



Co-designing Magic Machines for Everyday Mindfulness with Practitioners

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ABSTRACT

Many digital technologies have been invented to support mindfulness, the practice of bringing attention to the present moment without judgment. While most technologies focus on mindfulness meditation training for novices, in this paper, we explore designing technology to support everyday mindfulness activities for people with varying levels of experience. Through 9 magic machine workshops, 30 mindfulness practitioners explored and reflected on their personal experiences of everyday mindfulness, and generated designs that support their daily practice. Our findings identified six categories of designs conceptualized by our participants: everyday objects, physical spaces, wearables, metaphorical art, companions, and toys. We further analyze the practitioners' thought processes and considerations for designs that support everyday mindfulness, such as eliciting and regulating emotion and associating mindfulness with routine daily activities. Finally, we discuss the implications of designing individualized mindfulness products and the potential of using co-design magic machine workshops to explore a practical design space.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**.

KEYWORDS

Mindfulness, meditation, magic machine, co-design, well-being, mindfulness technology, everyday mindfulness

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1 INTRODUCTION

Mindfulness, a practice of bringing attention to the present moment without judgment [33], has many physical and mental benefits, such as reduced chronic pain, reduced stress and anxiety, and improved emotion regulation when practiced consistently [11]. These well-being benefits have driven the implementation of mindfulness interventions, e.g., Mindfulness-Based Stress Reduction/MBSR programs, and technologies, e.g., mobile meditation apps, immersive virtual reality environments, and wearables.

Mindfulness can be practiced in both formal and informal ways. While formal mindfulness practice (e.g., sitting meditation) is considered a more rigorous and dedicated contemplative practice, informal practice (e.g., a quick breathing exercise) has the advantage of being more flexible and easier to be integrated into one's daily routine [7, 29, 42, 43]. In our research, we focused on exploring the potential of future technologies for mindfulness in everyday life, including formal and informal practices, as they both contribute to one's mental well-being. Our goal is to explore how future technology can support mindfulness as an ongoing personal journey that considers individuals' prior experiences, wishes, and context of use, toward informing the design of mindfulness products. With a broad view of mindfulness technologies as tools and objects that support mindfulness in various forms, modalities, and scenarios, we hope to inform the design of more effective and personalized mindfulness products. We use the term *practitioners* to refer to individuals who practice mindfulness in various forms.

Specifically, our research is guided by the following questions:

- (1) What is the design space for everyday mindfulness products from practitioners' perspectives?
- (2) What are the practitioners' thought processes and considerations for designs that support mindfulness?

To address these questions, we developed a co-design workshop protocol that applies *magic machines* [4], a technique that encourages participants to bring their own creativity and personal knowledge into designing imaginative technology using simple craft materials. We conducted 9 workshops with 30 mindfulness practitioners, from novices to experts, to collaboratively explore how future technology can support mindfulness in daily activities.

In our findings, we identified six broad categories of designs that our participants imagined being part of their everyday lives for mindfulness: everyday objects, physical spaces, wearables, metaphorical art, companions, and toys. The design thinking process of

mindfulness practitioners was further analyzed to propose a set of design considerations for personalized everyday mindfulness products, including applying best practices, designing for eliciting and regulating emotion, incorporating mindfulness in everyday life activities, and considering design trade-offs.

Our research contributes to HCI by providing a thorough analysis of the design space and design decisions from the unique perspective of mindfulness practitioners, toward designing products that support mindfulness in everyday activities. The breadth of the design space leads to a more creative, flexible, and practitioner-centered approach to designing for mindfulness. Additionally, our research highlights the potential of using co-design magic machine workshop protocol as an effective tool to explore a practical design space. By centering the knowledge and experiences of mindfulness practitioners, we contribute to a more nuanced understanding of designing technologies that cater to diverse and individual mindfulness needs.

2 RELATED WORK

In this section, we review the conceptualization of mindfulness and highlight the importance of considering practitioners' interpretation of mindfulness for their mental well-being practice. We then analyze current technologies to support mindfulness and discuss their affordances and limitations in supporting everyday mindfulness practice. Lastly, we review the adoption of the co-design method in mindfulness research and its potential to facilitate a personalized mindfulness journey.

2.1 Mindfulness practice

Rooted in the spiritual Buddhist tradition of over 2000 years, mindfulness has been adopted in the West for therapeutic purposes, to improve an individual's physical and mental well-being by reducing chronic pain, stress and anxiety, and improving emotion regulation [11]. Mindfulness has also been operationalized for psychology research purposes [9] as (1) self-regulation of one's attention to the present moment, with (2) orientation of curiosity, openness, and acceptance to this present experience. Mindfulness can be viewed as a practice, a state, or a trait [35]. In this work, we adopt the widely used definition of *mindfulness* as "paying attention to the present moment without judgment" [33] and *mindfulness practice* as a set of mental exercises to achieve the state of mindfulness, by bringing awareness to the present moment with an open and non-judgmental orientation [35]. We complement these definitions with individuals' interpretations of what mindfulness is and how they practice it, referring to these individuals as *mindfulness practitioners*.

Mindfulness researchers have developed and evaluated the effectiveness of mindfulness interventions on stress reduction and increased well-being in various forms, duration and in a range of populations [18]. One example is the popular Mindfulness-Based Stress Reduction (MBSR), an 8-week mindfulness training program [8]. Interventions typically consist of group sessions accompanied by home practice, resulting in benefits to an individual's mental well-being [11, 67]. However, when the intervention is over, adherence to a mindfulness practice routine over time can be challenging, and failing to continue the practice results in a gradual diminishing of the benefits [58].

Mindfulness practice commonly includes *formal* meditation practice such as dedicated breathing exercises and body scan meditation and *informal* practice of bringing mindful awareness into daily activities. Prior work has shown that, alongside formal mindfulness meditation, informal practice such as mindful dishwashing has the potential to cultivate mindfulness and bring mental well-being benefits [29]. Informal mindfulness activities may allow novices to experience the benefits of mindfulness and increase the motivation to do more formal practice [67], and provide experienced practitioners a flexible form to maintain their practice [46].

In this paper, we consider how practitioners incorporate mindfulness in their everyday activities, including both their formal and informal practice. We allow practitioners to follow their own definitions of mindfulness, consider their goals, experiences, informal and formal practice, and the benefits and barriers they face in keeping consistent mindfulness, to support a meaningful ongoing mindfulness journey.

2.2 Mindfulness technology

A growing interest in HCI research and the industry to support mindfulness practice has seen mindfulness as a tool to obtain health outcomes, as a goal, or as a way of living [72]. While these categories are not mutually exclusive (e.g., one can strive to adopt a mindful lifestyle and practice mindfulness for relaxation or quality sleep), they can help position mindfulness in technology design.

One kind of mindfulness technology aims to detect a user state and deliver timely mindfulness interventions through different modalities (e.g. audio, visual, haptics) [16, 50, 56, 60, 65]. Accurate detection of the users' state of mind, such as when they are being mindful or mind-wandering, is a difficult technical problem and the physiological signals may be different from people's subjective feelings [40]. In a related field, affective computing [55], computational systems are developed to recognize, interpret, simulate, and respond to human emotions. These technologies share similarities with mindfulness technologies with the aim to help users recognize their emotions, evoke specific emotional states, or manage their emotions through mindfulness activities [62]. For example, Mood-Light [47] is a playful system that employs ambient colored lighting to provide feedback on an individual's current arousal levels, with the goal of helping users monitor their internal emotional states and foster relaxation.

Another, more popular kind of mindfulness technology focuses on providing guided mindfulness sessions through websites [38], commercial mobile applications (e.g., Calm, Headspace, Insight Timer), and immersive virtual reality environments [25]. These technologies provide rich resources to guide users, mostly novices, to do certain types of meditation [44]. Studies have shown that novices were able to fit the use of mobile mindfulness apps in their busy lifestyles [39] and achieved the mental well-being benefits of the guided meditations they offered [80]. However, we have limited understanding of the degree to which these technologies can support people beyond the learning stage to practice mindfulness without guidance or to adopt and use these technologies for informal practice in their everyday life.

