Exploring Movement-Rich Behaviour with the MoMo

The Potential of Digital-Physical Artefacts in the Movement-based Design Process

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Abstract

Movement-based design is an upcoming practice in HCI that is interested in designing for sports and movement practices. Artefacts, such as design cards, are oftentimes used to facilitate movement-based design sessions. However, these cards may hinder and draw away from the desired explorative, movement-rich behaviours in the design process. This research explored whether design method cards can be complemented with digital-physical artefacts that invite meaningful movements in the context of movement-based design sessions. Therefore, we developed the MoMo, a digital-physical artefact that is designed to foster movement more directly than design cards. Augmenting design cards with a digital-physical body is a novel research contribution and has not yet been seen in related studies. The results of a pilot study show that participants can extract the designed behaviours from the digital-physical artefact and wield it as intended. However, the data showed that there was limited interaction between the MoMo and the design process. Overall, this thesis presents the design of the MoMo through a Research-through-Design approach, the results of a pilot study, and a discussion on the potential of digital-physical artefacts, as well as a reflection upon the state of the field.

Keywords: Digital-Physical Artefact, Movement-Based Design, Embodied Design, Design Method Cards

1 Introduction

There is a growing interest in Human-Computer Interaction (HCI) to develop technological solutions for sports and movement practices [1, 43, 68, 57]. Movement-based design (MBD) is a design practice that is particularly interested in this since it places bodily experiences and movement at the core of the design process [57, 38]. During a movement-based design session, participants explore the movement of their bodies to gain experience, understanding and creativity, which leads to richer design knowledge [1]. This can be applied to design more fitting solutions in fields such as sports, health, play and rehabilitation.

A movement-based design session has several characteristics that contribute to a successful outcome. Andersen et al. defined these different elements as, e.a., playfulness, sensing, experimenting, and enacting [1, 34]. A study by Segura, Vidal, and Rostami affirmed the importance of play [68] in MBD, and described social play as an essential element that includes exploration (being open for newness), building (engaging with hands-on experiences with the design materials), and acting out (engaging in first-person perspectives) [68]. Other studies also described how knowledge stems both from the bodily senses and from the experimental findings that come through action and the experiencing of its consequences [84, 1, 83]. This leans on the embodied cognition theory, which believes that we do not only use our brain as an information resource. Rather, we tap into the information provided by our brain, body, environment and the relation between these aspects, such as the movement of our body through the environment [83, 84]. Overall, these characteristics of movement-based design help people to physically engage fully and openly, which benefits the outcome of the MBD session [34].

A movement-based design session can be supported by different types of artefacts. Props, such as playthings (e.g. balloons, toys, ropes, balls), crafting materials (e.g. paper, cardboard), or other tinkering materials have the ability to stimulate exploration among the participants [68]. Design cards are another type of artefact used to stimulate movement-rich exploration through their capacity to introduce a wide variety of design cues or methods [44]. A study by Khalid, Elbæk, and Kane showed that there exists a wide variety of design method cards for MBD [44].

1.1 Context

More recently, the Erasmus+ project "Method Cards for Movement-based Interaction Design" (MeCaMInD)[1] developed a set of card-based methods to make MBD more practically available to designers and researchers. This project is a collaboration between six European universities, financed by a Erasmus+ EU grant, aimed to provide (hands-on) knowledge on movement-based design for researchers and designers.

The MeCaMInD project believes that it is essential to involve movement in the design process when designing sustainable movement technologies and concepts. This will in turn benefit the health and well-being of people in Europe[2]. However, this requires people to have sufficient knowledge and skill to design *with* and *for* movement. To address this knowledge gap, the MeCaMInD project gathered existing methods and approaches into an actionable toolbox. The toolbox provides instruction cards so that people can apply the MBD methods through step-by-step explanations. The toolbox also includes design cards to facilitate a range of design activities. This allows people to apply the MBD methods in their own workshops.

The project thus builds upon embodied- and movement approaches that view the moving body as a 'creative material that requires physical exploration and can generate unexpected responses and insights' [80, 50]. This philosophy was used to develop the MeCaMInD design card set, which allows researchers or designers to apply movement-based methods in their own MBD workshops. These cards are not restricted to a certain profession, and can thus facilitate all

[1] https://www.MeCaMInD.eu/

[2] https://erasmus-plus.ec.europa.eu/projects/search/details/2020-1-DK01-KA203-075164

kinds of MBD workshops where the researchers or designers are working on their own design challenge. As an example, a MBD workshop at Uppsala University used the MeCaMInD cards in a workshop to design new technology for at-home rehabilitation.

The card deck, see Figure 1, exists of five different types of cards: Mood Setters, Movement Methods, Movement Concepts, Modifiers, and Instruction Cards[3]. The mood setter cards provide activities to create the right atmosphere in the group through icebreakers, warm-up and team-building exercises. The movement method cards describe MBD methods for ideation, evaluation, sensitising designers, or documenting ideas. The movement concept cards provide bite-size knowledge from various MBD-related fields. The modifier cards provide design cues to tweak the design activity and to find new perspectives and concepts (Figure 2) during the design process. The instruction cards provide explanations for the different cards, suggestions for music or props, and facilitation guidelines.

In a MBD workshop, it is desired that the users are able to give themselves over to unrestrained physical exploration. The modifier design cards aim to assist with this and facilitate movement-rich exploration. However, preliminary research of this thesis found that people might find it difficult to fully engage physically in the workshop, and that design cards might have adverse effects. Observations suggested that card-based artefacts may limit free exploration of the body, hinder iteration depth, and tie the user back to a static place (which is in-depth explained in Section 3). Modifier design cards thus seem to draw the focus away from a movement-rich setting that is required in a fruitful MBD workshop. These findings might harm the effectiveness of the MeCaMInD design cards and, more generally, other card-based design methods in MBD. Since MBD is such an upcoming field, it is valuable to have a closer look at how we can better apply design method cards. This can hopefully improve the way people use MBD in their design practices.

