Co-designing a Desk Robot Companion for Students with Chronic Insomnia: A Co-operative Design Approach

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Chronic insomnia impairs attention, memory and executive functioning during the day, affecting the very capacities university students rely on to plan and complete academic work. This paper reports a co-design process conducted over three sessions with a Computer Science student diagnosed with chronic insomnia, following the Double Diamond process. Using a diary study, directed storytelling, card sorting and an evaluation matrix, we identified the completion of academic tasks under fatigue as the problem to address. Across two ideation sessions, our co-designer rejected solutions that made outstanding workload visible or offered enthusiastic motivation, favouring physical artefacts that adapted to her fluctuating energy and provided a sense of company. The resulting prototype is a desk robot companion that accompanies study sessions, proposes breaks and helps decompose tasks into smaller steps.

CCS Concepts: • **Human-centered computing** → **Participatory design**; *Accessibility design and evaluation methods*; User studies.

Additional Key Words and Phrases: co-design, participatory design, chronic insomnia, university students, assistive technology, desk robot, task management, inclusive design

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1 Introduction

Insomnia is a sleep condition defined by the struggle to initiate sleep, largely diagnosed through the patient's own dissatisfaction with the duration or quality of sleep. Individuals typically report being unable to drift off despite being in bed, experiencing frequent nighttime awakenings with difficulty returning to sleep, waking up prematurely, or feeling exhausted in the morning [1].

Chronic insomnia, by contrast, is a significantly more complex condition. Patients experience daytime disruptions to their cognitive function, mood, and overall performance, creating consequences that affect not only the individual and their family, but also their friends, colleagues, and caregivers [2].

Insomnia disorders are characterised by these symptoms accompanied by significant distress or impairment, together with at least one form of daytime impairment, such as fatigue, reduced attention, concentration or memory, mood disturbance, irritability, reduced motivation and energy, or poor school or work performance [3]. A meta-analysis of objective performance measures found that individuals with insomnia show impairments across several cognitive domains, including working memory, episodic memory and aspects of executive functioning [4].

This condition is particularly consequential for university students, since their daily activity depends on these capacities: planning work, breaking it down into smaller steps, holding tasks in mind, and seeing them through to completion.

In this paper, we describe the process of co-designing a technological product aimed at aiding students diagnosed with chronic insomnia. Additionally, we will describe the techniques and methods used to engage our co-designer, a young student with chronic insomnia, in a co-operative design process, our findings throughout the procedure, and the resulting solution.

This work is guided by the following research question: how can a co-design process with a student experiencing chronic insomnia inform the design of a computational artefact that supports academic task completion under fluctuating energy levels?

2 Related Work

Cognitive behavioural therapy for insomnia (CBT-I) is the first-line treatment recommended by clinical guidelines, but a shortage of trained therapists and its face-to-face delivery format severely limit access [5]. Recent work has therefore focused on delivering therapy digitally: a meta-analysis of randomised controlled trials found that app-based interventions, primarily CBT-based, effectively reduce insomnia symptoms, and may improve sleep onset latency and total sleep time [6]. Beyond therapy delivery, the commercial landscape is dominated by sleep tracking, through wearables and nearables placed in the bed or bedroom, most of which monitor sleep times and stages while lacking peer-reviewed validation of their efficacy claims [7]. Participatory approaches are not absent from this space: the Sleep Ninja app was developed with adolescents through focus groups [8], and co-design has been used to adapt insomnia education materials in primary care [9]. Notably, participants in the latter study reported that recording exact sleep and waking times was itself stressful, and that the impact of insomnia on their daily life

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and social context received no attention in the materials available to them [9].

What these approaches share is a focus on sleep. Whether the aim is to treat the disorder or to measure it, the daytime impairment that patients report is left largely unaddressed. This gap matters for students in particular, since academic adaptation in students with chronic conditions is burdened not only by their health but by the continuous self-monitoring their condition demands [10], and chronic illness affects education both directly and through its social and psychological consequences [11]. It is also a gap that co-design is well placed to address: writing from the perspective of a person living with multiple chronic conditions, Gruman observes that patients' voices rarely play a role in developing the technologies intended for them, and that tools which add to the work of self-care go unused [12]. Our work takes this as a starting point, designing with a student for the hours when her condition is felt rather than for the hours she spends trying to sleep.

3 Methodology

This section focuses on the three co-operative sessions that took place with our co-designer, and on the work developed by our team before and after the sessions.