Further, while mindfulness meditation is an important part of mindfulness, other aspects of mindfulness, such as personal goals

for the mindfulness practice, applications to daily life, and long-term habit-building of mindfulness, are often overlooked due to the complexity of real-life context and vast individual differences. Akama et al. [1, 2], reflecting on their own mindfulness practice and use of technology in everyday life, brought up that technology will be only useful for supporting mindfulness if individuals are inclined to be mindful. Besides researchers' first-person experience of mindfulness, only a few technologies were designed to support mindfulness in everyday life, for example, "MindPhone" [71], a mobile app that prompts writing reflections and mental check-ins to decrease absentminded phone use and increase real-world presence. Similarly, Choi et al. [14] developed a mobile pneumatic-haptic feedback device that provides personalized tactile feedback to guide slow breathing during daily tasks. Beyond mobile devices, Rheden et al. [75] redesigned kitchen blenders to elicit mindful engagement with the blenders, following the principles of slow technology to support "reflection and moments of mental rest" [28].

In this paper, we explore how practitioners with different levels of mindfulness experience imagine what these technologies might be and how they might bring mindfulness into their daily lives. We hope that our participants' imagination and the insights we draw from them could inspire designers to generate completely new mindfulness technologies or different combinations of these existing technologies.

2.3 Co-design in mindfulness research

Mindfulness HCI research has primarily focused on designing (e.g., [60]) and evaluating (e.g., [19]) technologies to support meditation from the designers' and researchers' perspectives. While most work has incorporated user-centered approaches to better understand users' perspectives on meditation technologies and practices, few have fully embraced the potential of participatory design, which actively involves mindfulness practitioners in the design process. This involvement is particularly important considering the abstract and personal nature of mindfulness practice experiences [27]. Only a few efforts actively involved mindfulness practitioners in the design process [16, 20, 73, 79].

Our study adopted co-design, a methodological approach to involve "the creativity of designers and non-designers in the design development process" [63]. This approach transforms the role of users in traditional HCI research and design from passive objects of a study (e.g., participants in a survey, interview, or usability test) to active co-designers who apply their experience and creativity to create design solutions for themselves. Co-design methods typically apply workshop techniques [64] that encourage users' active participation in the design-making process, respecting their opinions and skills. This co-design approach is particularly beneficial for designing mindfulness technologies, as it facilitates a collaborative environment where mindfulness practitioners can actively contribute their personal and unique insights, experiences, and allows them to tailor designs to their specific needs.

Co-design workshops can be combined with other human-centered design methods depending on the goal of the research, such as the first-person method and somaesthetics [30]. For example, Cochrane et al. [16] conducted workshops with meditators with different levels of experience to explore their first-person experience in walking

meditation with EEG soundscapes. Zhu et al. [79] conducted a one-week design workshop with HCI researchers, designers, and students with a design background to explore how to design for digital mindfulness. It's worth noting that the mindfulness experiences of participants in these co-design workshops have varied, from recruiting all novices [76], all experts [20], or a mix of novices and experts [16]. Although involving novices in designing mindfulness technology can be insightful as they may need the support most, mindfulness is a practice-based technique and requires participants to have some level of practice experience in order to provide deep insights and reflection. With that in mind, in our research, we involve participants with a range of mindfulness experiences and levels of practice.

For the purpose of our research, we found the magic machine technique [4] to be the most appropriate form of co-design workshop. For example, Daudén et al. [20] conducted magic machine workshops with meditation experts to explore bodily sensations during meditation. The magic machine workshop is different from a traditional co-design workshop for its strong personal focus and the diverse, open, playful, and intuitive design outcomes it generates. Described as an "open-ended making to engage participants in the imagination of new things" [4], magic machines are used to explore abstract concepts and support individual visions in producing unique and meaningful design solutions. In this sense, magic machine workshops borrow from and combine elements from speculative design and design fictions [23], by allowing participants to explore imaginary future possibilities [10]. However, the focus of speculative design and design fiction is on critical reflection and future scenarios without necessarily involving users in the creation process. In contrast, magic machine workshops actively involve users, empowering them to contribute their unique perspectives and experiences.

In designing everyday mindfulness technologies, a co-design workshop that applies the magic machine protocol has the potential to encourage mindfulness practitioners to tap into their experiences, knowledge, and creativity to design mindfulness products for themselves.

3 METHOD

From May to July, 2022, we conducted 9 co-design workshops to bring mindfulness practitioners together, with the purpose of exploring and reflecting on personal experiences of everyday mindfulness, and to generate designs that could inspire technologies to support mindfulness in daily activities. The design of our workshops was inspired by Andersen's magic machine protocol [4], a technique that encourages participants to bring their own creativity and personal knowledge into the design, critically reflect on everyday mindfulness, and "*develop radically personal visions of a potential novel technological thing*". This technique combines aspects of various design techniques, such as future envisioning in speculative design [10, 23], and the physicality of embodied design [77], but distinguishes itself by emphasizing active user involvement, open-ended making, playfulness, and personal visions, which is ideal to explore the abstract, personal and bodily-based mindfulness experience.



Figure 1: Craft materials used for the magic machines

3.1 Participants

We used flyers, word of mouth, email lists of local wellness and meditation centers, and snowball sampling to recruit mindfulness practitioners. Participants signed up to participate through a Qualtrics form, which asked for their availability, how long have they practiced mindfulness, the frequency and forms of their practice, and their age group and gender.

A total of 30 participants (21 female, 8 male, 1 non-binary), ranged in age from 18-64, ethnicities (15 White, 13 Asian, 2 African American), and occupations (undergraduate and graduate students, university faculty and staff, mindfulness teachers, service workers, and more) participated. Their mindfulness experience came from a variety of traditions, and ranged from novices (e.g., 3 months of meditation class) to very experienced (e.g., 40 years of daily meditation practice). An overview of the participants' demographics is presented in Table 1. Each participant was compensated with a \$40 Amazon gift card.

3.2 Workshop procedure and protocol

We scheduled 2-hour workshop sessions in late afternoons and evenings and provided snacks. To each workshop we invited 2-4 practitioners across a range of mindfulness experiences, to allow the exchange of views and ideas related to forming and maintaining habits of mindfulness practice. Three members of the research team were present in each workshop: the first author, an experienced mindfulness practitioner, who served as the main facilitator, and two assistants who helped with the workshop logistics, observed, took notes, and answered clarification questions.

We started by obtaining written informed consent from the participants. We then had a 3-minute mindfulness breathing space exercise to bring participants to the present moment. We followed

by a round of introductions where each participant and researcher shared one favorite mindfulness exercise, which served as an ice-breaker. The main part of the workshop consisted of five parts, with instructions provided by the facilitator and in a workbook that was distributed to participants. Participants' workbook can be accessed here: <https://osf.io/s542d/>

Part 1. Writing reflections and discussion: Participants wrote responses to a list of open-ended prompts. These prompts include their own definition of mindfulness, informal and formal practices they do, benefits and barriers they encountered during their practice, their daily schedule, and whether and how they practice mindfulness in these activities. The purpose was to reflect on their personal experiences with mindfulness, critically examine its role in their daily lives, and provide a valuable record to refer back to in the following parts. After writing, participants shared their responses with a partner. (25 min)

Part 2. Brainstorming and affinity diagramming: After sharing, participants individually brainstormed at least 10 ideas to support mindfulness in their daily life that would be useful for their practice, jotting down each idea on one post-it note. Then, working together with the facilitators, the participants organized everyone's ideas on a whiteboard using the affinity diagramming technique. (20 min)

Part 3. Crafting magic machines: Participants then had a choice of working individually or in pairs to craft a magic machine for their mindfulness activities. We offered them craft supplies with various textures and colors, including colorful cardstock paper, pipe cleaners, playdoh, fabric, fluffy pom-pom balls, beads, strings, foil, and markers, as well as tools such as scissors, glue, paper clips, stapler, and adhesive tape. We emphasized two points: (1) Design for yourself, "*something that you would use yourself every day*", and not for the general public, to avoid a mindset of profit-based or

Table 1: An overview of workshop participants' demographics and the magic machines they created

