Towards Smart Rooms for Children: Mapping Children's Needs in the Context of Their Bedrooms in the IoT Era

Hadas Erel
Media Innovation Lab (miLAB)
School of Communications
Interdisciplinary Center
Herzliya, Israel
hadas.erel@milab.idc.ac.il

Nadav Viduchinsky
Media Innovation Lab (miLAB)
School of Communications
Interdisciplinary Center
Herzliya, Israel
nadav.viduchinsky@milab.idc.ac.il

Oren Zuckerman
Media Innovation Lab (miLAB)
School of Communications
Interdisciplinary Center
Herzliya, Israel
orenz@idc.ac.il

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Abstract
Children's bedrooms are private spaces for identity exploration and self-expression, defined in literature as "bedroom culture". With the rise of smart-home and Internet of Things (IoT) technologies, comes a great opportunity to create a "digital bedroom culture" that captures the rich meaning that bedrooms can have in children's lives. To properly understand how children perceive their bedrooms, and how they think smart-home technologies can be integrated into their rooms, we conducted interviews with 17 children in the context of their bedrooms. Using thematic coding, we mapped children's needs related to their bedroom into Emotional and Practical themes. When discussing "smart-room" technologies, children strongly associated them with practical needs and much less with emotional ones. We argue that smart-home and IoT designers should consider this gap and explore the possibilities of designing IoT technologies that will augment children's emotional needs in the context of their bedroom.

Author Keywords
Children; Smart Home; IoT; Bedroom; Qualitative Study

CCS Concepts
•**Human-centered computing** → *HCI theory, concepts and models;*

Introduction

The amount of time children spend in their bedrooms is dramatically increasing in recent decades [4]. Changes related to family size and private spaces in the home have redefined the bedroom as a private and safe environment that enables self-exploration and self-expression [4, 8], also known as bedroom culture [8].

Media and technology play an increasingly significant role in children's bedroom culture, as rooms are becoming media-rich [2, 8]. The bedroom is where media and identity intersect, providing contexts of identity exploration and self-expression for media use [4]. Internet of Things (IoT) and smart-home technologies are predicted to soon be abundant in homes, holding the potential to expand the ways children express themselves and develop their identity [9].

Related Work

HCI research in the context of enriching children's rooms can be classified into three categories: augmenting the room's space with digital experiences, construction kits for exploring technological processes within the child's room, and cloud-connected toys.

In the context of augmenting a room with digital experiences, two projects used screens in order to create an interactive experience. The 1997 MIT "KidsRoom" project, transformed a lab space into an interactive adventure story for children [3]. The "Smart Wallpaper" project created a digital hide and seek game using the room's walls [7].

Construction kits designed to promote learning through hands-on exploration can also enrich a child's room. One example is the "SmartTiles" project, programmable tiles that visualize dynamic behavior using light. The work's main focus is teaching programmable dynamic behavior, and the children's room was suggested as one potential use-case [6]. In addition, there are many commercial kits for designing technology-focused IoT experiences, including the Evive IoT Kit, SAM Labs, and more. These kits are not designed specifically for children's rooms, but children can use them within the context of their rooms.

Another commercial trend is cloud-connected toys or IoToys (internet of toys) predicted to become common in children's rooms. Leading examples are Hello Barbie, Smart Toy Bear, and CogniToys Dino [10]. Such technologies are exciting, yet presenting security and privacy challenges [10].

The technologies mentioned above can enrich children's rooms but do not specifically address children's bedroom culture. In this study, we present a qualitative analysis of children's reflections about their room's meaning, and ideas for using IoT technologies in the context of their room.

Method

We conducted a qualitative evaluation study with 17 children in the context of their room. The interview involved two main aspects: (1) the meaning children assign to their room; (2) children's reflections and ideas for integrating smart-home technologies in their room.

Participants

Seventeen children were interviewed (10 Male and 7 Female, age range 9-12, Mean = 10.58, SD = 0.79). Children were recruited from a local coding event, and through personal acquaintances with the researchers. We followed ethical guidelines including IRB, parental consent, children's consent, and Read's (2015) guidelines for research with children [11]. The children's rooms varied between a private room (P; 10/17 children), a shared room with another sibling (S; 5/17 children), and both types of rooms in two homes (PS; due to divorced parents, a private room in one house and a shared room in the other, 2/17 children). This

Figure 1: A child describing the activities he likes to perform in his room at the room's-meaning interview. Photographed with permission.

variance in children's rooms allows for identifying repeating patterns in all bedroom types. Most children had a basic understanding of smart-home technologies (e.g. they were familiar with Alexa, Google Home, etc.), and few children were also able to describe basic processes related to smart-homes (e.g. they gave examples for automatic processes controlling different aspects of the home environment).

