack the immediate interactivity children expect from digital experiences. Families suggested that physical probes could serve as an introductory touchpoint that could then be supplemented with multi-modal elements like physical cards, puzzles, or even digital 'Kahoot-style' quizzes. For example, C3 suggested: *"not putting this on a screen but making it like Kahoot*[3] *– 'What's your favorite piece of technology in your house?' or 'Write down your three favorites and compare'."* Such an approach would allow children to express complex ideas through varied modes of interaction beyond only writing and drawing.

Notably, for participating families the packet itself became a concrete, almost ritualistic object, as well as a recurring cue for together-time. C1 established a routine of working on the workbook only in the *"carpet [area in the living room] ... [to work on] this workbook ... not in my room ... because I needed my dad."* In other words, C1 explicitly linked *doing the workbook* to being in a *shared family space* and spending time with P1. P1 also shared that he used the *"Red Bag"* (the workbook packet) to initiate participation: *"I always ask C1, to encourage C1 to do the work, like 'C1, it's time to do the Red Bag [because the workbook packet was red (see Figure 2A)]!' And she [C1] calls it 'technology [bag]!' And then I said, 'Yes'."* Over time, the packet created a shared language: C1 recognized it as "technology [time]," turning the physical object into a recurring event of connection.

[3]https://en.wikipedia.org/wiki/Kahoot!

### 5.2 Curated Universality Provides Validation and Discovery of More Inclusive Design

In Step 1 (see Section 4), we debated the trade-off between bespoke (tailored) content and universal, literature-derived content. Our findings suggest that the curated universality of a "buffet-style" set of scenarios provided two benefits for children: (1) validation that their experiences with complex domestic technologies were not unusual, and (2) discovery of technologies and dynamics they had not previously noticed or named.

Children often found comfort in seeing scenarios that mirrored (but did not exactly replicate) their own lives. C2 described how encountering stories of other children using smart home technologies made her feel *"more natural ... [about] using complicated [technology relate] things,"* leaving her *"[feeling] a little safer about using stuff like this and less intimidated ... [after] I heard stories [in the workbook] about other kids using it and having fun."* Beyond validation, the diverse scenarios expanded how children noticed technology in their own homes. For example, C5 realized, *"I didn't know we had a thermostat ... I didn't know that it was called a thermostat,"* until encountering it in the workbook. Similarly, C1 described shifting from a passive user toward curiosity and attentiveness: *"[I] don't [didn't] know about like [how the smart lock] locked [work before] ... but now I notice about that. And I notice about like many technologies. How do we use [different technologies] and how to resolve the problems."*

Beyond validation and discovery, the workbook acted as a generative tool, inspiring families to suggest how such interventions could be evolved to support more diverse domestic structures, communication styles and cultural contexts in collaboration. P2 shared that her own parents, C2's grandparents, were *"not really super fluent in English,"* but P2 would love the idea of involving C2 and the grandparents in technology use conversations. P2 discussed how broadening the reach of workbook interventions could help normalize inclusive approaches to technology use, noting that a shift toward *"the broader public and families ... including families with children and older adults and people who have disabilities"* being already underway, but it requires continued attention to accessibility across age, culture, and language.

These suggestions indicate that while curated, relatable content invites children to recognize "invisible" technologies as part of everyday life, there are opportunities for future workbooks to move beyond the parent–child model. By designing for structural flexibility, researchers can create scaffolds that accommodate multigenerational households and diverse family components, allowing the entire family to co-speculate together.

### 5.3 Fictional Narratives as a "Third Space" for Safe Critique

Our decision to create visual narratives featuring fictional families (e.g., the Camerons, the Locketts) experiencing technology-mediated tensions (Steps 2–3) was intended to create a "third space" for discussion: a shared narrative ground where children could voice concerns they might otherwise suppress and where parents and children could critique a situation without immediately personalizing it.