Our co-designer is Carolina Matias, she is a 20 year old undergraduate college student in Computer Science and Engineering. She was medically diagnosed with chronic insomnia in 2025.

The methods and techniques used to structure the co-design sessions were based on the Double Diamond design process. This process entails that we first dedicate time to explore and understand the challenges our co-designer faces as a means to properly define a specific problem that is relevant, innovative, and feasible in the given time period. Once the problem is defined, the focus shifts towards the possible solutions to that issue, where we create, test, and improve various ideas until a final prototype is developed.

3.1 Exploring the Problem Space

Before the first co-design session, the team focused on finding and analyzing secondary research related to chronic insomnia, especially among young people. The knowledge obtained from this preparatory work allowed us to better identify the design methods that would be the most appropriate for the exploration of this issue, alongside the most relevant topics to address in our interactions with our co-designer.

Following this research, the team decided on four different design methods. The first method chosen was a diary study. A form comprising qualitative and quantitative questions was handed to our co-designer so she could fill it every day for 5 days before the first session. The questions tackled how her nights unfolded, her tiredness levels throughout the day, and the impact of her disorder in the social, academic, and emotional affairs (Fig. 3).

During the session, we carried out a directed storytelling interview to allow our co-designer to recount her stories and lived experiences. We guided her through three scenarios—a night when she experienced severe insomnia, the day following a poor night's sleep, and a night when she managed to overcome insomnia—adding follow-up questions to support her if she became unsure or lost (Fig. 4).

Complemented by the diary study and directed storytelling, a card sorting activity was conducted. The team and the co-designer wrote down various phrases and topics in post-it notes related to the most relevant or recurring topics that emerged during the previous two activities. Afterwards, the co-designer grouped the notes into different clusters, naming each formed category (Fig. 5).

Finally, the team developed an evaluation matrix (Fig. 6), which was crucial in deciding which was the problem most relevant to the co-designer. The x-axis of the matrix represents the frequency at which chronic insomnia affects the given concept, and the y-axis represents the impact chronic insomnia has on that said concept. The co-designer was tasked with placing the formed categories on the matrix according to how she perceived the influence chronic insomnia had on each of them.

Although the co-designer placed *Anxiety* as the most impactful and frequent theme, after further discussion she reasoned that it might be a harder topic to address directly, being a much more general category and present throughout all other related issues. Thus, it would be wiser to choose a problem within the following three high-importance themes: *Decision-Making*, *Studying* and *Socialization*. By focusing on one of these, we could actually realize a feasible solution that would nonetheless indirectly help with her anxiety.

After further consideration, and with her enthusiastic approval, the team came to the conclusion that our problem would focus on helping her maintain her focus and manage her energy during study sessions, especially on days where she is experiencing greater levels of fatigue due to her insomnia. We believe that addressing this issue could help our co-designer stay on track with her academic responsibilities and finish her work consistently, without feeling like she is falling behind her peers.

Finally, we arrived at the following problem statement: **"A student with chronic insomnia needs help breaking tasks into manageable steps so they can complete their academic work without falling behind"**.

3.2 Exploring the Solution Space

3.2.1 Exploring Solutions. Once we had clearly defined the problem we wanted to tackle and the problem statement had been agreed upon with our co-designer, we moved on to the ideation phase. We set out to answer the question: **"How might we help a student with chronic insomnia manage their focus and energy on tasks so they can complete their academic work without falling behind?"**

Before the second co-design session, all team members and the co-designer had individual timeboxing sessions where everyone was tasked with developing at least five different solutions to the defined issue in ten minutes. Additionally, our team researched existing technologies that could be applied to chronic insomnia, gaining deeper insight and ideas of the feasibility of technological solutions and what other products already address.

The second session began with the team and co-designer discussing the ideas developed during the timeboxing session. The

co-designer filtered the existing ideas so we could maintain the most promising ones, and reviewed the existing technologies found in our research. A key takeaway was that interfaces highlighting pending tasks worsened her anxiety. Instead, she strongly preferred adaptive solutions that adjust her schedule or environment based on her exhaustion level.

A second timeboxing session was held, focused on improving the most promising selected ideas. Afterwards, the co-designer evaluated and ranked each idea, allowing us to isolate the top five. This reinforced the previous conclusions regarding her preferences for adaptive physical solutions. However, she expressed dislike for products that provided enthusiastic motivation, finding them mostly distracting and ineffective.