Workshop	Pseudonym	Years of Practice	Gender	Age Range	Occupation	Magic machines
1	Lisa	15	F	55-64	Therapist	Mindful Fish Pond
	Monika	2	F	25-34	Graduate student	
	Jasmine	15	F	45-54	English teacher	Magic Bracelet
	Rachel	2-3, on and off	F	18-24	College student	
2	Morgan	1.5	F	18-24	College student	Magic Mirror
	Christy	1.5	F	18-24	College student	
	Ami	5	F	18-24	College student	Magic Pet
	Jennifer	Years, on and off	F	18-24	Graduate student	
3	Mike	20+	M	35-44	Mindfulness teacher	Mindful Mug
	Michelle	1	F	18-24	College student	Mindful Water Bottle
	Iris	3	F	18-24	College student	Mindfulness Clock
	Irvine	A few months	M	18-24	College student	
4	Mia	2	F	18-24	College student	VR Goggles
	Kate	1.5	F	18-24	College student	
	Aiden	4	M	25-34	Freelancer	Rosary Bead Bracelet
	Colten	12	M	35-44	College staff	
5	Ellie	10+	F	55-64	Mindfulness Teacher	Mindful Necklace + Wristband Kit
	Jeremy	9	M	25-34	Barista	Slow coffee
6	Lucy	2	N	18-24	College student	Mr. Stuart
	Bella	7	F	18-24	College student	Self-care Bed
	Sammy	6	F	18-24	Graduate student	Circle of Life
7	Carol	3	F	25-34	Graduate student	Magic Yoga Mat
	Collin	3	M	18-24	College student	Mindfulness Figurine
	Sandy	4	F	35-44	University professor	Mindful Glasses
	Elsie	6, on and off	F	55-64	College staff	Magic Pattern
8	Joan	2	F	25-34	Librarian	Pocket Couch
	Nathan	4	M	35-44	Janitor	
9	Karen	10+	F	45-54	University professor	Finger Lakes Relaxation
	Vincent	3 months	M	18-24	Graduate student	Sean the Talking Cat
	Stella	2	F	25-34	Graduate student	Massage Yoga Mat

replicating existing designs; and (2) We defined magic machines as "*an object with imaginative features*", to emphasize that their design doesn't need to be technically or practically feasible. (30 min)

Part 4. Presentations: Once done crafting, participants presented their magic machines to other attendees. They were asked to describe their creations, explain why they chose to use particular materials, and the feelings and functionalities they tried to convey. This was often accompanied by personal stories of their experiences with mindfulness and how their design fit in. Facilitators and participants followed up with questions to explore interesting points of the presented artifact. Participants then took a photo of their magic machine and uploaded it to a Google Drive folder. This

self-documentation was intended to support ownership of their magic machines. (15 min)

Part 5. Follow-up individual interviews: Finally, we conducted semi-structured interviews with each participant to get better insights into their magic machine design process and outcome, their interactions with other participants, and feedback on the workshop. (15 min)

3.3 Data collection and analysis

3.3.1 Data collection. With the participants' permission, we audio-recorded group discussions, presentations, and individual interviews, took pictures during the workshop, and wrote observation



Figure 2: Everyday objects: (1) Mindful Mug, a timer-installed mug that chimes a bell to signal undisturbed, mindful coffee-drinking [Mike]; (2) Magic Mirror, a bathroom mirror that gives different mindfulness prompts [Morgan and Christy]; (3) Mindful Water Bottle, a water bottle that requires mindfulness activity completion to drink water [Michelle]; (4) Mindfulness Clock, a clock that displays random mindfulness activities at random times and shows affirmation when the activity is completed [Iris and Irvine]

notes. We transcribed the audio recordings, replacing names with pseudonyms. Faces, if they appeared in photos, were blurred. We also collected participants' writing reflections in the workbooks and transcribed the handwritten content to a digital format.

3.3.2 Data analysis. All five co-authors participated in the data analysis, using the transcripts of writing reflections, presentations, individual interviews, and photos of the magic machines. We followed the guidelines of grounded theory [12] and the inspiration of its application in analyzing artifacts [74] for our data analysis. The analysis process included three phases, which were iterated multiple times until we reached stability in our findings.

Phase 1: we read the transcripts multiple times and generated initial categories such as nature, reflection, connecting, emotional regulation [33], everyday activities, playfulness, material selection, aesthetics, etc. These categories kept evolving as the analysis continued in phases 2 and 3.

Phase 2: we created a grid using a Miro board to organize our data analysis. The horizontal dimension included the categories from Phase 1, and the vertical dimension included the magic machines created by participants. For each magic machine, at least two researchers independently read through the transcripts, and identified excerpts that correspond to the categories. They copy/pasted these text excerpts in the cell that corresponds to the magic machine (row) and the relevant category (column). In this way, we populated the grid with excerpt data from the participants (Link to the grid: <https://osf.io/s542d/>).

Phase 3: we read the excerpts in each column to examine common patterns across the magic machines that are related to the corresponding category and extracted insights about that category. We also examined the board as a whole and grouped similar and related categories to obtain our high-level themes. For example, we grouped together the categories *routine*, *everyday activities*, and *reminders* under a high-level theme *everyday objects*.

4 THE DESIGN SPACE

Our first question asked: *What is the design space for everyday mindfulness products from practitioners' perspectives?*

To answer this question, in our data analysis, we grouped magic machines by goal, primary function, and form factor. This process yielded six broad categories of designs: everyday objects, physical spaces, wearables, metaphorical art, companions, and toys. These categories represent our own interpretative data analysis process of the magic machines and are not absolute or exhaustive. It is also possible that a magic machine could fit into more than one category. For example, the Mindful Glasses could be seen as both a wearable technology and an everyday object; the Magic Yoga Mat and Pocket Couch could be physical spaces and everyday objects; the Mindfulness Figurine could be both a decoration and a companion. In this section, we will present one or two detailed examples from each category and some relevant variations from the other magic machines. Additional examples can be found in the corresponding figures. We hope the breadth of the design space offers a creative, flexible, and practitioner-centered perspective to designing mindfulness products.

4.1 Everyday objects

Some participants decided to incorporate mindfulness into objects they already use in their everyday life (Figure 2), instead of designing a separate object to assist with mindfulness. Here, mindfulness is not an extra activity people need to complete but a concept embedded into one's daily activities and objects they already use in their everyday routine.

For example, Morgan and Christy discussed that they both felt that *"just the fact that you do [mindfulness activities] consciously every day itself feels like an achievement"* [Morgan] and wanted to find a way to incorporate reflection into their daily routines. They decided to design a magic bathroom mirror (Figure 2-2) because *"people center mindfulness around their morning or night routine, and that's where you go to the bathroom"* [Christy]. A bathroom

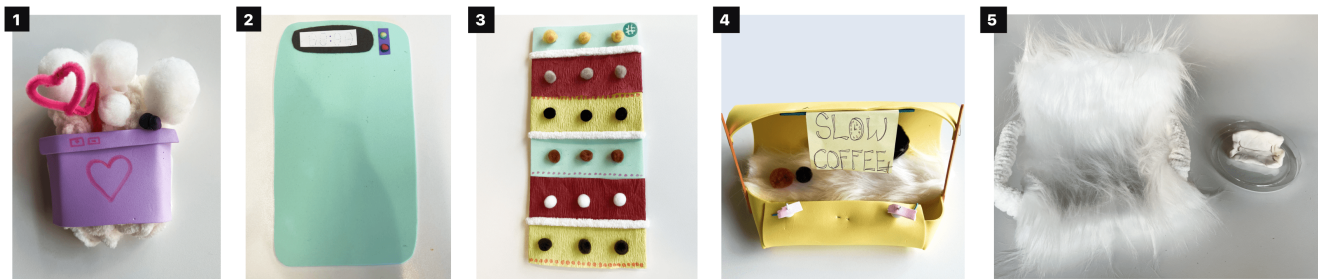


Figure 3: Physical spaces: (1) Self-care Bed, a personalized space for introspection and mindfulness [Bella]; (2) Magic Yoga Mat, a smart yoga mat with a timer to support reflection [Carol]; (3) Massage Yoga Mat, a smart yoga mat with massage balls to help relaxation and timer to aid meditation [Stella]; (4) Slow Coffee, a slow-paced coffee shop that encourages pause and social engagement with comfort [Jeremy]; (5) Pocket Couch, a portable, expandable couch that provides a cozy spot for mindfulness [Joan and Nathan]

is "a place you go often and you look [at] it often [...] it's a mirror in a way it's like you're looking at yourself, thinking about you and you know what's going on your life" [Morgan]. The magic is designed into the mirror in recognizing the person standing in front of it, and projecting on the mirror daily changing textual reflection prompts that serve as "a guide to help you to think of something and reflect on your day" [Morgan]. In this way, a daily morning or night bathroom routine is therefore augmented with a mindfulness activity of engaging with personal reflection every time they look at the mirror. A variation of this is Iris and Irvine's Mindfulness Clock, another everyday object that people look at frequently, which goes off at various times during the day, displaying random mindfulness activities that are personalized for the clock owner and fit with their daily routines.