Children shared that they engaged with the characters empathically and used them as proxies to express their own concerns. For instance, C7 expressed uneasiness about the Cameron family's use of monitoring cameras, recalling that she disliked when her parents once used a baby monitor in a similar way. C8 similarly noted that if her parents behaved like the Camerons, *"I would feel like they're invading my privacy."* At the same time, C8 also acknowledged a competing feeling: if her parents monitored her via camera, *"it would feel like they're there when they talk to me [via the monitoring camera] and that helps my anxiety."* These examples illustrate how the workbook helped children articulate co-existing feelings about monitoring (e.g., comfort and discomfort) through a relational lens, without needing to directly confront their parents.

Families also described the narrative format as making the workbook feel more like play than work. C7 shared that *"It was cute. I like the narrative-based approach to talking about each family of technologies as a family of technology is a literal family. That's cool ... [it] deserves to be called a playbook."* P7 similarly emphasized that narrative increased engagement for the whole family: *"I like how it's presented ... in a narrative form. I think that's a good way to approach it because it's more fun for the kids, it's more interesting for everybody."*

However, we also observed that maintaining this third space requires more considerations with different children's cognitive and linguistic levels. While the narrative approach introduced technology concepts effectively for most, at times it can be challenging for the youngest participants. C4 (age 6), for instance, found some questions both: *"confusing and good … Confusing was because some questions I didn't understand … fun because some questions were actually really fun."* This suggested C4's acknowledgment of the challenge and engagement, while also pointed out to include less *"confusing word"* for future workbook improvement. P4 said the workbook overall was a little challenging for C4 as a six-year-old and reflected that P4 had to *"dialing it down and making C4 understand things that are so intuitive and natural for us [adults]."* P4 further suggested including *"an easy appendix of certain words, like a glossary [that] kids might not understand,"* particularly if the workbook was intended for independent use by children without an adult reading alongside.

Together, these responses suggest that fictional narratives can function as both an engagement mechanism and an emotional safety mechanism, supporting children's expression while inviting broader family participation. For future design workbook probes, the efficacy of a narrative "third space" should be paired with age-appropriate vocabulary and visual aids for children to minimize confusion.

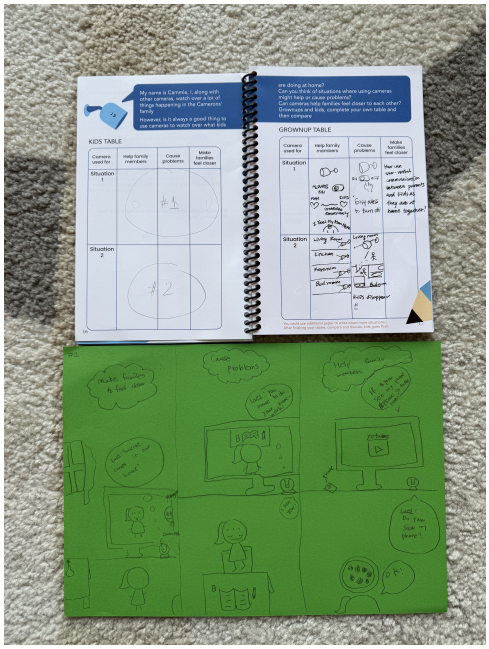


**Figure 7: An example of the Comparative Table activity answers from Family 1. C1 drew her answers of the on the green paper. P1 wrote down grownup answers on the right side of the workbook.**

### 5.4 Bounded, Collaborative Prompts Enable Perspective-Taking

Pilot sessions taught us that broad, open-ended questions did not consistently support children in generating responses, particularly for younger participants (Step 4). In response, we designed more bounded, collaborative prompts such as role reversal, comparative tables, and co-design rules, which required family members to respond on the same page and compare viewpoints. In practice, these prompts surfaced differences in perspective and created structured opportunities for discussion between children and parents.

For example, the Comparative Table activity (see Figure 7) revealed a clear contrast within Family 1. P1 considered cameras (grownup table) as positive tools that support connection, maintaining communication, creating a sense of presence across distance, and offering reassurance for children. In contrast, C1's responses revealed growing sensitivity to autonomy and parental control. Her drawing expressed discomfort about being monitored, suggesting that cameras could shift from tools of care to sources of pressure, where everyday activities (e.g., studying, entertainment) became moments of evaluation. These side-by-side responses often prompted families to reflect on how the same technology can be experienced simultaneously as protection and as mistrust, depending on relational role and context.