After reviewing and improving upon the final ideas, the co-designer chose the one she found the most compelling: a small desk robot that accompanies the user throughout their studying sessions. To start, the user inputs their pending tasks and current tiredness levels. The companion then quietly monitors her behavior to gauge focus and energy. Based on this, it suggests study plans, breaks down larger tasks into manageable steps, and advises taking breaks during moments of fatigue.

3.2.2 Delivery of the Solution. To simulate the user experience, our team started working in the development of a low-fidelity prototype. Initially, we had each team member sketch 2 to 3 robot designs. The co-designer then selected the three most appealing blueprints (Fig. 7). With her consent, the team then selected the most feasible and innovative concept out of those three (Fig. 8).

This concept was a simple design: a small robot consisting of a rotating sphere mounted on a support base, with a surface screen capable of displaying different facial expressions.

We developed our low-fidelity prototype by using paper to build the robot's physical body, and small paper cutouts glued to pens to represent computer notifications. The third co-design session was conducted using the Wizard of Oz method, where we walked through different social interactions between the co-designer and the prototype. The team prepared four different scenarios where the only variants were the personality of the prototype and its means of communication. Each scenario consisted of the same script: the co-designer would turn on the robot, input the task she aimed to accomplish, focus on the work, and then progressively lose focus. The prototype would either have a more energetic demeanor or a more passive approach to interacting with the co-designer. Additionally, the product would either interact with the co-designer solely through voice command or through computer notifications.

The co-designer showed great interest in the product's different expressions and animations, which helped solidify the belief that an expressive product would make the interactions more effortless and meaningful for the co-designer. The team also learned that the co-designer preferred a mixture of both voice command and digital notifications, where the product would adapt the mode depending on her needs or explicit commands. Finally, the co-designer leaned towards a robot with quieter expressions and movements while she was focused on her studies, so as not to distract her, except for when she was distracted and losing momentum for a period of time. In those cases, she would rather the product be more enthusiastic in its attempts to communicate and aid her.



Fig. 1. Low-fidelity prototype of the desk robot.

Lastly, taking into account the insights shared with us by the co-designer, the team developed a high-fidelity prototype of the product, named Mylow, highlighting and refining its interactions and demeanour towards the user.



Fig. 2. High-fidelity prototype of Mylow, 3D printed.

4 Findings and Discussion

In this section, the findings and lessons learned throughout the design process are discussed, focusing on the creation of the final prototype.

4.1 Designing Mylow

Designing an Active Companion. The co-designer greatly valued the social aspect of having an encouraging physical product that is capable of adapting its demeanor to her necessities, acting as a peer that can provide helpful advice when needed. The team, along with the co-designer, explored different ways in which the product could act as an active companion, without being too disruptive, while keeping in mind that the co-designer was not interested in a companion that was too silent, as it could lead to it going unnoticed. During the third session, the team observed that a healthy combination of both approaches was the best strategy to adopt. In this manner, the desk robot could act more passively whenever the user is more productive, showing quietly signs of happiness so it is still discreetly showing support for the user's progress. On the other hand, when the user is getting distracted, the robot should be more lively in its approach, as a means of effectively catching the

co-designer's attention. Nonetheless, the robot should still adapt its approach to the co-designer's levels of stress and exhaustion: in this case it is more appropriate to have the product reach out to the co-designer in an eye-catching yet comprehensive manner. Figure 9 summarises the resulting behaviour as a state machine.

Privacy Concerns. For our product to be able to analyze and base its actions on our co-designer's needs, the final implemented prototype would need to observe its user through visual sensors. This way, it would be able to detect when the co-designer is visually distracted or exhausted. This was the co-designer's main concern, as it could be an intrusive form of monitoring her mood and environment. As such, the team and the co-designer reached an agreement where the robot would be able to be switched on and off whenever the co-designer pleases.

Adaptability and Variety. Throughout the sessions, the co-designer consistently preferred products that adjusted to her necessities rather than products she had to adjust to. This emerged in two distinct forms. The first concerns the channel of communication: she did not want to choose between voice interaction and on-screen notifications, but expected Mylow to switch between them according to context, moving to the screen when she put on headphones or explicitly asked for silence, and returning to voice once the session resumed. The second concerns intensity: the same event should not always produce the same response, since the appropriate reaction to a brief lapse in attention differs from the reaction to exhaustion at the end of a long session.