Another example related to daily morning routines was by Mike, an experienced practitioner, who wanted a simple design that could help him be mindful without distractions from his phone: "without having your phone there, you can have that quiet moment [...] in the morning before you start your day." Mike designed a Mindful Mug (Figure 2-1) with an embedded timer to focus on drinking coffee for a period of time: "so if you wanted to drink your coffee or tea mindfully for five or ten minutes in the morning, you could set the length of time and a number of bells that you want. And when a bell rang, you would take a sip and just place it down and taste, and then just have quiet time after your sip, and then another bell would come and you could either set it to be regular or random." Mike is aware that the timer is a "redundant functionality with phones but [he] likes to get rid of the phone at certain times." Here, a timer added to a mug turns drinking coffee into a routine mindful activity.

A coffee mug, water bottle, bathroom mirror, and clock are all essential functional objects that participants utilize in their everyday lives. Inspired by the ubiquity of these essential objects in their daily routines, participants incorporated mindfulness into them, thus integrating and even unifying their "everyday" with their "mindful" activities.

4.2 Physical spaces

A few participants designed large-scale physical spaces (Figure 3) to transform their everyday physical environment to make it conducive to practicing mindfulness and being more present in this environment. We identified three main transformations of the environment: physical comfort, slow pace, and absence of distractions.

For physical comfort, Joan, a librarian, explained that while she would like to meditate during breaks in her work day, her office chair is uncomfortable for her to sit down and meditate: "when I'm on my lunch break, I wish I had a more comfortable place to be, so that I could take more time to be mindful. But my space isn't very comfortable and my chair isn't." Together with Nathan, she designed the Pocket Couch (Figure 3-5): "it expands so that at any moment if you need to take a break and to be comfortable and to have a place to practice mindfulness, you have a comfortable spot to do that, and you can carry around with you all the time." They focused their design on comfort, through the soft material and the arm rests, and portability, "so you could take it outside and maybe go under a tree," turning every physical space into a "cozy spot" [Joan].

Physical spaces can also offer a slower pace that is more conducive to mindfulness. Jeremy, a barista, designed Slow Coffee (Figure 3-4) as a response to the social and cultural aspects of everyday life. Slow Coffee reflected his inner conflict between his observation of the fast coffee culture and his desire for a slow pace and pause for himself, his customers, and co-workers. He realized that the difficulty for him in practicing mindfulness was that his work environment centered around movement and productivity, "nobody wants to slow down and they're all just sort of annoyed and impatient". He designed a slow-paced coffee shop where people could take a pause, be present in the experience, and communicate with one another: "I think it could be a lot of different things, like physical comfort, the aesthetics of this space, but also the social moment, to acknowledge someone, to be acknowledged, is a great pause. And then, engaging with the beverage and it being made and what that looks like, and sounds like, and feels like. I mean, there's like a lot of noises going on, and a lot of smells and tastes... to me, it's a beautiful place to practice all of our senses and engage and make relationships with those and with other people."



Figure 4: Pictures of wearables: (1) Mindful Glasses, glasses that get words cover the glasses and require mindfulness activities to have clear sight [Sandy]; (2) Rosary Bead Bracelet, a bracelet that works like a fidget spinner to help reduce distraction and relieve anxiety [Aiden and Colten]; (3) Mindful Necklace + Wristband Kit, a personalized, daily reconstructable necklace and wristband kit that has different color beads for achieving different mindfulness goals [Ellie]; (4) Magic Bracelet, a bracelet that senses emotion and returns it with related mindfulness activities in the connected application [Rachel and Jasmine]

Finally, physical spaces can also be designed to remove distractions from the outside to make it easier to practice mindfulness. Carol was inspired by a phone app she uses with *"down-time features [that limit] any social media or email notifications from [...] 10 PM to 9 AM"*, and wanted to integrate this feature into a tranquil space for her mindfulness yoga practice. She designed a Magic Yoga Mat (Figure 3-2) that blocks interruptions from the outside and includes a programmable timer *"in case you just wanted to use this mat for 30 minute or 10-minute meditation, and you could have the timer allow you to do that without trying to open your eyes and look at a clock or something to interrupt your meditation."*

Mindfulness can be practiced everywhere, but not all spaces are conducive to easily doing so. By transforming their spaces in various ways, participants created a more inviting environment for mindfulness practice. This transformation could happen at home, in the office, or when they were out and about.

4.3 Wearables

Participants also designed wearable devices such as necklaces, bracelets, and eyeglasses (Figure 4), with the purpose of reminding, prompting, or facilitating mindfulness practice. Carried on and connected to the body, magic wearables can sense emotions and thoughts and respond with reminders in various modalities (visual, tactile) to support mindfulness activities across different locations. Similar to essential everyday objects, they integrate mindfulness activities with another functionality, in this case, the aesthetic of jewelry or accessories that participants reported wanting to personalize and wear.

Some participants incorporated smart features into their wearables. For example, Rachel and Jasmine designed a Magic Bracelet (Figure 4-4) *"made of a magical metal, which actually senses emotion"* [Jasmine]. The detection of emotion is sent to an app on one's phone, so that *"people would be able to use it on the go"* [Rachel], and the app provides recommendations for how to respond: *"if you're having a specific mood or emotion or intense amount of emotions[...] So in this one we sense that you're currently upset, so it would have this like, 'try this mindfulness exercise in order to calm me down' or*

some recommendations of what you can do, like take a 25-minute nap, be careful about how you project your emotions, or call a loved one. And so in this one, it says we sense that you're currently feeling joyful, spread the joy, compliment a stranger, hug a tree, and pet a puppy. So it will call attention to your emotion and then afterwards, give you some prompts about what you can do in terms of further steps" [Rachel]. Similarly, Sandy's Mindful Glasses read her brainwaves and identify her thoughts (Figure 4-1). These wearables help recognize and reflect on one's emotions or thoughts by displaying them privately to the wearer, in the case of the bracelet in an accompanying phone app, and in the Mindful Glasses as words floating across the lenses. The digital features offer suggestions for mindful activities to respond to one's emotions, or simply *"to settle those thoughts"* [Sandy].

In contrast to smart features, others designed wearables that intentionally excluded digital features that distract from their mindfulness practices. Aidan and Colten discussed the problem of *"too many features. So actually, what you want is something to shut off some of the features. [...] I mean the machine I want to design is something that effectively removes features so it's like an anti-machine. I mean it doesn't do things in reverse. Feature subtraction machine"* [Aidan]. In response, they designed a Rosary Bead Bracelet (Figure 4-2) to fidget around with the beads to quiet one's mind and engage in deep reflection *"like a mindful facilitator"* [Colten]. Similarly, Ellie, referring to herself as a "Luddite," also rejected digital features in her design of the Mindful Necklace + Wristband Kit (Figure 4-3), and instead focused on the hands-on, interactive, and traditional experience of jewelry making. She imagined wearing the bracelet with the beads, and any time during the day she engages in a *"mindfulness break"*, she would take a bead off the wristband and place it on the necklace pendant. The physicality of the design serves as a tangible reminder and facilitator for the practice of mindfulness, as she explained, it's *"having a physical reminder for me, as opposed to time just slipping away."* Aidan, Colten, and Ellie, all recognize the potential of interacting with a non-digital tangible object to support and recognize their mindfulness practice.

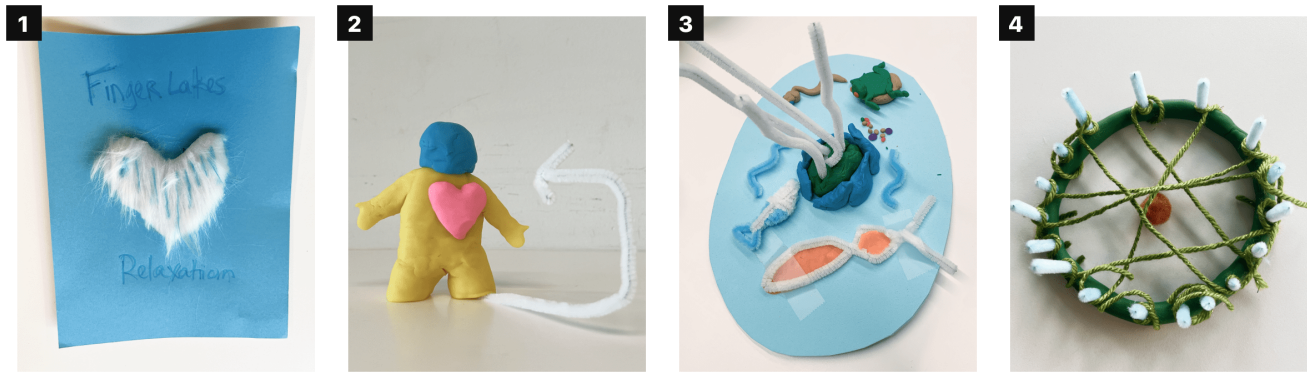


Figure 5: Metaphorical Art: (1) Finger Lakes Relaxation, an interactive wall art piece that helps relaxation through soothing texture [Karen]; (2) Mindfulness Figurine, a figurine that uses colored pieces to remind the user to stay mindful [Collin]; (3) Mindful Fish Pond, a decorative fish pond that grows with the mindfulness progress of the user [Lisa and Monika]; (4) Circle of Life, a visual representation of the user's connection with other mindfulness practitioners [Sammy]

Wearable designs, regardless of intelligence and technical feasibility, are publicly displayed on the body, and as such also serve as expressions of one's aesthetics and personality.