Procedure

The interviews were 1.5 hours long, with one child at a time, in the child's room. Children were told that they could stop the interview at any time without any implications and that their personal information will not be shared with anyone. Each session began with a short conversation (approximately 10 minutes) about the child's routine and hobbies to create a relaxed atmosphere, followed by a room's-meaning interview and a technology-photos interview. In most interviews, children's engagement level increased gradually and they were excited to share their perception of their room, and their ideas for using technologies. In the post-activity interview, all children reported they enjoyed the activity.

Phase 1: Room's-meaning Interview

The room's-meaning semi-structured interview was designed to provide an understanding of the rooms meaning from the child's point-of-view (see Figure 1). Children were asked 7 open-ended questions about the room's function and meaning including: "In general, what does your room mean to you?", "What are the main activities you like to do in your room?" (See supplementary material for all questions).

Phase 2: Technology-photos Interview

The technology-photos interview was designed to elicit children's reflections regarding smart-home technologies for their room. Photos were introduced one at a time representing basic categories of smart-home technologies: (1) Inputs (e.g. smart microphone and light sensors), (2) Outputs (e.g. LEDs screen and speakers) and (3) Actuators (e.g. gears and motors). The technologies were presented without any context. Each category was represented by several photos. Children's ability to understand the photos was validated in a pilot with two children and resulted in 13 validated photos (see supplementary material). The researcher gave a short description for each technology and children were asked to come up with ideas for possible applications of that technology in their "smart-room". For example, the researcher showed a photo of a microphone and said: "Let's imagine this is a smart microphone that can understand everything you say and can perform your instructions, how would you use it?". Motors and gears were harder to understand and required additional explanation (see Figure 2).

Analysis

The qualitative data was analyzed using Thematic Coding [5], involving four stages. First, responses were transcribed and read several times, 1558 quotes were divided into two distinct datasets, 651 quotes concerning the room's meaning, and 907 quotes concerning children's ideas for "smart-room" technologies. Second, two individual raters reviewed all transcripts independently and identified initial themes, inconsistencies were discussed until resolved. Third, the two raters analyzed a selection of the data independently, inter-rater reliability was verified (Kappa = 88%). Fourth, the two raters analyzed the rest of the data according to the mutually agreed themes.

Findings

The analysis resulted in two high-level themes reflecting children's needs in the context of their bedroom: (1) emotional needs, and (2) practical needs. The themes were evident in both the room's-meaning interview and the technology-

Figure 2: A child suggesting ideas on how a “smart camera” could be used in his room, during the technology-photos interview. Photographed with permission.

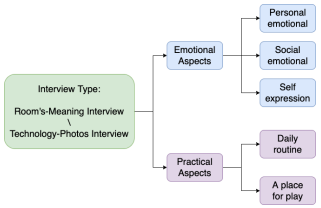

Figure 3: Qualitative analysis: themes and sub-themes

photos interview (See Figure 3). Children’s quotes are presented with their gender (F/M), age, and room type (P-private/S-shared/PS-both).

Room’s-meaning interview

All children (17/17) discussed both emotional and practical aspects of their room (56.6% and 43.4% of children’s quotes, respectively, see Figure 4).

Emotional aspects

All children (17/17) frequently mentioned emotional aspects (56.6%, averaged across children, sd=0.16). These aspects were discussed in a personal, social, or self-expression context, detailed below.

Personal-emotional. All children (17/17) described their room as a secure, intimate, and private place. They used words such as “my own”, “private”, and “safe”: “I like that the room is just mine, other things in the house are shared by everyone, but my room is just mine, I feel safe here” (p.12, F11P). Children perceived their room as an intimate space, where they are free to show their true selves: “My room is my private place, I can be who I am, it reveals me as a person without any masks” (p.8, M11P). Some also mentioned emotion regulation: “When I’m sad, I come here, here I have my things that comfort me” (p.5, F10PS).

Social-emotional. Most children (14/17) described their room as a place for having a meaningful interaction with friends and family: “When a friend comes over, we can have a heart-to-heart conversation in my room, this is the place to talk about what’s really going on” (p.8, M11P). Children wanted their parents’ presence in the room when they needed comfort and encouragement: “When I’m sad, I want them to come into my room, and comfort me” (p.12, F11P).

Self-expression. 10/17 children described their room as a space that they can use for expressing themselves, their style and taste: “The room is meaningful to me because I can design it as I wish” (p.13, M11P).

Practical aspects

All children (17/17) also associated their room with practical aspects (43.4%, averaged across children, sd=0.16). Children’s responses were divided to "daily routine" and “a place for play”.