Beyond surfacing differences, these structured activities encouraged parents to view technologies through their children's eyes. P1 described that the workbook *"helped me arrange my thoughts, and get me more inspired to … idea[te] something for my kids."* P2 noted that the process surfaced previously unrecognized feelings:

*"we didn't know that [our child] feels that way."* Several parents described this perspective-taking as enjoyable and enlightening; P3 reflected, *"I thought that [the workbook activity] was very interesting and made us both think about what does make something appealing to kids ... But [through the shared activities] C6 really made me see that differently."* P4 similarly thought it was *fun to hear her [C4's] perspective just because we think of things in a certain way and her understanding is completely different."*

These prompts sometimes deepened parents' observational awareness and trust toward their children. P3 recalled that *"we were talking about technologies make you have a better relationship"* when describing changes she observed in C3. P5 reflected that the activities highlighted her child's honesty and moral reasoning: *"I observed about him [talking to C5] 'you're a pretty good kid in terms of you want to be honest and follow the rules, and you recognize that there's rules about things and why they're here'."*

However, our deployment also revealed that bounds alone do not always guarantee speculative depth. For some children, even though they understood the illustrated scenarios, they still experienced a literal interpretation gap when asked to connect fictional problems to their own lives. For instance, P7 gave an example where C7 interpreted prompts *"very literally."* When asked to incorporate a pleasant experience (C7 wrote mom's cooking) into a new vacuum design, C7 struggled to move past the literal act of cooking to the feeling of "pleasantness." P7 had to explain to C7: *"I think we're supposed to be thinking about ... how could a vacuum ... in a way that would be,"* C7 later understood and added *"a little pleasant, less scary."* Similarly, C1, an English-as-a-second-language speaker, noted that while the illustrated scenarios and bounded questions helped, she might still experience challenges articulating their ideas and needed parental support because *"sometimes I can solve [the prompted questions], but sometimes I can't."*

Together, these accounts suggest that bounded, collaborative prompts represent only the first half of a participation scaffold. While these prompts successfully create structured moments of comparison and role-based reflection, relational bridging could further supplement them. Future work should focus on designing these "bridges" as intermediate steps that help children translate literal, lived experiences into slightly abstract and speculative thinking.

### 5.5 Deployment Infrastructure: Materials, Care, Coordination

Our process highlights that method design involves both creating workbook content (Steps 1–5), and the relational infrastructure (Step 6) that supports families through the longitudinal journey. The effectiveness of the workbook relied on a combination of material content quality, a consistent communication support, and collaborative coordination of engagement within the home.

Families explicitly recognized the care invested in the workbook and materials. P3 shared: *"As a parent I especially appreciate your intentionality around creating a workbook, providing materials that are accessible and fun for us both ... C3 and I continued to talk about how much we both enjoyed this experience."* This response suggests that material quality is not merely aesthetic; it is relational. By providing a complete packet (including drawing materials and a folder), we signaled that we valued families' time, supporting engagement as an act of shared commitment rather than a transactional task. P7 echoed this sentiment, noting that the physical materials helped transform the study into an *"experience of doing something together rather than doing work."*

However, sustaining this experience over several weeks revealed a challenge in the initiation of activities. Weekly researcher emails served as a successful support mechanism for adults; P7 valued the check-ins, explaining: *"I liked the weekly check-ins ... Those kept it in the forefront of my mind, even if I didn't respond."* He noted that the emails prompted him to think, *"okay, what should we do this week?"* rather than feeling guilty about what had not yet been completed. Yet, while these emails supported parental awareness, they did not necessarily provide the family with a shared rhythm. C7 shared the difficulty of maintaining a consistent schedule for the workbook: *"I found this workbook really fun. I think it's a really good idea, but like daddy said, we didn't really set up a schedule. So when I was sitting around drawing and then daddy's [P7] like, 'Hey [child name], let's go get our workbook'."*

This interaction highlights that for long-term domestic deployments, support structures can signal researcher presence and care without demanding immediate response, creating a safety net that allows families to drift (due to schedules) and return to the study without guilt. It also shows that even when children are highly motivated, they are often reliant on the parent to initiate the shared activity. This presents an opportunity for future workbooks to move beyond parent-facing reminders and toward shared, child-led mechanisms that empower children to integrate the workbook into the schedule on their own terms.