For example, Ellie imagined her necklace and wristband as a kit, where bead colors would have different meanings, including personal achievements, reminders, or even *"recognition that [the user is] not practicing mindfulness"*, and that each user could create their own combination of wristband and necklace beads on a daily basis to fit their personal goals. The public display of the jewelry would also help her be accountable to her mindfulness practice, because *"at the end of the day, I would have my necklace showing that, indeed, I made more attempts to be present during the day"* [Ellie].

4.4 Metaphorical art

We identified some magic machines centered around metaphorical art (Figure 5). These objects decorated participants' spaces while symbolizing their mindfulness journeys, reflecting their hopes, needs, and struggles with their mindfulness practice, or encouraging them to expand their practice.

In some cases, simply looking at the magic machine serves the purpose of a reminder of one's mindfulness practice and motivations. For example, Collin's Mindfulness Figurine (Figure 5-2) represents his desire to be a more mindful version of himself: aware of his own anger and more empathetic to others. Envisioning it being placed on his desk to be glanced at when needed, he designed the figurine with various *"symbolic pieces"* that represent his mindfulness journey. Collin describes and explains the intention behind the different design features: *"So number one, I purposely made the head blue. And that was basically just to remind you to not really get super emotional, especially [if] you get mad. [...] And then the big heart on the chest also comes from a place of love, just trying like understanding. And, like if someone's having a problem, just trying to understand first, like, what's really bothering them. And then this arrow is pointed back at him. It's pointed, I really wanted to point inward. So really understanding how people are feeling. I think a lot of times when people come to you and they have to talk about*

their problems, they don't really want you to tell them or give them a solution to their problems, they really just want to be heard. [...] And then the last piece is I made him with open palms and I think that's just a sign that you're not there to cause any harm."

Others created more interactive art pieces that dynamically change in response to one's mindfulness practice. For example, Monika and Lisa, despite different years of mindfulness experience, both reflected on the benefits of meditation for them, discussed how their mindfulness journeys have changed, and emphasized the importance of dedication to the practice. Their Mindful Fish Pond (Figure 5-3) used living creatures and moving seaweed to represent the ever-changing state of their emotions and mental state. The natural elements in their Mindful Fish Pond serve as a decoration of their space: *"whenever you're doing housework or some other daily routines, when you look by the window, you can always take a look at this"* [Monika], and a metaphor of their mindfulness state and journey. Monika explained: *"it can be linked magically to our own meditation routine. So like when we are making progress in meditation, then the seaweed will grow. And then it also makes us to appreciate the cycle of life,"* and Lisa added: *"which might itself be a mindfulness reminder."*

By creating metaphorical art, participants combine symbolism and aesthetic metaphors with mindfulness to enhance their environment and deepen their connection to mindfulness in their daily routines. While it may appear as a simple decoration to some, the significance of metaphorical art lies in how each piece represents the unique values, beliefs, and emotions of the participant and how it encourages their ongoing mindfulness practices through a personal connection.

4.5 Companions

A few participants designed animated companions (Figure 6) to facilitate their mindfulness practice. These designs represent the method of practicing and achieving mindfulness by interacting with someone [57]. For example, Ami and Jennifer identified that while taking a break could be an opportunity for a mindful activity, they



Figure 6: Companions: (1) Mr. Stuart, a therapeutic figure with a shredder mouth that takes in user's frustration [Lucy]; (2) Sean the Talking Cat, a magical talking cat that acts as a therapist for the user by listening and interaction [Vincent]; (3) Magic Pet, a magic pet with animal-like features that encourages mindful breaks by suggesting meaningful activities [Ami and Jennifer]

often find themselves "go[ing] to our phones, and scrolling on social media mindlessly" [Ami]. In response, they designed the Magic Pet that encourages mindful breaks (Figure 6-3). Ami explained how the pet works: "you can turn it on if you want to, program your break times into it and it will remind you to take a break. And it has feet. So [it] moves around, in your room, or wherever you are, and moves towards you when you're taking a break [...], it'll come towards you and then and so it'll be like, you know, an inviting cute little feature. Like, here's the activity that you've been recommended." Ami gave an example of a fun and enjoyable activity that the Magic Pet would recommend: "based on the ingredients you have in your kitchen, it'll give you a simple recipe you can sort of make, here we have oatmeal, apples, you can make overnight oats. [...] Having this sort of pet encourages us to be mindful, embrace, and engage in meaningful activities instead of just browsing social media for the sake of browsing."

Instead of a companion that encourages mindfulness activities, other participants envisioned therapist-like features in their magic companions. For example, Lucy described her need to talk with someone: "I get very anxious and not confident when I have a bunch of emotions bottled up. And what I realize is that if I can just talk to someone about it, it immediately gets so much better". She designed Mr. Stuart (Figure 6-1), a therapeutic figure that listens to her negative thoughts and eliminates them: "This is a piece of technology that you can yell to. And it would not make any sound, it would suck up the sound that you're yelling. [...] Its mouth is like a shredder, [...] it will shred everything." Talking to Mr. Stuart allowed Lucy to externalize her negative thoughts and feelings and practice letting go through the shredder-shaped mouth, which concretizes the non-judgmental acceptance in mindfulness.

Starting to practice mindfulness can be difficult for some people, and having support from these animated companions brings more joy to the practice and can mitigate feelings of loneliness. By externalizing their thoughts and feelings through everyday interactions with these companions, participants are also able to concretize the abstract nature of mindfulness, making it a more tangible and accessible practice.

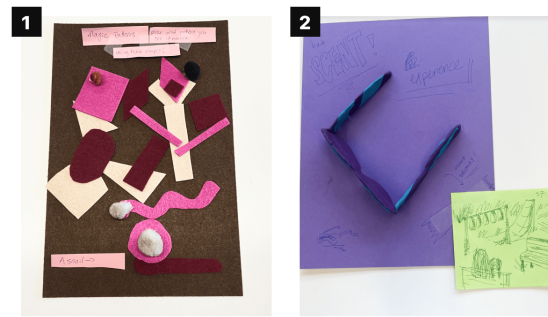


Figure 7: Toys: (1) Magic Pattern, an application that involves the user moving shapes around to represent patterns they see in nature [Elsie]; (2) VR Goggles, a pair of VR goggles that allows the user to revisit their memories and reflection on unnecessary worries and thoughts [Mia and Kate]

4.6 Toys

Participants incorporated playfulness into mindfulness toys (Figure 7) that facilitated their practice in everyday life, with the purpose of expanding the possibility of cultivating mindfulness beyond meditation, with greater joy in practice. Some of the examples in the previous categories also incorporated joy and playfulness as a design choice, for example, Ami and Jennifer's Magic Pet. In this category, we identified designs where the primary purpose was to encourage mindful playfulness through toys.

For example, Elsie talked about her enjoyment of being outdoors and observing shapes and patterns in nature: "I notice what flowers look like or what a leaf looks like. And even in vegetables that I buy in the grocery store, sometimes I see patterns. [...] And then you're looking and noticing and you're aware". She designed the Magic Pattern (Figure 7-1) inspired by a Colorforms toy she had when she was little. It is a digital application that encourages her to observe patterns in nature, and then recreate the patterns using given shapes in the app: "if it were an app on a phone, I maybe would just take it out if I see a cool flower and just try to make a little representation of it to enhance my awareness of the item that I'm looking at." She believes

this Magic Pattern can heighten her awareness and curiosity about natural elements in her surroundings.