1.2 Objectives

In this thesis, we are thus interested in participants in movement-based design workshops that are facilitated by design cards. As an example, these participants could be researchers or designers aiming to solve a challenge in a movement-related field, such as rehabilitation or sports. They partake in design exercises that use body movement as a medium through which the design challenge is explored. However, participants might have a difficult time fully using their bodies and movements and might not feel comfortable. In addition, the proposed MeCaMInD design cards might not help the participants to overcome this, and instead hinder them from physically exploring.

[3]https://mecamind.eu/order.php

Experts noted that silly or funny icebreakers might help with this issue since they provide an 'excuse' through which people can start moving. Similarly, this thesis will explore if a physical artefact can provide an 'excuse' or medium through which people can feel more comfortable using their bodies. This artefact could provide a safe framework through which people can start moving. For example, the shape might encourage people to hold it and twist their body, leading to the experience of different postures and ways to balance. These interactions could offer the user an accessible way to get started with using explorative movements, which stand at the basis of an insightful MBD workshop.

Therefore, the aim of this thesis was to explore how artefacts, an often used design material in MBD, can be used to enrich design method cards and help people engage physically in MBD workshops. This led to the following research question: *'What is the potential of a digital-physical artefact to stimulate physical exploration in Movement-Based Design Sessions?'*.

1.3 Approach

To answer the research question, we developed the MoMo (Movement Modifier), a digital-physical object that aims to modify the movements that one employs in a MBD workshop. The digital dimension of the MoMo aims to make two elements of movement, magnitude and direction, more tangible. These movement actions are embodied in various interactions that can be explored with the MoMo. The shape of the object is designed in such a way that it contains movement potential, such as wiggling, shaking, holding, or stroking. The MoMo also incorporated the strengths of design cards, their ability to provide a large variety of design cues, into interactive audio prompts. These three layers aim to strengthen each other and encourage the user to explore movement alongside these dimensions. More concretely, this means that the user interacts with the device through physical movements/interactions. For example, the shape might stimulate the user to hold it and rotate their body from left to right. The digital dimension could stimulate the user to rotate faster or slower, which already induces a physical experience that might add to the design process. The design cues can add an extra link to the design process. For example, it could give a design cue with the emotion 'anger'. The user might follow by rotating their body very fast and forcefully or continue exploring different emotions and their effect on the body movements. In this way, the MoMo is designed to encourage movement exploration and be an effective alternative to the design cards in MBD.

This study employs a Research-through-Design (RtD) approach, which utilizes design practices to generate a research outcome [30]. Research and scientific knowledge are synthesised into a functional prototype, to reflect upon a complex and in-concrete problem [40]. In this thesis, a speculative

Figure 1. The design card set from the MeCaMInD project (Image from the MeCaMInD website)

Figure 2. A few examples of the modifier cards from the MeCaMInD card deck (Image from the MeCaMInD website)

prototype, grounded in research, is developed and evaluated in a real-world context to provide more insights on how we can design for movement in MBD. A RtD process allows for many iterations of the research artefact, leading to new reflections and more refined knowledge over time. We recognize that our process will be limited by the thesis' time span rather than by reaching a certain state of the design.

The design practice from the RtD process is structured around a design thinking approach. This is a non-linear, iterative process that moves between the 5-stages: empathize, define, ideate, prototype, and test [51, 85]. This thesis will follow this design thinking approach and the process is visualised in 3. It includes a literature review focused on the state of the art of the MBD field (empathize, section 2); semi-structured interviews with MBD experts (Define, Section 3) and an iterative design process to develop the MoMo. This iterative design cycle includes the development of low-fidelity prototypes, early pilot testing, a second iteration of prototypes (Ideate and Prototype, Section 4), and a testing phase during a design workshop with HCI master's students from

Uppsala University (Test, Section 6 and 7). Finally, in Section 8, we discuss the potential of a digital-physical artefact in the MBD field, as well as challenges with facilitation and bodily design that are present in the field.

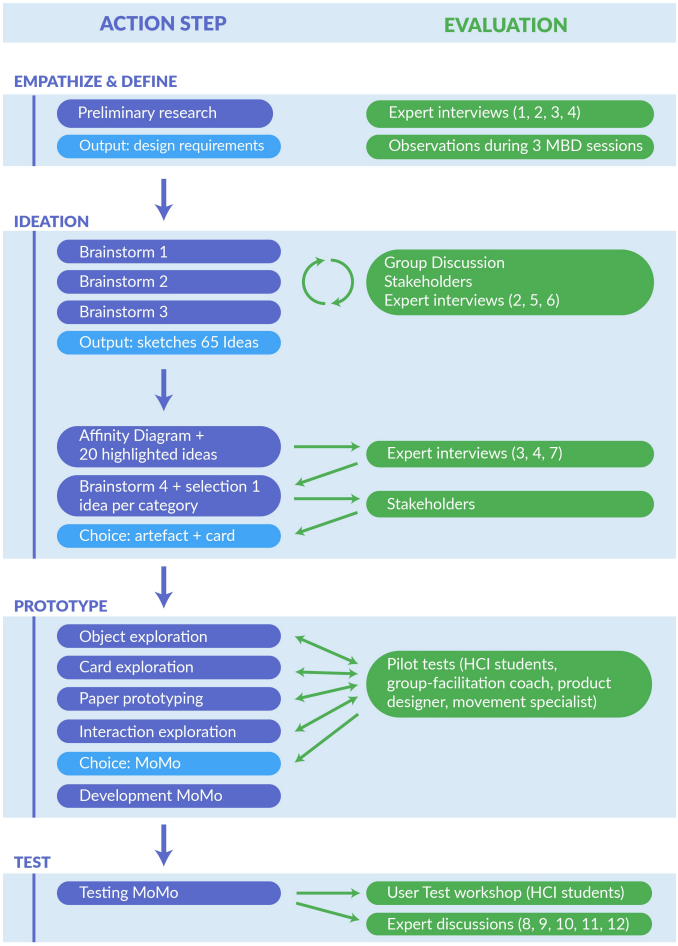


Figure 3. Overview of the design process flow, including action steps and evaluation moments.