Daily routine. All children (17/17) mentioned routine activities including sleeping, doing homework, and watching TV: “My room is a place to sleep in, to play in and to work in” (p.3, M9S). Children explicitly stated that these activities are practical: “I get dressed here, it’s not something I like or don’t like, I just do it here” (p.16, F11S).

A place for play. All children (17/17) mentioned playing activities including “jumping on the bed”, “playing on the computer or a console game”, “puzzles”, and “board games”: “Sometimes I play on my new computer and sometimes I like playing with my dolls” (p.4, F11PS). Children also mentioned play in a social context: “I love being with my sister here, we usually speak and play here, jumping from bed to bed” (p.6, M10S).

Technology-photos interview

In the technology-photos interview, all children (17/17) mentioned both emotional and practical uses for “smart-room” technologies. However, practical uses were substantially more dominant in children’s responses (74.3% of children’s quotes), while emotional uses were much less frequent (25.7% of children’s quotes).

Emotional aspects

All children (17/17) suggested both personal-emotional and social-emotional uses for “smart-room” technologies, how-

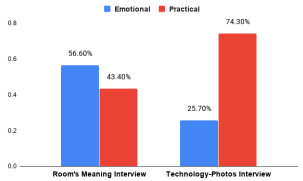

Figure 4: The percentage of children's suggestions for "smart-room" technologies associated with practical, and emotional use-cases.

ever, these aspects were much less dominant and comprised only 25.7% of children's quotes in the technology-photos interview (averaged across children, sd=0.11).

Personal-emotional. 17/17 children suggested uses in a personal-emotional context, for example: "The camera will identify when I am sad according to my facial expression and will provide comforting words to relieve my sadness" (p.2, F11P).

Social-emotional. 12/17 children suggested uses related to social interactions with others, for example with parents: "In case of emergency, like when a bug enters my room, the camera will notify my parents and will reach them even if their phone is on silent mode or if they are on another call" (p.2, F11P). Some suggested enhancing co-located social interaction: "If someone is entering the room, it will greet him and say hello" (p.7, F10S).

Self-expression. 14/17 mentioned self-expression uses. For example, children wanted the technology to adjust the room's design to their preferred style: "The color sensor will sense my shirt's color, and will change the light accordingly" (p.8, M11P).

Practical aspects

Practical uses were highly dominant in all children's suggestions and comprised 74.3% of children's quotes in the technology-photos interview (averaged across children, sd=0.11). As in the rooms-meaning interview, children associated their ideas with "daily routine" and "room as a place for play".

Daily routine. 17/17 children suggested uses for daily activities, including changing the room temperature, turning on lights, and organizing the room: "The machine will clean the room when it's messy" (p.13, M11P). They also suggested that technology will control the media in their room: "I will activate the TV with the microphone, I will tell the microphone to play a video, and it will be played on TV" (p.9, M10S).

A place for play. 15/17 children suggested uses for play and games, including physical and digital games: "I have a can that I like to place in different locations around the room. I try to hit it with a rubber band. I can use the motor to rotate the can, making the game more challenging" (p.11, M11P).

Discussion

When children discussed the meaning of their room, they mentioned both emotional and practical aspects. The emotional aspects were closely related to bedroom culture. Children perceived their room as a safe space that provides privacy, and allows for identity exploration, emotion regulation, and self-expression [4, 8]. They described the room as a space where they can show their true selves and perform activities that represent who they are. The practical aspects were related to daily routines (sleeping or doing homework) and play activities (computer games or board games).

When children discussed smart-home technologies for their bedroom, a different pattern emerged. Practical use-cases were much more dominant, (e.g. turning on the light or cleaning the room) than emotional use-cases (e.g. technology for sensing emotional state or supporting meaningful communication with others). The low frequency of the emotional use-cases for smart-home technologies indicates that children do not naturally associate IoT devices with the bedroom culture. However, all children were able to come up with at least one idea for an emotional use-case, suggesting that the low frequency can be related to the common use-cases of existing IoT technologies that are typically designed for making everyday life more convenient [1]. Chil-

dren's familiarity with these technologies may have biased their ideas for possible use-cases.

Our findings indicate a gap between children's needs as reflected in the "bedroom culture" and the way children imagine familiar smart-home technologies in their rooms. While both practical and emotional aspects were dominant in children's descriptions of their room's meaning, the practical aspects were significantly more dominant when they discussed technologies for their room. This finding indicates a difference between IoT technologies, and other digital technologies such as TV and computer, known to enhance the bedroom culture [8]. While this gap should be further explored, an initial insight implied by our findings concerns children's ability to suggest at least one personally-meaningful emotional use-case for "smart-room" technologies. Based on this insight, we encourage interaction designers and HCI researchers to explore the potential of addressing children's emotional needs in a "digital bedroom culture", by promoting emotional use-cases over the existing practical ones.

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