With the wish of practicing mindfulness as *"a preventative method as opposed to 'post-anxiety' activity"* [Mia], Kate and Mia designed VR Goggles for visualizing past memories. The goggles help them go back to talk to their younger version of themselves and reflect on unnecessary worries and thoughts, providing a virtual space for them to observe their mind non-judgmentally. The vivid revisiting and reflecting process also provides healing power and trains their awareness of recognizing endless worries and the ability to let go. Mia explained: *"talking to the child version of me helps to ground me a lot, to realize that I was projecting a lot of anxiety back onto myself."* While this fictional VR goggle design is technically infeasible or difficult, it represents participants' desire to be grounded more playfully.

Play is human nature. Children are often fully engaged when interacting with toys, involving various senses, such as sight, hearing, smell, and touch [24]. While practicing sitting meditation of mindfulness can sometimes be abstract and boring, participants creatively incorporated playfulness into the practice of mindfulness as an alternative way to support sustained practice.

5 FROM MAGIC MACHINES TO DESIGN CONSIDERATIONS

The previous section outlined broad categories of the magic machines designed by participants, which may be useful for considering the types of everyday mindfulness products to design. In this section, we take a step further to present and discuss our findings in response to the second question: ***What are the practitioners' thought processes and considerations for designs that support mindfulness?*** While grounded in our participants' magic machines, we hope that these findings are useful for designers of everyday mindfulness products beyond the magic machines. Some considerations may initially seem general; we provide explanations for how they specifically relate to mindfulness technology design. A summary of the design considerations can be found in Table 2.

5.1 Apply best practices: nature, relationships, self-reflection

Previous research has shown that mindfulness is directly related to connecting to nature [31], social relationships [21, 34], and self-reflection [11]. Our participants often responded to these evidence-based best practices directly in their designs to effectively facilitate mindfulness.

5.1.1 Connect to nature. Designs that encourage participants to go out to nature or bring nature in can directly facilitate mindfulness practice. While the benefits of incorporating nature in mindfulness have been explored and applied in some mindfulness technologies such as the natural scene in immersive technologies [17, 36, 60] and nature sounds in mindfulness apps [19], these technologies mostly focus on utilizing audio and visual modalities. In contrast, our participants creatively connect to nature through more diverse senses. For example, when designing the Magic Pattern toy, Elsie considered the tactile feeling of recreating various shapes of objects she finds in nature: leaves, flowers, and trees, which help to *"enhance*

one's enjoyment of nature". Other participants considered in their designs going out to spend time in nature, like Nathan and Joan's portable Pocket Couch, which *"you could take it outside and maybe go under a tree,"* or bringing nature into their homes, like Monika and Lisa's Mindful Fish Pond with a harmony of fish, frogs, seaweed, and pebbles.

5.1.2 Foster relationships. Designs that help connect to and interact with other people in a meaningful way is another way to support mindfulness, especially the openness, receptivity, and awareness of others. For example, Jeremy, who observes in his daily barista job people being in a rush, impatient, and annoyed, designed his Slow Coffee to offer opportunities to be *"soft for the people serving the coffee and soft for the people out waiting for the coffee. [...] People get to pause and get to know each other and talk about the day, [...] [to help] relationship[s] get uplifted and slowed down."*

Designs can also help foster a community of mindfulness practitioners, to offer peer support in the mindfulness journey, and to make one's practice more accountable. For example, Sammy reflected on her core value of relationships: *"Relationships are super important to me. And so one of the things that I wrote on the post-it, it had to do with connecting with others, and spreading the practice of mindfulness, as well as learning from others who practice mindfulness."* Her Circle of Life design is a visualization of her connections with other mindfulness practitioners, sharing their practice with the community and *"learn from them about how they practice mindfulness. [...] Hey, I know that you practice mindfulness through journaling, and I really want to increase that in my daily life"*.

5.1.3 Support self-reflection. Mindfulness inherently involves self-reflection, and our participants' magic machines, as well as previous research [5, 13, 73] included features that encourage self-reflection to support mindfulness. While the benefits of self-reflection have been acknowledged, the initiation of self-reflection is not easy. Our participants utilized novel ways of displaying self-reflection prompts and created interactive self-reflection technology to support mindfulness. For example, Morgan and Christy's Magic Mirror incorporated reflection through its daily changing prompts that serve as *"a guide to help you to think of something and reflect on your day"* [Morgan]. Christy further explained: *"You're looking at yourself, thinking about you, and you know what's going on in your life."* Self-reflection can be prompted using other modalities besides text prompts, for instance, Mia and Kate's VR Goggles create an immersive memory experience to help reflect on one's memories, which is similar to Peesapati et al.'s Pensieve [53].

Our participants not only incorporated self-reflection in the design outcome, but also in the *design process* itself: reflecting on what they want to get out of mindfulness, what benefits they receive from mindfulness, and what formal and informal practices they find helpful. Some of our participants expressed that the workshop enabled them to reflect on their own mindfulness practice, as Jasmine said: *"It gave me an opportunity personally to reflect on some of the mindfulness things I've been doing, and made me pause and think about activities that can be converted into sort of a more mindful activity."* This reflective design process [66] can help support a personally meaningful mindfulness journey by identifying the

Table 2: Summary of design considerations from practitioners' perspectives and examples

Categories	Considerations	Descriptions	Examples
Apply best practices	Connecting to nature	Consider going out to nature or bringing nature in	Magic Pattern, Pocket Couch
	Foster relationships	Support connecting to and interacting with other people in a meaningful way	Circle of Life, Slow Coffee
	Support self-reflection	Display prompts in novel ways and encourage reflection on mindfulness journey.	Magic Mirror, VR Goggles
Design for emotions	Evoke emotions	Evoke calmness, peace, gratitude and joy by utilizing specific color and materials	Mindful Fish Pond, Mindfulness Figurine
	Support emotion regulation	Support recognizing the present emotions and practicing mindfulness	Magic Bracelet
Incorporate in everyday activities	Add mindfulness to daily routine activities	Add a mindfulness exercise to, or associating it with a daily routine activity	Mindful Water Bottle
	Use everyday objects as reminders and facilitators	Incorporate different modalities into every object to remind people to start the practice, and facilitate each practice session	Mindful Mug, Massage Yoga Mat
	Situate the practice	Consider the location of the practice to determine the size of the design, where it should be placed, and its relationship to the body	Pocket Couch, Mindful Necklace + Wristband kit
Trade-offs	Outcome vs. process-oriented	Focus on relaxation outcome from a single meditation session vs. the process of practicing mindfulness	Magic Clock vs. Mindful Necklace + Wristband Kit
	User vs. machine control	Provide flexible control to use technology support vs. technology determine the support type and level	Mindful Necklace + Wristband Kit vs. Magic Glasses
	Public vs. private visibility	Design for use out in public vs. in private settings	Magic Bracelet vs. Magic Mirror

motivations and appropriate forms of practice and how the design fits in this practice.

5.2 Design for eliciting and regulating emotion

Emotions are one central element of mindfulness [26]. Practicing mindfulness involves cultivating non-judgmental awareness of the present moment, which includes one's thoughts, feelings, and bodily sensations. More than half of the participants wrote (in Part 1. Writing reflections and discussion) about the emotional aspects of their mindfulness practices, as both wishes and experienced benefits. Further, in their magic machine designs, participants responded to these aspects through emotion-evoking [59], emotion regulation [69], or both.

5.2.1 Evoke emotions. A mindfulness product may focus on evoking emotions such as calmness, peace, gratitude, and joy, which may be useful when users need a break, or to practice a routine activity to start or unwind their day. Some of our participants applied this principle, similar to commercial mindfulness products (e.g., Calm, Headspace). For example, when describing the Mindful Fish Pond, Monika explained how the gentle movement is designed to evoke calmness: *"seaweed can make a certain movement that is very calming. And we also made little fish and waves, pebbles, [and] frogs around it. So they will all be moving in a gentle calming way."*

Similar to Normans' three levels of emotional design (visceral, behavioral, and reflective) [51], our participants also used a variety of design strategies to evoke emotions, one of which was color. Blue was a popular choice to represent calmness, as Karen explained her choice of blue for the Finger Lakes Relaxation: *"I like blue a lot I feel*

like blue is very soothing." Other participants used bright colors to represent positive emotions, such as yellow (*"It's a positive, happy color"* [Morgan]) and red (*"I felt like a child playing with bright colors"* [Sandy]).