2 Related Work

In order to place the later design decisions and processes from this study in context, it will help to have a basic understanding of how we can facilitate and design for movement in movement-based design. We will therefore explore topics related to movement, design of artefacts, MBD, and other related fields. In this way, the following section aims to provide an appropriate knowledge basis, where extra focus is placed on keeping the information compact and grounded in a rich amount of resources.

2.1 Theories in Design

There are different theories which apply to our thesis. Here, different fields are acknowledged to portray where this thesis is situated.

Embodied Cognition

Embodied Cognition is a theory describing the way people think, behave, and make sense [22, 80, 84]. The theory developed as a reaction against the dominant view of Cartesian dualism, where the brain is seen as a 'machine' that receives input and produces an output. Embodied cognition takes the perspective where the brain, body and environment together form a cognitive network where sense-making happens. This includes not only the brain but also the bodily senses and relations between the body and its physical and social context. One perspective in embodied cognition adopts the view that tools and artefacts do not directly represent meaning, but rather the meaning is made when they are incorporated in the context of a social setting, with elements like social roles, culture, norms, etc [22]. This is called socially situated practice. Another trend in embodied cognition disagrees with the notion that humans internally represent and plan actions [22]. Rather, humans navigate the world by continually using the senses and their direct interaction with the environment. This perspective is called sensorimotor coupling and enactment. Related is the notion of an affordance, which describes 'the way the world shows up for a perceiver as directly affording some action, based on the sensorimotor coupling in place' [22, 35]. Also related is the notion of enactment, which describes how we can create meaning in the world through sensorimotor couplings [22, 84]. So, meaning is enacted through action-perception couplings, that are maintained by ongoing interactions between our body and the environment. Research by De Jaegher describes that 'Sense-making plays out and happens through the embodiment and situatedness of the cognitive agent: her ways of moving and perceiving, her affect and emotions, and the context in which she finds herself, all determine the significance she gives to the world, and this significance, in turn, influences how she moves, perceives, emotes, and is situated.' [19].

Movement-based research

There are several disciplines of design research that have a movement-based focus, building upon bodily practices, such as somaesthetics, movement-based interaction and movement-based design. This thesis is predominantly focusing on the latter since it is done in the context of an existing movement-based design project (the MeCaMInD project). Movement-based design builds upon the belief that it is essential to involve movement in the design process when developing new practices, artefacts or interactions for sports and physical activity [80, 25]. It involves both designing for movement,

as well as designing of movement. In both cases it is recommended to use bodily movement as a medium and use the experience that follows as design knowledge [62]. The body is viewed as more than just a physical entity in the environment. It is a sensing body that creates meaning by interacting with objects, the environment and other beings. These dynamic interactions, as well as play and playfulness, are the breeding ground for creativity in the MBD design process [62, 25]. In this, we can also recognise embodied cognition theory. Common practices in MBD included bodystorming, embodied sketching, service walkthrough, experience prototyping, and others [68, 83]. Also common in MBD sessions, are the usage of artefacts or materials, and the guidance of a facilitator, which will be further touched upon in Section 2.3.

2.2 Our Place in the World of Movement

As stated earlier, movement-based design uses body movement as the primary tool to explore a design challenge. Since movement is such a broad term, it is valuable to zoom out and explore the different lenses through which we can look at movement. This section will shortly go over different movement-perspectives, and discuss which are relevant in the context of this thesis. The different perspectives are established after a feedback session with one of the thesis' supervisors, as well as through a brief literature review. Literature was searched on the literature database 'ACM Digital Library'[4], by means of an iterative search process. Including the following search words: influence movement on health, influence physical activity on learning, movement and education, bodily knowledge, social aspects of physical movement, emotional aspects of physical movement, embodied experience of movement, movement and identify, the self and body movement, skill and movement, movement and creativity, and design and movement. Articles were selected in an iterative process, where references and citations were used as new starting points. The findings were clustered, and the following seven perspectives were abstracted.

1. *Movement for movement*
   Movement can be performed for the sake of movement or physical activity. This includes taking part in sports or fitness, with a focus on pure bodily exercise. Looking at movement in this context, we can see that it is associated with endless positive health markers, both physical and psychological [18]. Movement improves physical parameters such as cardiovascular fitness, bone strength, muscular functions, metabolic balance, or healthier organ systems [37, 18, 24]. Factors related to psychological health include improved brain functioning, cognitive functioning, improved mental health, self-efficacy, or perceived competence [37].
2. *Movement and skill*
   Movement can also be looked at as a form of bodily knowledge, in the light of skills and skill acquisition. This includes aspects such as muscle memory, reflexes and automatic behaviour [66]. For example, a piano player that has mastered a musical piece and is able to play it 'from his fingers' [66]. A study by Rominger et al. also showed a positive relation between physical activity and performance gains in cognitive skills like speed/accuracy tasks and memory tasks [63]. They further noted that physical movement induces an improved creative performance.
3. *Movement and the self*
   Tsakiris writes that 'The self is first and foremost situated within a body' [76]. Our perception of self and our identity are thus deeply rooted in the body's interactions with- and movements in the world [66, 76]. Two fundamental aspects of this, are a sense of agency and a sense of ownership over the body [76, 74]. The way we move also communicates to ourselves who we are, as well as it links us to others. Our way of moving is strongly dependent on our social environment, since this influences our posture, movement and expression [66]. These behaviours are not 'natural' but are rather learned through the norms and appropriate behaviours that are set by the social environment we are part of.
4. *Movement and emotion*
   Movement can also be looked at through the lens of emotion. Movement can provoke or generate emotions: for example, feeling pleasure while running, or feeling pain when performing a movement wrong. Scheer writes that: 'Experiences of emotions are very often described as a merging of body and mind, as a physical involvement in thought' [66]. Movement also plays a role in understanding and simulating emotion, or enhancing and predicting emotion [66, 69]. Performing certain movements that express an emotion can be used to 'enhance corresponding affective states and therefore could be used for emotion regulation' [69]. The study noted that 'feelings and attitude are affected by changing muscles and joints through adoption or mimicry of a certain facial expression, posture, head movement, muscle contraction, or certain expressive whole-body movements' [69]. Movement can therefore be valuable in emotion regulation by decreasing negative emotions or increasing positive emotions through the corresponding motor behaviours.
5. *Movement and social interaction*
   Movement plays an important role in our social world, through interaction, communication and language [61]. Body movements and experiences are used to simulate information from other's bodies and face about their feelings and emotions [61, 69]. Nonverbal emotional displays are very important in social interactions since