## 6 Discussion

Workbooks have become a useful probe format in HCI and CCI for surfacing values, imaginaries, and everyday practices in domestic technology contexts [27, 36, 92, 98]. Yet existing smart home workbooks focus on adult participants and individual reflection, even when the topic of research inquiry (e.g., monitoring, access, control) concerns family relationships and negotiations [14, 27, 71, 78, 88, 98]. Our work contributes a family-centered re-framing: a workbook can be designed as both a prompt for individual speculation, and an *intergenerational co-participation ground* that supports children and parents in jointly noticing, interpreting, and re-imagining smart home technologies.

Importantly, we offer value at two methodological levels. The design narrative (Section 4) provides a *reproducible six-step design process model* for developing family-centered participation scaffolds. While we focused on smart homes as a case study, this process is transferable beyond the smart home context. It offers a systematic roadmap for researchers to translate empirical evidence (e.g., from literature or preliminary findings) into (1) device-specific use cases, (2) narrative scenarios, (3) child-friendly visualizations, and (4) collaborative activities for any shared domestic technology. By following these steps, researchers can adapt the workbook-as-probe method to various domestic technologies, helping families reflect, articulate, and negotiate their shared digital experiences. Second, the triangulated lessons (Section 5) provide an in-use account of how these design decisions played out when the workbook lived in the family setting over weeks. By detailing both the *making*

(process) and the *use* (lessons), we provide a roadmap for HCI/CCI researchers to develop and deploy similar participation scaffolds that balance adult–child dynamics in domestic technology research.

## 6.1 From Probe Artifact to Participation Infrastructure in Family Life

Classic probe traditions position artifacts as *"part-made"* objects that invite participants to respond in personally meaningful ways and generate interpretive, multi-layered material over time [36, 92]. In family settings, however, probe participation is not only individual interpretive act, but also shaped by co-presence, negotiation, and family dynamics [39, 62, 78]. This reminds us to not treat a workbook as a prompt activity booklet, but to design the workbook so as to give families the opportunity to reflect and notice the relational dynamics mediated by domestic technologies.

Our work suggests that designing workbooks for families is better understood as designing a *participation ground*, with supported structure that specifies (implicitly or explicitly) who initiates engagement, how turn-taking occurs, where children can respond independently, and how families move from interpretation to collaborative ideation. This perspective aligns with CCI arguments that children's participation requires methods attending to power and communication rather than just question wording [2, 31, 61, 89]. This participation ground perspective also extends domestic HCI probe research, where material kits and diaries are often used to accommodate privacy and observation constraints [20, 47, 53]. Our contribution, beyond a new workbook topic on smart homes, shows the needed shift in method goals: the workbook becomes a ground, a medium for *intergenerational shared sensemaking*.

## 6.2 Research Through Design as a Way of Sharing Method Knowledge

A recurring critique of creative methods in HCI is that they are often described as artifacts (what was deployed) without sufficient explanation of the design reasoning that produced them (why these choices, in this order, under these constraints) [3, 96]. By foregrounding a six-step design narrative, our paper treats method-making itself as a Research through Design (RtD) outcome: the contribution includes a workbook and a documented process through which a workbook becomes *adaptable* by others.

This matters because workbook probes sit at the intersection of design and method [36, 37, 104]: they blend scenario construction, visual communication, prompt design, and deployment logistics. Prior workbook work in smart homes has demonstrated what such artifacts can do for adult participants (e.g., eliciting values around IoT data collection or cameras) [27, 71, 98]. Our design process model makes visible a different set of design moves required when the intended participants include children, and when the intended interaction is collaborative rather than individual. In doing so, we contribute to a growing body of methodological writing that treats design rationales, iterations, and material choices as knowledge production and not just as the research context.