Besides visual elements such as color, participants also considered the physical qualities of the materials for evoking emotions, especially for products that are supposed to be touched by or interact with the body. One strategy was using materials with soft textures such as fuzzy fabric, pompoms, and foam. Karen explained that her choice of fuzzy fabric for the Finger Lakes Relaxation is like *"how petting an animal is so soothing or wearing a really soft sweater, like having something texture-y."* When describing his design choices for the Slow Coffee design, Jeremy also explained that the texture of the materials mattered, to represent *"something bright and soft and cozy and comfortable"* as opposed to *"cold and distant."*

We note, however, evoking positive emotions may only be helpful in the short-term when users need to remedy their negative emotions and experiences, as Ami wrote in her reflection that mindfulness helped her *"bringing my emotions back into balance and restoring my energy levels."* In the long-term, mindfulness products need to go beyond evoking relaxation to cultivate an individual's ability to deal with their emotions [22].

5.2.2 Support emotion regulation. Mindfulness is not aimed at automatically changing a person's emotional status. Instead, the ability to intentionally regulate one's emotions was seen by participants as one motivation for mindfulness practice, as Ellie explained: *"I do recognize that when I do more minutes of mindfulness, my emotional quality of life is better"*. Mindfulness trains people to observe their

bodily sensations and thoughts as they are, and take a pause before reacting. In this sense, emotion regulation involves two steps: recognizing one's present emotions and practicing mindfulness to deal with them.

Participants included features that measured their stress and other emotions using bio-signals and provided recommendations for mindfulness exercises. For example, Rachel described the two steps of emotion regulation in the design of the Magic Bracelet, to *"call attention to your emotion and then afterwards, give you some prompts about what you can do in terms of further steps"*. The specific mechanism by which emotion was recognized was what some participants considered as the "magic" behind their designs, calling for the need for advances in *Affective Computing* that aims to identify, analyze, and respond to human emotion [55], to help people learn to reflect on and regulate their emotions [61].

5.3 Incorporate mindfulness in everyday activities

Mindfulness technology can support everyday mindfulness beyond the classic form of meditation, as a few of our participants mentioned practicing mindfulness in their existing daily activities *"like driving, eating, breathing, even exercising"* [Collin]. Here, we describe three strategies we identified in which participants incorporated mindfulness in their daily activities.

5.3.1 Add mindfulness to daily routine activities. Similar to other habit-building, maintaining mindfulness practice is difficult for most participants. They acknowledge the benefits of mindfulness to their mental well-being, and still encounter difficulties such as *"lack of time, especially during the academic year when my schedule is really packed"* [Irvine]. Based on our analysis, we found that our participants considered designing mindfulness into daily routine activities, by adding a mindfulness exercise to, or associating it with a daily routine activity.

To do so, participants integrated features into their designs that transformed existing daily routine activities into informal mindful activities. For example, the Magic Mirror gives different reflection prompts whenever being looked at *"to help you to think of something and reflect on your day [...] because a bathroom is a place you go often and you look at [the mirror] often"* [Morgan], adding a self-reflection activity to an already existing morning or night bathroom routine. In addition, participants considered adding a mindful practice immediately before or after an existing activity. For example, Michelle said she always carries a water bottle and regularly drinks out of it. Wanting to practice more mindfulness, she designed a Mindful Water Bottle that prompts her to complete a mindfulness exercise or emotion check-in before drinking water. Associating an essential daily activity like drinking water with a mindful exercise lowers the barrier to initiating mindfulness practice.

5.3.2 Use everyday objects as reminders and facilitators. We actively and passively interact with many objects every day. These omnipresent everyday objects have the potential to serve as salient and stable cues as reminders to start or end the mindfulness practice. Participants considered incorporating different modalities into everyday objects to remind them to start the practice, like Ami's

Magic Pet that senses her break time, moves toward her, and reminds her, through audio and visual instructions, to do a mindful activity during her break. Another example is Karen's Finger Lakes Relaxation, a decorative tapestry that she would place in her home office on her desk or on a bulletin board. It invites her to look at the calming blue color and touch the soft soothing texture, and these visual and tactile sensations serve as reminders of the calming power of nature.

Participants also incorporated features into everyday objects that support one's mindfulness practice, like the timer in Carol's Magic Yoga Mat and in Mike's Mindful Mug, which facilitates meditation for a certain amount of time. Besides, these objects can provide guidance during the practice, like Stella's Massage Yoga Mat, designed with *"little strips of vibrators to let you know when to move on to your calves, to your knees, to your hips, that sort of thing. [...] it's also nice if you realize, as you're walking through your body that, man, my shoulders are super tight that you could have strips that just vibrate to tell you to focus on that area."* The Massage Yoga Mat is designed to guide Stella in her practice to focus on the sensations of the different parts of her body through vibrations in the yoga mat as opposed to more common guided audio instructions.

5.3.3 Situate the practice. We already discussed how participants were intentional about where they practiced mindfulness: at home, during breaks at work, or outdoors. They carefully considered the location of the practice to determine the size of the design, where it should be placed, and its relationship to the body. Practicing mindfulness in a fixed location allows for designing large or heavy products, such as the Self-care Bed and the Magic Mirror. On the other hand, wearables, jewelry, and small objects such as a water bottle that can be carried around to practice mindfulness anywhere. The technically infeasible solution is the futuristic Pocket Couch, carried in the pocket and expanding *"at any moment if you need to take a break and to be comfortable and to have a place to practice mindfulness"* [Joan]. The Pocket Couch and other designs demonstrate participants' need for spaces that are conducive to practicing mindfulness through physical comfort, social norms related to slowness and reflection, and reduction or elimination of distractions.

5.4 Consider design trade-offs

In addition to design considerations discussed above, here we outline trade-offs that our participants considered in their designs. These trade-offs represent conflicting or complementary values for designing mindfulness technology. We discuss, based on our analysis, considerations for finding a balance or choosing what to emphasize in a design.

5.4.1 Becoming mindful: Outcome vs. process-oriented. Similar to previous mindfulness design research [44, 79], we identified two orientations toward supporting mindfulness in our participants' magic machines. Outcome-oriented designs operate similarly to a meditation session that brings relaxation and clarity, by helping users achieve a mindful state as a result of using them, and almost all mindfulness designs are naturally outcome-oriented to some degree. However, too much focus on the outcomes may reflect a view of mindfulness being sort of a remedy, as opposed to a holistic view

of one's well-being, and overlooking the profound benefits of consistent mindfulness practice. Recognizing this, some participants considered, through the interaction with their designs, balancing between focusing on the outcome of mindfulness (e.g., achieving calmness and joy), and the process of practicing mindfulness. For example, Ellie designed the Mindful Necklace + Wristband Kit, in which each time she engages in a mindful activity, she would move one bead from the bracelet to the necklace, so that, *"at the end of the day, I would have my necklace showing that, indeed, I made more attempts to be present during the day."* She further imagined a hands-on activity in which she would reconstruct the kit at the end of each day, to be intentional toward her mindfulness practice in the following day. She explained, *"the exercise of putting it together in and of itself is a mindful experience."* This reminds us to be careful about leading users to be too focused on or judgemental about the outcome of every mindfulness activity through the design, and instead look at the process of interacting with the design as a mindfulness activity in itself.

5.4.2 Control: User vs. machine. Previous research discussed the control in mindfulness technology, arguing that technology should not take away the user's control, such as by being too evaluative of the user's mindfulness practice [20]. Our participants designed their magic machines with varying levels of machine control over the mindfulness activities they support, from implicit control (e.g., the Mindful Fish Pond that grows with its users' mindfulness progress) to active and explicit control. For example, Sandy, who is nearsighted, designed Mindful Glasses that require her to *"do mindfulness activities to be able to have clear sight"*, explaining that mindfulness apps don't work for her because *"I swipe them away. [...] But if I had to see, then I would do it. It kind of forced me in a different way."* Similarly, Michelle's Mindful Water Bottle prompts her to do a mindfulness exercise in order to be able to drink water. These extreme examples of blocking access to essential needs (seeing, hydrating) seem opposite to the non-judgemental quality of mindfulness. At the same time, they convey the reality that our participants were aware of the benefits of mindfulness and wish to practice more, but didn't always prioritize it in their daily lives.