[4] https://dl.acm.org/

they communicate emotions, feelings, and meaning [69]. Both facial expressions as well as bodily expressions (movement, posture) play a very important role. This sensory-motor simulation helps us to 'recognize, understand, and respond to the emotion' [61]. This is not only important for the perception of other's social state, but it also influences our own emotional state [69]. Movement can also be found in our language, through conversation gestures, or in our vocabulary. For example, through metaphors such as 'my blood is boiling', or 'I can sense your thoughts' [66]. Another study by Wilson and Golonka complements this and writes that 'catching a fly ball and talking about catching a fly ball are two different kinds of tasks' [84].

6. Movement and goal-directed behaviour
   Movement can also be practically looked at through whether or not a goal is achieved. This goal-directed behaviour uses intentional movements to evaluate and carry out actions that work towards achieving a goal [72]. For example, the movements needed to make a cup of coffee, or the daily movements an elderly person is able to perform. This is in contrast to reflexive, non-goal-oriented movements [74].
7. *Movement and cognition*
   Embodied cognition (EC) centres around the idea that the thinking cycle happens both in brain, body and the environment [84, 75, 58]. It thus goes against the more traditional view of a mind-body split. Embodied cognition uses the notion that the quality of cognition is dependent on how well all the available resources are used for processing, including movement of our bodies through the environment [84, 75]. This perspective on movement thus assumes movement can have the purpose of 'provoking, extending or enhancing thinking' [75]. As an example, a study by Sixtus et al. noted that adults performed better in mental arithmetic when it was linked to physical body movement [70]. Other studies also found an improved learning capacity after physical activity [18]. Overall, it was stated that body movement was linked to 'an ability to support, increase, and re-activate the cognitive processes useful for each type of learning'[18].

With this overview of different lenses, we can better specify what type of movement we are designing. The overview also provides us with a vocabulary to reflect upon the design. Movement-based design is about designing with movement in order to achieve design knowledge. This finds resonance within *Movement and skill* (creative performance), *Movement and the self* (personal experiences, listening to the body), *Movement and emotion* (feelings, emotions, experiences that come up), *Movement and social interaction* (designing together with others, in a social setting), and *Movement and cognition* (knowledge and understanding through brain, body and environment).

We can thus now look at the broader term 'movement', as it is used in this research, with more color and nuance. A research focused on the separate movement types was out of the scope of the research, and therefore the remainder of the research will talk about movement in the broader sense, encompassing these five movement perspectives.

2.3 Facilitation in MBD

A facilitator is a guide that helps participants reach the design goal of a workshop and, in MBD particularly, helps them use bodily exploration in the design process [16, 73, 81]. Since a digital-physical artefact adheres to this same goal, although through different means, we can reflect upon the role of a facilitator in the light of a facilitating digital-physical artefact. An extensive literature review on facilitation was performed during the Research Topic phase of this thesis. The review is built up by Grounded Theory from existing literature and finished with a large map of all the facets of facilitation. A top-level overview of this map with the different facets of facilitation is shown in Figure 4. This section summarises the main conclusions from the review that are relevant for digital-physical artefacts, whereas the full review is added to Appendix F. The full review also includes more details on the Grounded Theory process and the formation of the themes.

Practicum The literature review showed that most of the aspects that contribute to a successful MBD workshop require thoughtful preparation, planning and critical thinking upfront. These preparation elements are divided into structure, tools, environment and method.

Materials are an often used element in a MBD workshop, such as technologies [39, 48, 56, 83, 27, 36, 27, 15], craft materials, or design tools (such as design cards) [65, 29, 17, 27, 83]. These tools are used as media to explore, express, discuss, reflect or transfer thoughts [65, 29, 17, 27, 83]. In movement-based design, movement itself can also be seen as a tool that is used in the process. In the case of this thesis, we are interested in an artefact that can help people to better use this movement tool. The literature review also brought up that it should be questioned how exactly the artefact will serve exploration, reflection or discussion, what its role in the workshop is, how much attention or energy goes towards it, and whether or not the tool could have unintended side-effects.