Variety is what makes this adaptability legible over time. A companion that signals in exactly the same way on every occasion quickly becomes background noise, which is precisely the outcome the co-designer feared when she described motivational products as distracting and ineffective. By giving Mylow a range of expressions, movements and tones, the same underlying message can be delivered differently depending on circumstance, and the escalation from a quiet idle state to a more insistent one becomes meaningful rather than arbitrary. This also allows the robot to stay present without demanding attention: small, varied signs of life during focused work convey company, while a visibly different attitude marks the moments when Mylow is trying to intervene.

4.2 Lessons from the Co-design Process

Low Fidelity Delivers Breadth. Building the prototype from paper and pens allowed us to run four distinct scenarios within a single session, varying both the personality of the robot and its means of communication. A functional prototype at that stage would have restricted us to one personality and one channel, and would have taken most of the time we had to build.

4.3 Future Improvements

While the high-fidelity prototype captures the behaviours our co-designer valued most, several directions remain open for future development.

Improved Expressiveness. To make Mylow feel more alive during periods of inactivity, its expressions could be made dynamic through small idle movements and occasional larger animations. Colour changes to the facial display could also convey emotion and catch the user's attention when needed, extending the expressive range beyond eye shape and rotation alone.

Adaptive Personalization. Machine learning capabilities would allow Mylow to learn the user's energy cycles over time, anticipating drops in focus before they occur rather than reacting to them, and adjusting its personality to match an individual study style. This would build on the preference our co-designer expressed for a product that adapts to her exhaustion levels rather than imposing a fixed routine.

Privacy-Preserving Sensing. The agreement reached with our co-designer, that Mylow can be switched off at will, addresses her concerns but does not remove the underlying tension between effective monitoring and intrusion. On-device processing, where visual data never leaves the robot, would allow the system to detect distraction and fatigue without recording or transmitting images of the user's environment.

Evaluation Beyond a Single Co-designer. Our process was shaped by the needs of one student, which is both the strength and the limit of this work. Testing Mylow with other students diagnosed with chronic insomnia would show which of the preferences we identified are generalized and which are particular to our co-designer.

5 Conclusion

In this paper, we conducted a cooperative design process divided into three different co-designer sessions. Each session focused on different stages of the Double Diamond design process, including the co-designer throughout the entire process of exploring, ideating, and defining a product that could aid her in the completion of her academic tasks as she struggles with chronic insomnia. Our findings emphasize the relevance of a co-operative design approach, and the lessons learned throughout the process highlight the fact that, when designing a product with a co-designer, it is important to include them in the choices being made and in the entire creation process. This serves as a foundation for future work in developing technological solutions for the daytime impairments students with chronic insomnia face in their daily lives.

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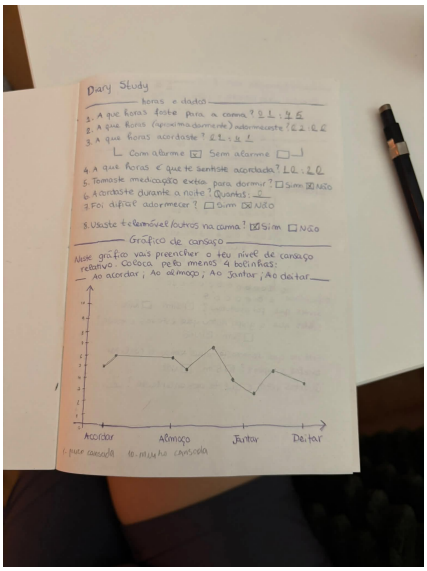
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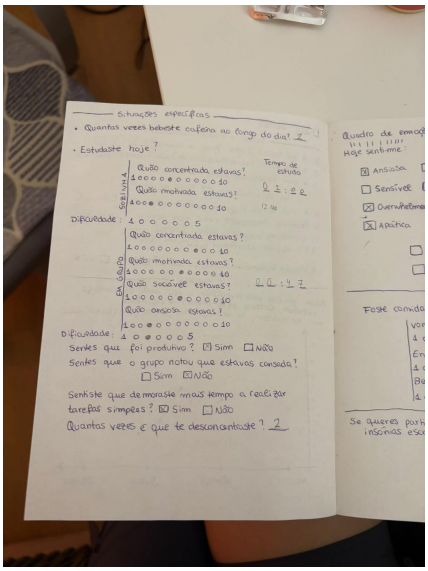
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A Appendices