## 6.3 Intergenerational Co-Speculation as a Participatory Goal

Participatory design and CCI have long argued for children's meaningful involvement in technology design, emphasizing methods that create space for children's agency and creativity [2, 30, 31]. At the same time, domestic technology research highlights that parents remain central actors, as mediators, co-users, gatekeepers, and interpreters of children's experiences [64, 66, 78]. In smart homes, these roles intensify because technologies are shared, ambient, and often opaque [26, 88, 101]. Our workbook shows that *intergenerational co-speculation* can be a way to consider both sides. Co-speculation differs from collecting two parallel perspectives (a child interview plus a parent interview). It aims to capture how families discuss meanings and futures together, including disagreement, compromise, and role-based differences in what counts as "good" technology. This complements multi-method approaches such as the Mosaic framework, which assembles a richer picture by combining different child-centered approaches [16], by adding a component designed explicitly for joint discussion and co-ideation, in our case, children and parents jointly reason about futures in ways that reveal negotiated values.

## 6.4 Limitations and Future Work

We consider several limitations and opportunities for future work. First, creating an illustrated workbook with a comprehensive material packet is resource-intensive. Unlike digital tools, the physical materials require time and effort to assemble and distribute. The relational maintenance required to sustain the relatively slower pace, such as personalized weekly check-ins demands a high level of researcher involvement. Future researchers must weigh the benefits of deep, reciprocal research process against the logistical constraints of larger sample sizes.

Second, we designed the workbook probe and deployed it with a group of nine families, providing a snapshot of a small sample within a particular demographic, and thus it is an open question as to how their evaluation of the workbook would generalize to larger and more diverse groups of children and families. We acknowledge that certain family characteristics likely shaped how families engaged with the workbook; for instance, the high level of parental education and socio-economic status may have facilitated the structured family reflection and discussions. Families with different socio-economic backgrounds or more significant time constraints might experience this co-speculation process differently. This also suggests that while core lessons like tangible materiality and fictional narratives may hold across diverse contexts, the longitudinal support structure (Lesson 5) may be more contingent on a family's specific socio-economic context and available bandwidth for research participation. Future research should examine how workbook probes operate across more diverse household structures and caregiving arrangements, including situations where time, space, or parental availability are more constrained.

Finally, while we focused on parent-child co-speculation, smart homes also shape other domestic relationships, including siblings and extended family. Extending workbook probes to these relational

forms would be a promising direction for future domestic technology research to capture a more holistic picture of the connected home.

## 7 Conclusion

Smart home technologies are becoming an integral part of family life, shaping how households coordinate routines, enact care, and negotiate autonomy. However, these technologies can be difficult for children to notice, describe, and critique, leaving children's perspectives underrepresented in HCI/CCI research accounts of domestic technologies. This paper offers a methodological response: a family-centered design workbook probe that supports intergenerational co-speculation about smart home futures. Situated within a larger multi-stage study [85], we contribute a reproducible six-step design process model that translates research evidence into narrative scenarios, child-friendly visualizations, and collaborative activities. By evaluating this approach through a 2–3 month in-home deployment with nine families (children 6–11), we demonstrate that the workbook functioned as more than a data collection artifact; it served as a participation scaffold that created repeated touchpoints for conversation and enabled families to jointly externalize and discuss otherwise invisible smart home possibilities. Triangulating our design rationale with families' workbook use and reflections, we distill transferable lessons for designing workbook probes as participation scaffolds, combining tangible unplugged materiality, curated-yet-universal scenarios, narrative third spaces, bounded collaborative prompts, and relational deployment infrastructure, to better respect the realities of family life while centering children's and families' voices in domestic technology research.

## 8 Selection and Participation of Children

Because participation required families to own multiple smart home devices, have children actively using them, and commit to a multi-step in-person study involving planning and logistics, recruitment took months. We advertised widely through social media, mailing lists, flyers, local schools, children's hospitals, library and institution events. We utilized an initial participant interest survey to collect parents' email. Then we follow up with interested parents to schedule a quick call to explain the study details, share consent forms, and answer any their questions. We asked parents to discuss this research study with their children before joining the study. After each family signed the IRB-approved parental consent form and joined the study, we interact with the child participant from each family twice: the first time is during the home visit for child-led smart home tour; the second time is a home visit to conduct the parent-child exit interview. For both home visits, we obtain child assent right after we arrive at their home. We informed both children and parents that they could take breaks during the study, or stop at any time. All adult researchers completed ethics and safety training for children at our institutions, and ensured that children felt comfortable to participate in the study activities. We anonymized all children's data for the analysis.