It can be scary to act out in a new environment with new people [62]. Therefore, the mood and energy in the room should be facilitated for the best possible participant commitment and engagement [62, 71, 27, 48, 32, 60]. The facilitator can do this by suggesting changes to different elements of the workshop, e.g. structure, content, mood & energy, playfulness, group dynamics, stage engagement [62]. For example,

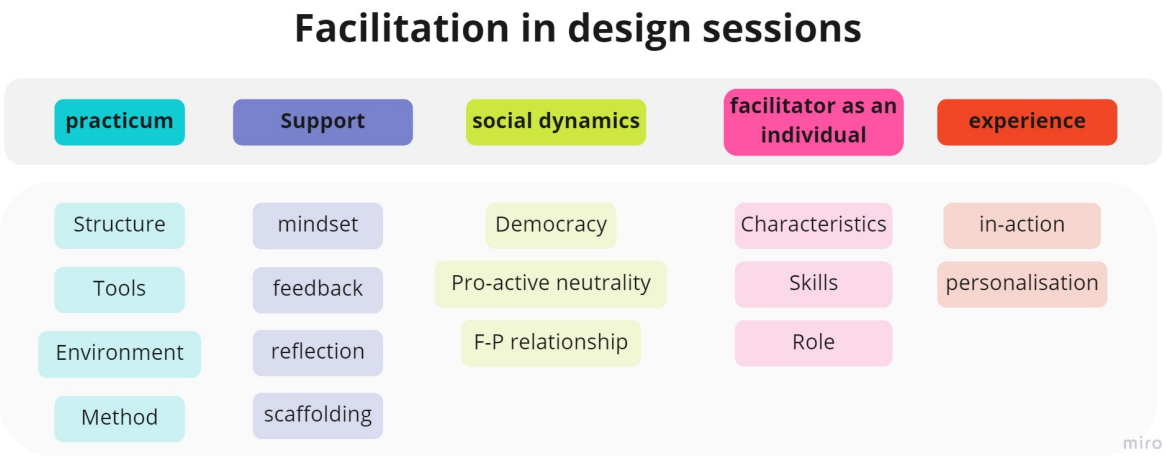


Figure 4. A high-level overview of the different facets of facilitation.

the facilitator could change the content of a design activity and make it more challenging, when he sees that it is too easy for the participants and their engagement reduces. In the case of a digital-physical artefact, we believe that it can be designed to facilitate content (through design prompts and by initiating movement-focused interactions), playfulness (through its shape and interactions) and engagement (through its shape and interactions).

Support The most prominent factors that influence the impact of the facilitator on the design process are the ability to provide support through scaffolding, feedback, and reflection.

A facilitator can apply scaffolding by progressively exposing the participants to more complex materials or tasks to close the gap between their current and needed abilities [42, 27, 32, 62]. The scaffolding process can take place through increasing the complexity of activities, materials, technologies or questions [27, 48, 82, 32, 17, 62, 36]. Having this in mind, an artefact could thus also implement scaffolding steps by increasing the abstractness or difficulty of design cues. We could also include the artefact in warm-up exercises to create familiarisation with the object.

A facilitator can provide feedback through in-action responses e.g. encouragement, examples, or reflective questions and discussions [71]. Reflective questions or initiating discussions can help the participants become aware of their senses, experiences and feelings so that they can use this as design knowledge. Feedback should be delivered in the context of an immediate experience, through both words and actions [71]. The facilitator should also step in and out of the design process of a group, provide appropriate & personalised responses, and reflect upon the effect of the feedback afterwards [17].

By learning this, we can seek to apply the support principles in the design of an artefact. Through its movement sensors and feedback modalities, the artefact has the strength to provide ongoing, instant feedback on the movement-rich interactions. For example, if people rotate the object, it can give instant audible or visual feedback. Although a facilitator can also provide feedback on movements, an advantage is that an artefact can be used independently by the group. There can also be multiple artefacts present, providing groups with ongoing, continuous feedback. In this way, it could assist the facilitator and provide extra facilitation to the participants. However, it could be a challenge to provide appropriate, personalised feedback that fits the needs of the participants. It might also be more challenging to provide fitting remarks, questions or reflections.

Social Dynamics The atmosphere in the group is very important for creative processes. One thing that influences the atmosphere in the group, are disrupting asymmetries in the social dynamics [17]. An example of unequal social dynamics was given by Dahl and Svanæs, where the opinion of an older physician was, without discussion, favoured over the opinion of a younger nurse [17]. Factors that relate to the social dynamics are the power distribution between parties and the neutrality of the facilitator.

The facilitator has a role in balancing unequal power distributions. In their research, Dahl and Svanæs noted the importance of this, and stated that safe and equal power distributions are a fundamental principle of designing with participants, such as participatory design [17]. However, this is not always a default property of design sessions. The facilitator can influence the power distribution by taking active action to equalise asymmetric power relations between participants and perform reflection-on-action on his own actions and non-actions [17, 86, 71].

The neutrality of the facilitator can be influenced by adapting equidistance, fairness and impartiality. This will help to balance the people, process and content of a workshop[86, 81]. Being a neutral facilitator will benefit his relationship with the participants. This relationship is also influenced by the participants' perceived trust and transparency of the facilitator [67, 49, 62].

Reflecting upon these topics raises the question if an artefact can influence the complex power distributions of a group. Perhaps this requires a more nuanced human response by the facilitator. We can further learn that participants should have the feeling that the artefact is trustworthy and valuable to their design process.

Facilitator as an individual The characteristics of the facilitator are relevant since they influence how the method will be carried out [49, 81, 67, 17]. There are different types of characteristics, skills and roles that influence the impact of the facilitator on the design process.

Important characteristics of a facilitator include interpersonal abilities (exceptional communication skills, applying the LEAPS method, and showing flexibility, sensitivity and neutrality), managing the process (time, planning, and organisation), and certain personal characteristics (adaptability and emotional resilience) [49, 17, 62, 81, 60, 32, 29, 73, 71]. But also skills such as the ability to identify problems, perform reflection-in-action, design expertise, and the ability to act intuitively [49, 54].

Here, a human facilitator has the strength of having rich and nuanced capabilities, which allows for adequate reactions to unexpected situations. An artefact lacks these strengths and falls shorter on these nuanced characteristics such as emotional resilience and complex problem-solving abilities. However, it is good to understand these important traits since they could potentially be, to a certain degree, incorporated into the design of the artefact.