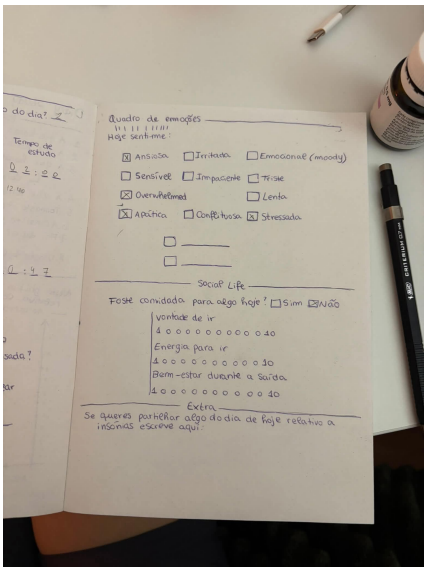
This appendix collects the materials produced during the co-design sessions.



(a) First page of the diary, where the co-designer plotted her energy levels across the days of the week.



(b) Second page of the diary, covering specific daily situations rated on numeric scales and other yes or no questions.



(c) Third page of the diary, recording emotional state and energy through checkboxes and rating scales.

Fig. 3. A handwritten diary study, delivered to our co-designer 5 days before the execution of the first co-design session.



Fig. 4. Directed storytelling session, in which the co-designer recounted her experiences of studying while fatigued.

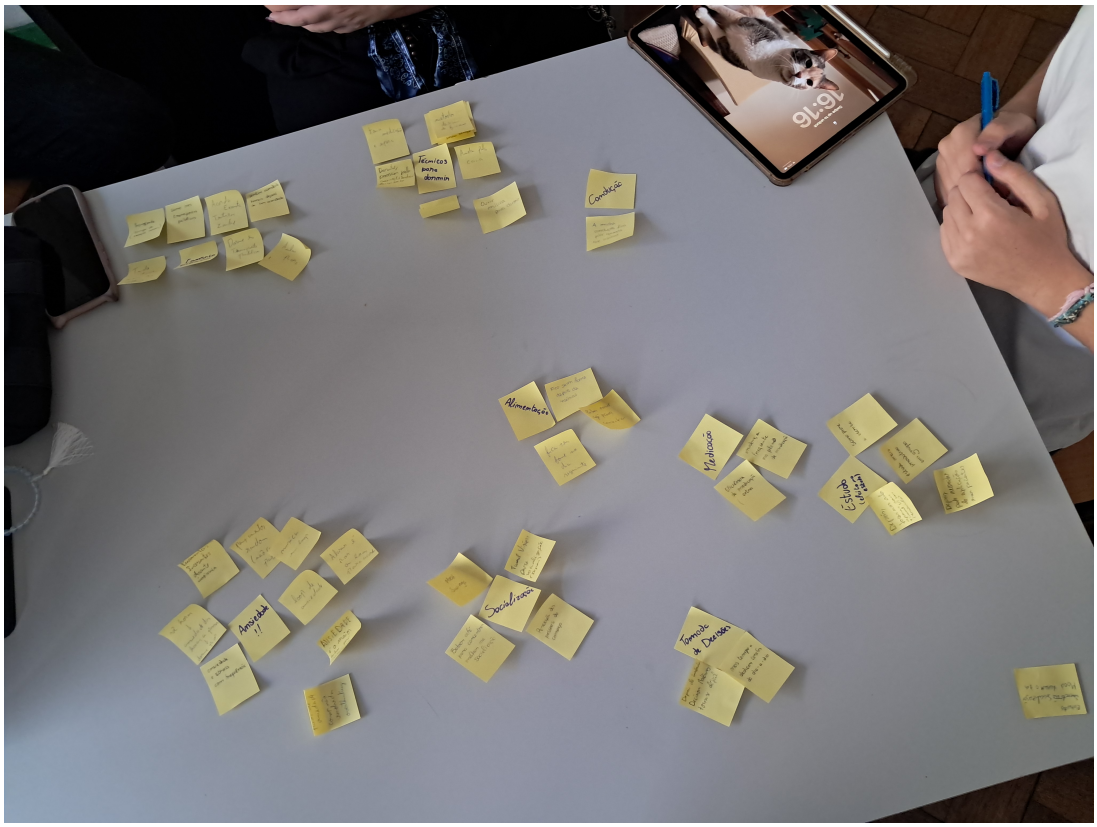


Fig. 5. Card clustering activity, in which the co-designer grouped topics raised during the diary study and the interview into named concepts.