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## A Appendix: Smart Home Devices and Corresponding Scenarios for the Design Workbook

### A.1 Family 1 who loves monitoring cameras

(1) **Scenario 1**: A child is walking toward home (coming from school). While walking, the child looks at the camera app on her phone to check on her pet rabbit. As the child walks to the driveway, the front camera captures the movement and sends the parents a notification on their phone that the child is home. In this scenario, there is the view of the parents watching the child via camera, while the child is watching the rabbit on her phone. *Because the child can monitor the rabbit as a form of care, can access the camera independently, and the parents monitor the child's arrival as a form of protection, this scenario covers three related principles: Principle 1 (Safety, Privacy, and Protection), Principle 2 (Learning and Empowered Participation), and Principle 3 (Inclusive, Accessible, and Customizable Interaction Design).*

(2) **Scenario 2**: The same child goes to the kitchen and sits down to watch TV. There is a camera in the living room. At this moment, a remote family member who likes to watch the kids hanging out in the living room drops in to check in with the child (this makes the remote family member feel connected to them). Meanwhile, the parent speaks with them over the camera and says, "Don't watch for too long and get your homework done before I come back! I'll know if you keep watching TV because I can track your screen time too!" *In this scenario, there is exaggerated parental monitoring, and a remote family member uses the camera to feel connected, so Principle 1 (Safety, Privacy, and Protection) and Principle 4 (Connected and Collective/Collaborative Family Experiences) are demonstrated.*

(3) **Scenario 3**: A child accesses the camera from the smart home central control (on the smart display stand placed on the kitchen counter) and disables the camera so their friends can come inside and hang out. *In this scenario, it shows the child's privacy needs for not being watched all the time, which relates to Principle 1 (Safety, Privacy, and Protection). As the child has access control to turn off the monitoring, it demonstrates Principle 3 (Inclusive, Accessible, and Customizable Interaction Design).*

## A.2 Family 2 who can't live without their smart lock

(1) **Scenario 1**: A family of four—two parents and two children (ages 9 and 7)—is setting up their new smart lock system by installing the smart lock app on the parents' phones, the 9-year-old's phone, and the smart display on the kitchen counter. The lock app on the child's phone and the smart display only allows certain lock features for children, but not full access such as creating a new code. On the parents' phones, they have the complete lock log and record. *This scenario demonstrates Principle 1 (Safety, Privacy, and Protection) and Principle 3 (Inclusive, Accessible, and Customizable Interaction Design) through parental protection measures, parents' need to ensure the child arrives home safely, and children's controlled access to the system.*

(2) **Scenario 2**: The lock app has an education section that includes (1) vivid and fun videos that demonstrate to children how the lock works, and (2) lock safety tips that initiate family discussions with children, including different scenarios such as Wi-Fi outages, low battery, forgotten codes, and not sharing codes with others. It also covers potential family responsibilities and consequences for children to consider. *This scenario demonstrates Principle 2 (Learning and Empowered Participation) as children learn about proper smart lock use and safety practices.*

(3) **Scenario 3**: Every day, the two children take the school bus to get home, and the parents normally receive notifications through the lock system. One afternoon, the parents need to work slightly later. Suddenly, they start receiving back-to-back lock notifications. They check the entryway camera, which has been disabled. As it turns out, the children invited some of their friends over to play. *This scenario demonstrates Principle 1 (Safety, Privacy, and Protection) through monitoring capabilities, and Principle 3 (Inclusive, Accessible, and Customizable Interaction Design) as children have access to disable the camera but cannot disable lock notifications.*