Experience The 'experience' entails the factors that contribute to the way participants experience the design session. The facilitator and the practicum work together to provide a (learning) experience for the participant. The design outcome flows out of this experience. There are two main factors that the facilitator can balance that influence how the participants experience the design session: in-action and personalisation.

'In-action' describes how something is happening *in the moment*. This includes in-action feedback of the facilitator (feedback applied in the direct context of the participants doing), the promotion of in-action reflection (participants reflecting upon their current feelings and experiences), the encouragement of exploration by doing (exploring open-minded, unexpected outcomes), and the facilitator's ability to manage the flow of the session (by real-time managing the dynamic changes in the people, the tasks, technology and interactions) [71, 48, 62].

Personalization is about observing the real-time participant state and adapting the session to their specific needs [71]. This can be done by looking at the emotional state of the individual participants, their attitudes and changes over time, and differences among participants regarding their skills and creativity levels. The facilitator can make adaptions after intuitively 'feeling' if the group is ready for adjustments on feedback, experiences, methods or support [71, 50, 62, 32]. This intuitiveness is sometimes also called 'having sensitivity' to the participants and the design process [16]. Other elements that the facilitator can adapt during the session are the communication pace, the structure, the activities, the critical questions that are asked, scaffolds, etc.

From this, we can learn that the design of a facilitating artefact can be strengthened by including timely, in-the-moment responses directly related to the participants' interactions. The artefact could also stimulate interactions that are relevant to the individual design processes of participants. This could be done through, for example, stimuli, cues or feedback responses that fit the context. However, it might be a challenge for the artefact to have the appropriate level of personalisation since the device is pre-programmed in a more general way that doesn't fit continuously changing levels of creativity, emotional states or social dynamics.

2.4 Artefacts in Design Thinking

In this thesis, we are aiming to design an interactive artefact that can stimulate explorative movement. Therefore, it is useful to look at related work in this area to see what we can learn from this.

Research by Halskov and Dalsgård concluded that design artefacts, such as cards (Figure 2) or more tangible objects, can influence the dialogue, argumentation and expression of participants [29]. This helps with fruitful cross-pollination of ideas and the stimulation of new experiences or playfulness, which is in line with the values of movement-based design [62, 68]. Even more so, artefacts can be key drivers in the ideation process of MBD [68]. They can represent 'affordances, constraints, and symbolism' which can serve as design input, or they can be moved and acted upon by participants. Other options are physical artefacts, digital artefacts and socio-spatial elements [68]. A combination of these dimensions is, to the best of our knowledge, not yet developed in the field of MBD. However, some research warned that technology could mediate an activity too dominantly and thus take the user's full attention [68]. Therefore, artefacts need to be carefully designed to manage the activity and the attention of the participants, which in turn influences experience and engagement. Related to this, is the design approach of activity-centric design [79]. Where there is a focus on designing an activity, rather than designing an object. This not only includes the (non-) technological thing but also the social and spatial arrangements [79].

2.5 Mind-wandering, Fidgeting and the Creative Process

At the start of this thesis, a preliminary study was done to explore how the modifier cards are used in a MBD session, see Section 3. This workshop also made clear that by introducing objects to a design session, people were inclined to start fidgeting with these objects. Therefore, it is interesting to look closer at research on fidgeting and its potential for the MBD process.

Mind wandering is described as a state where thoughts are unable to remain fixed on a single topic, particularly when engaged in attention-demanding tasks [55, 40]. This has undesired effects on decreased abilities e.g. attention, memory, focus, or learning. However, research also highlights the positive effects of, especially intentional, mind-wandering on creative processes [2]. A study by Baird et al. suggested that engaging in simple, undemanding tasks has the ability to facilitate creative problem-solving and enhanced overall creativity [2]. It further opens up space for reflection upon the self and others, and making new, abstract connections [40]. A study by Bruineberg and Fabry on absent-minded mobile phone usage, noted how mind-wandering can also be enacted through an external object [11]. This type of mind-wandering is thus projected outwards and is described as 'extended mind wandering' [11]. It can drift between being intentional and unintentional [11, 40].

Fidgeting can facilitate intentional, extended mind-wandering since it results in small, repetitive physical movements that are made with external objects [59]. Research by Baird et al. suggested that fidgeting through an object can enhance energy levels and arousal to maintain levels of focus and attention [2]. This could be explained by the theory of 'attentional anchors', which serve as a construction that provides a centre on which thoughts can be focused [23]. It is believed that fidgeting objects can serve as such an anchor, so that the wandering mind stays relatively close to this object, and only 'wanders' in close proximity of the object [40]. In this way, object-mediated fidgeting can benefit creative processes, attention, and engagement, and limit mind-wandering in unrelated directions. This helps the user to focus on the task at hand with more ease [26]. In this way, fidgeting with an artefact in MBD might help people to better focus on the design task, or to stimulate the creative process.

2.6 Technology for Movement

Since we aim to design a (partly) digital object, it is useful to look at the state of the art of other technological objects that are designed for movement.

We found that there are different studies focused on designing interactive systems to encourage movement [20, 36]. Research by Delden et al. developed concepts to stimulate movement in playgrounds [20]. In their study, different interactive systems augmented the space to encourage playful and movement behaviour. Other research by Van Renswouw et al. explored the design space of interactive environments to encourage physical activity behaviours to later design an interactive running system [78]. They distinguished between concepts based on their interaction modality (haptic, auditory and visual feedback, or elements related to storytelling, mindfulness, and guidance), and intervention strategy (triggering an experience through fun, gamification, performance, or social support). Ugur Yavuz et al. took a different approach, where they designed playful interactions through interactive, soft materials. The study concludes that soft materials can encourage a more intimate interaction between participants as well as open up a new range of bodily interactions such as hugging, stretching, and caressing [77]. All these studies took a Research-through-Design approach while focusing on different dimensions of encouraging movement.