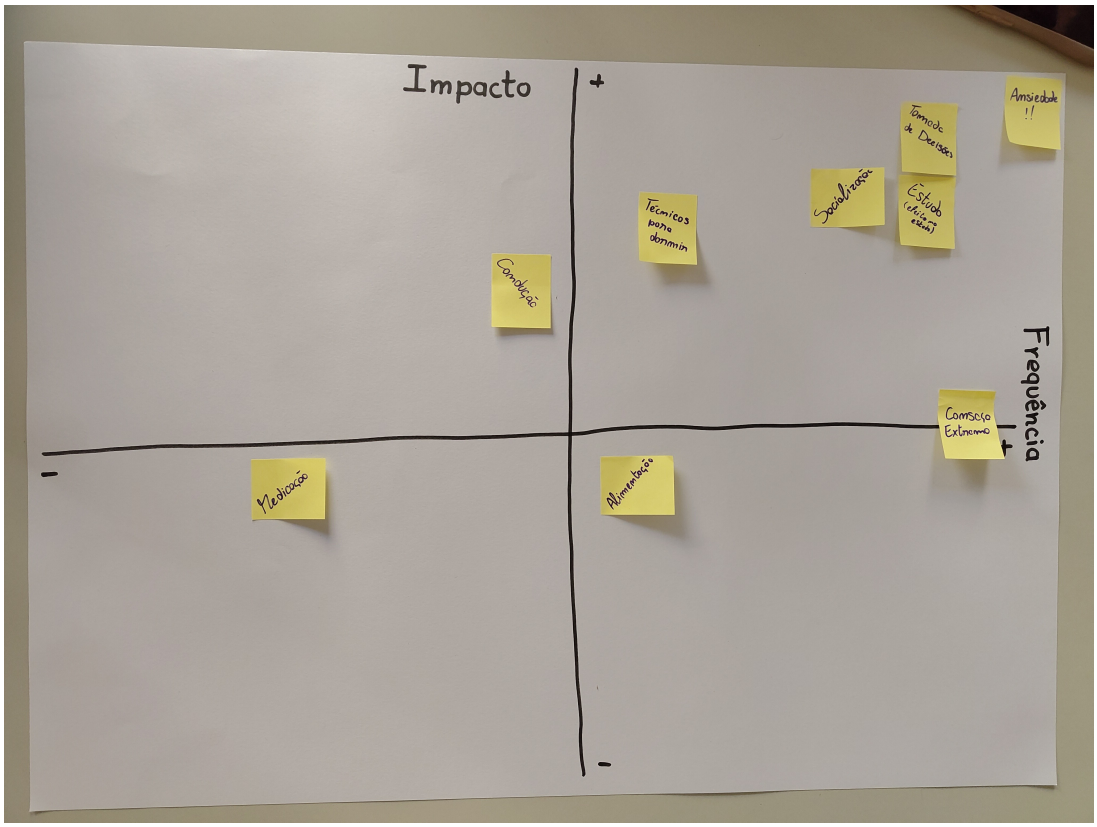


Fig. 6. Final state of the evaluation matrix, positioning each concept by the frequency and impact with which chronic insomnia affects it.

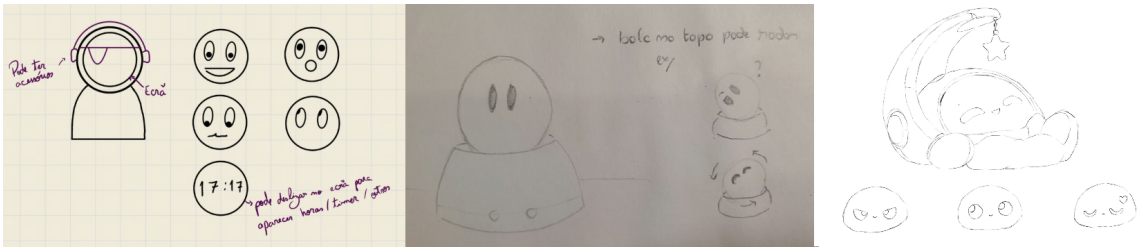


Fig. 7. The three ideas chosen by the co-designer, after parsing through all the design blueprints created by the team.