## A.3 Family 3 with the versatile thermostat

(1) **Scenario 1**: A child likes to mess with the thermostat despite their parents forbidding it. The parents bought a new thermostat that allows a child lock feature on the software, permitting the thermostat to only be adjusted by a few degrees above or below the target temperature, preventing accidental major adjustments. *This scenario demonstrates Principle 1 (Safety, Privacy, and Protection) through the safety child lock feature, and Principle 3 (Inclusive, Accessible, and Customizable Interaction Design) by showing that children can access and control the smart thermostat within a limited range.*

(2) **Scenario 2**: A scenario shows two children wanting different temperatures, both of which differ from what the parents prefer. One child's preference is too hot for the other, while the other child's preference is too cold for the family. The parents utilize the thermostat as a mediator to help the children, as the thermostat provides the best temperature based on data analysis of the household situation and helps families discuss the issue. *This scenario demonstrates Principle 4 (Connected and Collective/Collaborative Family Experiences) and Principle 5 (Adaptive and Predictable Systems), as the device considers shared use and family members' different preferences, offering solutions based on family data, weather, and other data sources needed to mediate the situation.*

(3) **Scenario 3**: A fourth-grade child is learning about energy saving at school. The smart thermostat provides an educational section for the parent and child to sit down and learn about the family's schedules and preferences, geofencing, energy reports, weather adaptation, air quality monitoring, heating and cooling, and how everything affects family members' health and well-being. Every month, the thermostat generates a kid-friendly and fun "My Home Energy Use Report," prompting the child to review the information with parents and follow recommended steps where the family could improve based on habits, time of year, events, etc. *This scenario demonstrates Principle 2 (Learning and Empowered Participation), Principle 4 (Connected and Collective/Collaborative Family Experiences), and Principle 5 (Adaptive and Predictive Systems). Through using and adjusting the thermostat and the app providing extensive related information, children can learn many things and have conversations with parents. Children learn, participate, care about home and other family members, experience shared family experiences, and the system is aware of what's happening in many aspects to provide families with energy use information and best practices.*

## A.4 Family 4 with the fun and annoying smart lights

(1) **Scenario 1**: The system shows diverse control options for children (e.g., voice, button, automation, apps) for different times of the day and daily activities: bedtime, night light, storytime, movie time, family time, morning time, party time, and relaxing time. *This scenario demonstrates Principle 2 (Learning and Empowered Participation), Principle 3 (Inclusive, Accessible, and Customizable Interaction Design), and Principle 4 (Connected and Collective/Collaborative Family Experiences) by involving children's use of lighting to assist in the transition of routines and activities, prompting shared experiences.*

(2) **Scenario 2**: Children like to use lights to play pranks on family members, such as changing the bathroom light to red when one parent is in the shower, making a sibling's room light super bright at night, or turning the light back on after it was scheduled to turn off for bedtime. Sometimes parents are really annoyed by this behavior. *This scenario demonstrates Principle 3 (Inclusive, Accessible, and Customizable Interaction Design), showing that children have access to control lights but may cause inconvenience to other family members.*

(3) **Scenario 3**: Family members use colorful lighting to communicate how they feel. There is a smart light panel with each family member's name, and families have agreed on what each color signals. Each day, family members are invited to log their day with lighting. Over time, if the lighting/mood log signals that family members are not doing well for a certain period of time, the light app will prompt reflections

and activities for the families. *This scenario demonstrates Principle 4 (Connected and Collective/Collaborative Family Experiences) by using light to communicate mood and create moments for families to know where each other is at each day. The opportunity to show family moods and prompt reflection and activities creates shared communication opportunities.*

## A.5 Family 5 with the irritating robot vacuum

(1) **Scenario 1**: The vacuum is automated and often works on its own, which can be unpredictable for children and makes them feel scared. For instance, a child might be napping in their room when the vacuum suddenly enters through the door. Or on a school day when the child gets sick and can't go to school, the child might be playing on the floor next to the couch while their mom is in her office doing emails. At 10:15 AM, while the child is playing in the corner of the living room, the robot vacuum suddenly approaches. In the child's mind, the vacuum is like a random monster that is unpredictable and annoying. This child doesn't understand how it works, when it decides to operate, and the child hates being around it. *This scenario demonstrates Principle 1 (Safety, Privacy, and Protection) and Principle 5 (Adaptive and Predictable Systems) because the vacuum doesn't make the child feel safe to be around, and it lacks situational awareness of a child's presence.*