Users may need different levels of support for mindfulness at different times, with more support during stressful times and less when life is going well. When technology support is less needed, it may be useful to have the machine facilitate small and short "maintenance" mindfulness activities. During times when one feels that they need it more, technology could check in about their current status, which form and frequency of practice would be most helpful, and provide reminders and resources accordingly. Allowing flexibility of the control at different times has the potential to maintain the practice in the long run, as Ellie explained, *"I'm not so into hard and fast balls. But I do think that sometimes having a physical reminder for me, as opposed to time just slipping away, and then I didn't follow through with the intention that I made in the morning."*

5.4.3 Visibility: Public vs. private. Some of the magic machines our participants created, especially wearables, were designed for use out in public, or could seamlessly move between the private and public spheres, e.g., the Mindful Water Bottle. A design carried outside in public benefits users by serving as a constant and easily noticeable reminder for them to practice mindfulness anywhere

they go, e.g., the Magic Bracelet that *"call[s] attention to your emotion"* [Rachel]. However, as previously discussed [15], mindfulness designs presented in public may bring social acceptability concerns [37] such as being judged or questioned by others, as Ellie explained about her Mindful Necklace + Wristband Kit: *"Is there a way to do it where no one asked me: what's that?"*

Other participants created designs specifically for use in private settings, such as Mr. Stuart and the Magic Mirror. These designs were seen as beneficial for situations where behaviors are considered unacceptable in public, such as yelling out one's emotions at Mr. Stuart and a bathroom routine with the Magic Mirror. Considering what are socially-acceptable behaviors in different situations is important for the visibility of mindfulness designs to seamlessly fit into the scene without causing unnecessary self-consciousness.

6 DISCUSSION

Our findings present design categories for mindfulness technology, thought processes, and considerations from practitioners' perspectives. In this section, we discuss how our research expands the HCI literature on designing for mindfulness, limitations, and future work.

6.1 From generalized solutions to individualized design

One unique contribution of this study is incorporating the perspectives of mindfulness practitioners in the design of mindfulness products that can result in more relevant and personalized technology. Previous research has reviewed different mindfulness technologies such as mindfulness mobile apps [19, 44] and immersive technologies [68], and provided frameworks to classify mindfulness technologies [72, 78]. Unlike this research, our work took on a generative approach, incorporating the creativity of mindfulness practitioners. This resulted in a set of design categories of mindfulness technologies, of various form factors, interaction modalities, and scenarios of use. Further, this generative process allowed us to see, from the practitioners' perspective, what design factors need to be considered in mindfulness technology, to be useful in their personal mindfulness journeys.

The variety of the generated designs restates the importance of personalized mindfulness technologies [45, 52]. Although generalized solutions have the benefit of accessing a wide range of users, a personalized solution may create a deep personal commitment to the product and the practice and increase long-term engagement, as has been shown in the first-person method [15]. For example, previous research investigated different interaction modalities (audio, visual, tactile) for mindfulness, finding inconsistencies in the effect of modalities on attention and relaxation, as well as inconsistencies with people's preferences [32]. Our research underscores the potential of the 'magic machines' in allowing participants to tailor their own mindfulness practices according to their individual preferences to the appropriate modalities (audio, visual, tactile, vibrations, etc.). This highlights the importance of personalizing mindfulness technologies at multiple levels, such as modalities, form factor, purpose, scenarios of use, and a wide range of design considerations, to foster a mindfulness practice that resonates with each individual user.

In addition, our findings also highlight the connection between embodiment and mindfulness practice, via the interplay of physical body, materials, and context in embodied design [77]. Through envisioning playful interactions and physical engagement in the magic machine building process, our participants come up with creative and concrete ideas for understanding and practicing the abstract concept of mindfulness. For example, the practice of "letting go" of thoughts, a core component in many mindfulness exercises, has been embodied in some participants' prototypes (e.g., Mr. Stuart helps externalize and release thoughts, VR Goggles help visually revisit and reflect past memories). For other participants, their bodies served as a source for their creative mindfulness ideas (e.g., the self-care bed and the massage yoga mat). This opens up new possibilities for mindfulness practice, suggesting the integration of traditional mindfulness exercises and tangible, embodied interactions with technology could be a rich and engaging approach to cultivating mindfulness [20, 70, 76].

6.2 Using magic machines to explore a (practical) design space

The magic machine technique has been developed as an approach that focuses on raising questions and critically reflecting on problems rather than offering direct technological solutions [3, 4], leveraging the imaginative freedom of speculative design [23]. Magic machines address abstract topics and welcome "seriously silly", anti-solutionist ideas, as a way to explore problems from a new angle [10]. We appreciate this approach as a way to investigate the problem space, by envisioning novel mindfulness practices and technologies that challenge traditional norms and expectations of mindfulness. Building on this, through our workshops, we also found the potential of applying magic machines to solve practical problems by enabling participants to address their own genuine personal needs. Through analyzing the magic machines created by participants, we created a classification of various types of mindfulness designs and extracted a set of design considerations that participants applied in the design process, further underscoring the potential and versatility of this method.

Andersen's magic machine protocol outlines several steps: introduction, prompt, material making, being done, description, group discussion, and documentation [4]. In our adapted protocol, we augmented the original procedure with certain activities before the material-making stage: writing reflections and brainstorming followed by affinity diagramming. First, writing reflections provided an expressive writing opportunity [54] for participants to reflect on their past and present mindfulness experiences, successes, and struggles, which helped them understand the existing problem space of their own practice. Second, brainstorming and affinity diagramming encouraged them to creatively think about what they could do to bring mindfulness to their daily life thus moving them from reflecting on their past and present, to a future-oriented designerly-mindset [48].

Following this process, the material-making activity of building magic machines allowed participants to detail and materialize their abstract thoughts into tangible objects. Moving from reflecting on the past and present to thinking about the future, and from the abstract to the concrete, each activity was carefully selected

and built on the prior step, collectively facilitating non-designer participants to apply design thinking to address a practical personal problem that they genuinely care about. This allowed us to explore the potential design space from the participants' point-of-view, and we hope our workshop procedure opens the door for future co-design researchers to use the magic machine technique or other variations of speculative design to respond to practical issues in people's lives.

We note that the magic machine approach has generated some unrealistic imaginative solutions (e.g., Pocket Couch), or solutions that require extensive development and research to implement working products out of the "magic" design concepts (e.g., Magic Mirror). However, in contrast to "absurd and useless making as critical practice" [41], we identified some down-to-earth, workable magic machines such as the Magic Pattern, Mindful Necklace + Wristband Kit, and the Mindfulness Figurine, which mostly applied low-tech designs for mindfulness. The different levels of technological feasibility and the range of high-, low-, and no-tech solutions [6], allowed us to explore the design space more broadly. A future direction might involve combining magic machines with principles of autobiographical design [49], inviting the same participants to attend the workshop multiple times to iterate their magic machines based on real-life feedback. In between visits, participants would take their magic machines into their daily life as prompts for generating ideas for the next iteration. This longitudinal and iterative process could enhance the design and utility of the magic machines, making them even more personally meaningful and effective for mindfulness practice, and facilitating both critically reflecting [10, 23] and practically designing and iterating.

6.3 Limitations

It is crucial to acknowledge the majority of the participants were from a specific local community composed mostly of university students, staff, and faculty as mindfulness practitioners. This factor may impact the generalizability of the results to other non-academic populations. Despite these limitations, our study still holds considerable significance by incorporating the diverse perspectives of mindfulness practitioners with varied experiences in in-person workshops. We recognize the limitations of the user group and we strived to provide to design a thorough workshop protocol that can be used by future researchers to utilize and extend to other populations. Another limitation is one workshop per practitioner produced only one version of their mindfulness prototype, providing a limited understanding of the long-term use and iterations of mindfulness products. We hope future research could try to conduct multiple co-design sessions on the same group of participants and gather feedback on the real-life test in between sessions. Besides, we also plan to adopt an autobiographical design approach within the research team and utilize the co-design workshop protocol, which will be valuable to design mindfulness products that incorporate long-term use and iterations.

7 CONCLUSION

In this paper, we presented findings on 9 magic machine workshops involving 30 mindfulness practitioners to explore how future

technology can support mindfulness in daily activities. Our contributions are twofold, (1) a thorough analysis of the design space and design decisions, from mindfulness practitioners' perspectives, toward designing products that support mindfulness in everyday activities and (2) an extension of the co-design magic machine workshop protocol that can be adapted to explore other well-being topics, as it provided individuals with an opportunity to use design activities to reflect on their everyday activities and mindfulness practice.

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