Overall, studies interested in movement-based interaction expressed a need for 'tools to experience movement' and 'the interaction modalities to reveal the motivation and drive to move in response' to a task [13]. Tools enable the participants to take part in these kinds of movement-based experiences. This was illustrated by the design of the ´Bodyharp'; a technological instrument that encourages bodily interaction to create music[13]. Other studies noted that MBD experts are 'positive yet critical towards adaptive technologies, carefully accessing the affordance on whether the tool is suitable for the design' [57].

2.7 Designing for Movement

There are different studies that make a bridge between movement and design. From these, we've adopted the following three design heuristics, which can later be used in the design of an artefact.

1. This thesis aims to implement movement-rich actions in the design of an artefact. Every movement has a direction and a magnitude. Emphasising and embodying these two properties can be used to make movement more tangible. They can be measured by acceleration, which is derived from the second derivative of position over time, and is often used in HCI research focused on body movement analysis [45, 21, 14]. For this, we can use an accelerometer, which is a sensor that measures acceleration as well as orientation[5]. The design heuristic thus describes that: *emphasising and embodying direction and magnitude in the design of the artefact, by using an accelerometer, can make movement more tangible and approachable for the user.*
2. An artefact will be designed in order to stimulate meaningful movement during the design process. Therefore, it is important to understand the nature of the artefact and its action potential. Research by Bødker and Klokmose states that artefacts have a role of mediating

[5]https://learn.adafruit.com/adafruit-circuit-playground-express?view=all

activity and practices [5]. In this study, the artefact mediates between the user and the exploration of meaningful movement. The physical aspects of the artefact provide the conditions for the physical manipulation and motor functions it allows for. Bdker and Klokmose also state that 'the artefact is the meeting place for several activities and actions by the users ... and the artefact gets used through repertoires of actions and operations developed across these activities.' [3]. The design heuristic thus describes that: *the design of the artefact has to contain movement potential so that it allows for a rich repertoire of movement actions.*

3. Playfulness is an important aspect of movement-based design and it is valuable to see how this can be embodied into an artefact [62, 68, 57]. Research on the materiality of play has become more important in making tangible and embodied interactions [77, 41]. Different studies stated that textiles can contribute to new dimensions of play, by enhancing the tactile experience [77, 41]. As an example, soft materials invite caressing, hugging, stroking and touching [77]. Research by Giaccardi and Karana dissected the experience people have with and through materials into sensorial, interpretive, affective, and performative levels [28]. These experiences shape people's doing and practice. The pilot tests and expert discussions of this thesis, further discussed in Section 3, also suggested that the sensorial input of smooth materials, soft fabrics and a dynamic form can promote feelings of playfulness, safety, agility and tactility. This is especially useful in shaping the doing and behaviours of people in movement-based design. The design heuristic thus describes that: *the design should invite playfulness, which also includes using appropriate materials and textures.*

2.8 Conclusions

The related work section aimed to gather knowledge on how we can design an artefact that facilitates movement. This builds upon the movement-based design theory, which emphasizes using body movement as a creative medium in the design process, as well as including play and playfulness. We also abstracted several lessons from the literature study on facilitation. This was done on the basis of the five different facets of facilitation, including the practicum, support, social dynamics, the facilitator as an individual, and the experience. This review also highlighted different challenges a facilitating artefact could face, including personalised feedback, having awareness of the social dynamics, and providing appropriate in-the-moment responses. The related work study also touched upon the strength of fidgeting, and its potential for the creative process. As well as different design heuristics we could include, such as designing with the different dimensions of movement, including a variety of movement actions in the design, and designing for playfulness. In the upcoming chapter, we will enrich these theoretical findings with an additional empirical study.

3 Preliminary Study

Before starting with the development phase of this thesis, we are interested in the current ways in which designers, facilitators and researchers organise MBD workshops. Therefore, a preliminary study was done to map the common practices and challenges with movement-based design and design cards. This section will go over the findings from this pre-study and transform them into concrete design guidelines for the design phase.

3.1 Methodology

The design process steps from the preliminary study are shown in Figure 5.

Observations were done during 3 movement-based design workshops where the participants were using design cards (from the card deck developed by the MeCaMind project) that were specifically designed to guide the MBD workshop. Participants had diverse backgrounds (Chile, Dutch, Spanish, Swedish and Danish) and experience in either interaction design or movement. One workshop took place at Uppsala University and was held with members of the HCI department. The main researcher of this thesis also participated in this session. The session was recorded with multiple GoPro cameras to capture different angles of the room, including one body camera worn by a participant. The second workshop also took place at the HCI department of Uppsala University. The third workshop took place at a Danish high school with students from a sports class. The main researcher didn't participate in these last two workshops, but the video recordings were carefully watched and afterwards discussed with a researcher who was present at the workshops. The different workshops were all analysed by annotating the video clips of the different cameras. This analysis aimed at understanding the influence of the modifying cards during the design process and their potential limitations.

Semi-structured interviews were conducted with 4 experts in bodily movement design (3 MBD experts, and 1 improvisation-theatre expert) and diverse nationalities (Dutch, Danish, Spanish, Swedish). The interviews followed a set of prepared questions, see Appendix B, but left room for unexpected conversation leads [47]. The questions centred around the experts' experience with movement-based design sessions, facilitation and design artefacts. Verbal or written consent was received from all participants, and all interviews took place digitally. The consent form was reviewed and approved by the ethics committee of the University of Twente. They are also included in Appendix H. The audio recordings were analysed through the 6 phases of thematic analysis: becoming familiar with the data, generating initial codes,

searching for themes, reviewing themes, defining themes, and writing up [4, 52].