Fig. 8. Final design idea for the prototype, chosen by the team members with the consent of the co-designer.

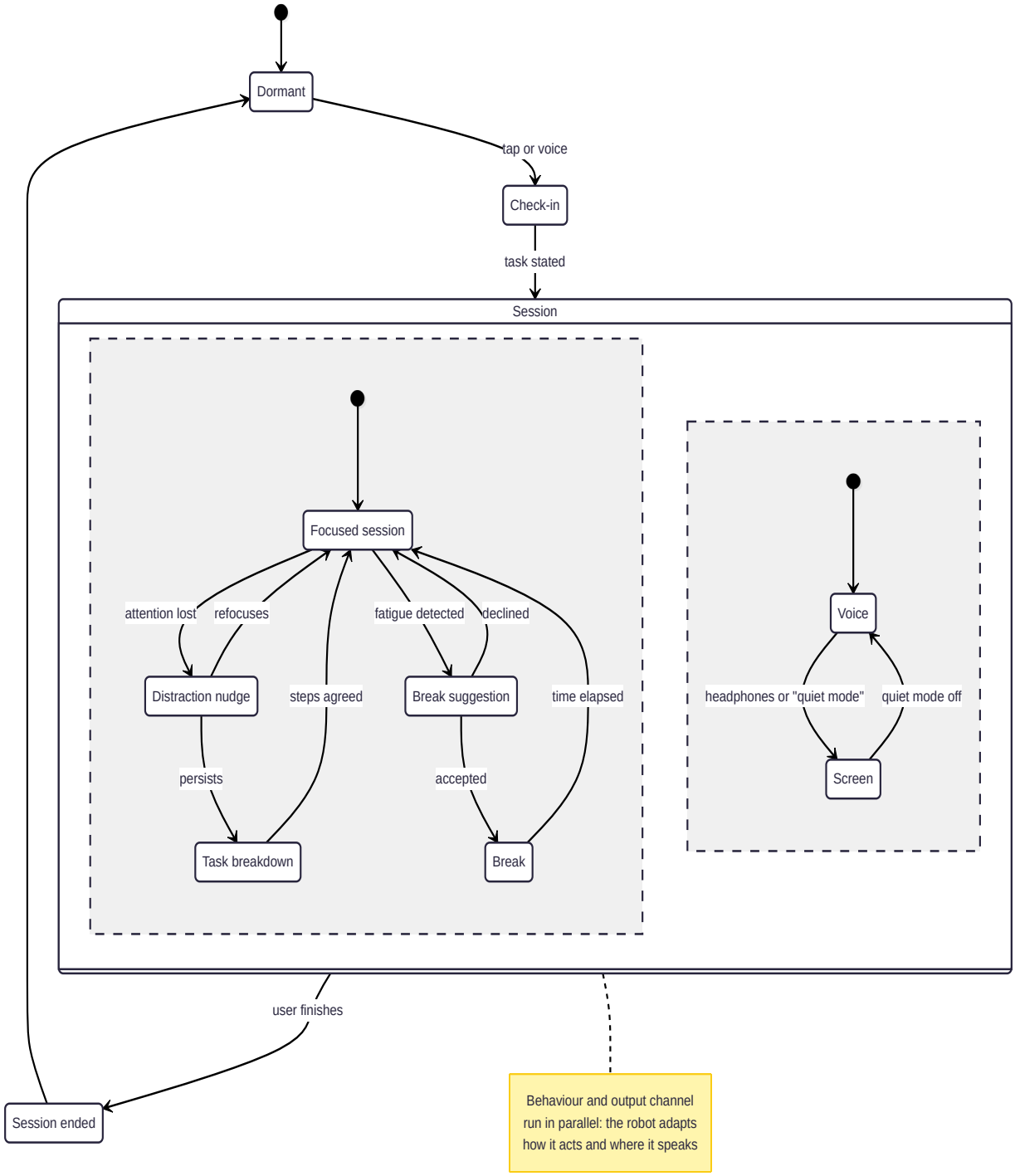


Fig. 9. State machine of Mylow. Within a study session, interventions escalate from a subtle nudge to a break suggestion and return to the focused state, the output channel runs in parallel and determines whether the robot responds through voice or on-screen notifications.



Fig. 10. Third co-design session, in which the co-designer handled the low-fidelity prototype while a team member walked through its behaviour.