## A.6 Family 6 with a cool fridge

(1) **Scenario 1**: The inside of the fridge has a camera to scan food and identify what you have, which can be integrated for grocery shopping lists or cooking recipe recommendations. The opening and closing sensor tracks who took what food from the fridge and builds data summaries linked to each member's health data. The child can input what they want from the grocery store on the fridge to communicate with the parents. *This scenario demonstrates Principle 2 (Learning and Empowered Participation), Principle 3 (Inclusive, Accessible, and Customizable Interaction Design), and Principle 5 (Adaptive and Predictable Systems). Children use the fridge to communicate grocery needs with parents, and the fridge is adaptive to the family's other data sources.*

(2) **Scenario 2**: The display on the fridge serves as the hub for information exchange among family members because of its convenient location. The smart fridge display often prompts family members to leave notes for each other. For instance, when the child opens the fridge door to get milk in the evening, the fridge prompts, "What would you like to plan for your family to do together this weekend?" or "What are three things you are grateful for today?" *This scenario demonstrates Principle 2 (Learning and Empowered Participation), Principle 3 (Inclusive, Accessible, and Customizable Interaction Design), and Principle 4 (Connected and Collective/Collaborative Family Experiences). Children can easily use this feature, creating shared experiences and opportunities to care for each other, similar to the Animal Crossing game message board where animals on the island exchange information that everyone can see.*

(3) **Scenario 3**: The fridge initiates cooking games for parents and children to create shared involvement and prompt families to spend time together. Like Duolingo, where you learn about language, the fridge display teaches children about cooking and related information in bite-sized segments and activities based on what food is available in the fridge. The fridge also prompts parents about how stressful they find cooking together with their child. If it's too stressful for the parent, the fridge takes that into consideration and helps manage the child's participation. *This scenario demonstrates Principle 2 (Learning and Empowered Participation), Principle 4 (Connected and Collective/Collaborative Family Experiences), and Principle 5 (Adaptive and Predictable Systems). Cooking can be an important part of family life, and children's involvement promotes learning, household skill practice, confidence, etc. Children get to participate, learn, and create shared experiences with family members. The fridge is aware of the current grocery situation at home to suggest what to cook rather than creating stress about buying new ingredients to start cooking.*

## A.7 Family 7's smart display is a central commander

(1) **Scenario 1**: Smart speakers/displays are utilized frequently by children. A scenario shows two children asking the smart speaker for weather, schedule information, looking up information, and watching videos. The goal here is to show that each child wants to command the device for individual requests, ignoring collective use, and the smart speaker can't figure out which child to respond to. It's also difficult for parents to step in and help mediate the situation. A potential design mechanism is that when the device detects multiple command requests from multiple family members, a negotiation check-in mode is activated: "I sensed that a few people in the family want to do different things. How about we take turns and each get 5 minutes?" *This scenario demonstrates Principle 2 (Learning and Empowered Participation), Principle 3 (Inclusive, Accessible, and Customizable Interaction Design), and Principle 4 (Connected and Collective/Collaborative Family Experiences). The smart home control center serves as the place for navigating shared and individual use, and when conflicting moments appear, the smart speaker helps mediate the situation.*

(2) **Scenario 2**: A child's smart home control dashboard lives on the smart display (also on the child's iPad since it's a smart home app). Children have the power to control and access smart home actions that could affect other people, such as turning on other people's room lights, turning on speakers, unlocking doors, and switching scenes. Every time the child does something, the control system recognizes that it's the child who is about to make a change and reminds them that their actions would influence other family members' experiences. This creates an opportunity for promoting shared care, duty, and responsibilities among household members. *This scenario demonstrates Principle 2 (Learning and Empowered Participation) and Principle 4 (Connected and Collective/Collaborative Family Experiences). The smart home*

*control center serves as the place for navigating shared and individual use, reminding children about shared use and that children's smart home actions could affect other family members.*

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