Figure 5. Overview of the design process flow, showing the preliminary research steps

3.2 Findings

This section will go over the findings of the observations and interviews. The main findings are discussed and summarised in a conclusion.

Observations

The observations of the different MBD sessions showed that the design cards didn't promote extensive movement. On the other hand, artefacts and other materials did stimulate physical exploration. They formed the main reason participants showed movement-rich behaviour.

In one workshop, the participants used three modifier cards at a time and changed the card configuration two times throughout the workshop. Once, a card was put aside because of the experienced constraining design cue. One participant mainly handled the cards, and placed them on the ground, in the middle of the circle. The other participants didn't touch the cards during the session. The participants formed a group around the cards and roughly maintained these positions and group order. Even when moving away from this spot, they would mostly return back to their original position. The placement of the cards also determined a 'middle point', around which the participants moved and came back. Once the cards were positioned, the participants physically bent forward to read the cards and stayed static to think. In the beginning, no conversation started. One participant, who had taken a facilitator-like role, prompted the participants to go and explore the materials: '*So where would we put this on our body? Come on, go pick materials!*'. Further along in the session, when the discussions fell silent, the participants tended to come close to the cards and physically bend forward towards them again.

The cards mostly served as input on which the conversation started. After that, it was mostly the participants that followed up with each other. Sometimes, the conversation would get close to the design cue of the card again, and the participant would acknowledge and name the card input. The cards were also used a few times when the conversation fell quiet. The participant who took on a facilitator-like role said '*Let's stay with this combination, but let's think of something completely different. What else can we do?*'. It shows that the cards were mostly used as a prompt upon which the conversation would continue upon. It also set the boundaries in which the participants could explore and ideate. A few times, one of the participants would draw the conversation back when it had drifted too far off of the cards, for example: '*But that is not feedback, it is sensing. Let's get back to things related to feedback.*' In another movement-based design workshop, the cards limited the participants to enter a reflective, iterative design process, where they would rush through the card deck without deepening exploration.

There were a variety of artefacts in the room. People often took one thing and played with it in their hands, while standing still. In these cases, the artefacts prompted continuous fidgeting. The conversation would mostly centre around one participant enacting an idea with the artefact, often the artefact he was fidgeting with before. The conversation that followed would lean strongly on that particular artefact. People tend to only move when testing out the artefacts to explain an idea.

The participants mostly made small movements and were mainly to enact a movement or idea. For example, touching the arm, moving it up and down, or squatting. The movements in combination with an artefact nudged the participants to reflect. '*Oh, this actually feels really relaxing, it numbs the pain in my knee*' or '*This feels really restricting, my muscle has no space*'. The other participants would follow up on these experiences. Ideas for potential solutions were thus built upon these experiences. Besides, the participants tend to move only in their own spot and they would mostly keep this spot for the whole design session.

Conclusions

So overall, the cards had the ability to prompt new design focus points, after which the conversation would naturally flow further. The participants would ideate and discuss together and would come back to the cards when the conversation fell silent. It was also used to set some boundaries on which the participants could lean on. This shows that the cards had value in guiding the ideation session. However, the cards themselves did not promote significant amounts of movement. They didn't invite the participants to work together or move throughout the whole room. The cards were also placed in a very static, and rigid manner: on the floor in the middle of the circle. This constrained the participants to stay in the same spot and drew them back to the middle point of the room. It was mostly the artefacts that helped the participants to explore movements. They also promoted fidgeting behaviour. Although the movements were not very innovative or outgoing, they were context-specific and part of the design process.

Interviews

The interviews from the preliminary study were used to form a better understanding of how movement-based design sessions look in general, and how experts prepare them. When looking at the total picture of a MBD workshop, experts highlighted two key elements to take into account: the desired end goal and the level of the participants. First, the end goal helps to determine the design challenge and how far the participants can come. Participant 3 (P3) noted '*I need to know where I want to get with them, so: what is the end goal I want to achieve?*' This also includes asking yourself if the outcome goal should be a refined concept, or if it should be an exploration of possibilities. This determines if the participants will mostly be diverging, or if there should be space for converging. Secondly, the participant's level of experience and comfort to engage in movement-based design determines the starting point of the workshop. This context determines the types of activities, and how far the process can reach.

P1, P2 and P3 all noted that warm-up exercises are essential to prepare the participants mentally, socially and emotionally. This gets them ready to act and engage physically, with each other, with the environment and with the resources that are used in embodied design methods. This step of preparing the participants is very important in creating the right mindset so that they are ready to engage. P3 stated '*It's really hard to start from zero 'I just got here' to 'I want to move and engage with each other'. You need to scaffold that engagement so that people feel safe, secure, and ready to act*'. P2 stated that the groups that took part in energizer activities showed much higher energy levels later on. They also explored and investigated movement and artefacts more.

'Scaffolding' is often used throughout the workshop, which means using smaller tasks or steps that progressively build up towards the end goal. This ensures that participants feel control and trust in the process. It is also common to include a scaffolded version of the main design activities and materials of the main design activities so that participants already build confidence, familiarity and sensitivity to those activities. The end goal of the warm-up phase is that the participants feel safe, comfortable, and ready to freely engage with the main design activity.

The main activity of the MBD workshop is often scaffolded with a progressive build-up towards the end goal. This allows the participants to feel like the activities make sense, they trust the process and the facilitator, and they build a sense of control. This feeling of control is very important so that they have a way out and '*feel and have control on how much they are going to share, how much they will engage. As they see that everything is okay, they move forward in the process.*' (participant 3). Trust is an important factor, and P2 noted that '*Only when people realised why movement was so important, they stated incorporating it more*'. There is also often a positive feedback loop that draws participants in, since engaging socially and physically gives a lot of energy back to them.

The expert interviews and the observations both showed that there is a large preference for workshops where artefacts have a central role. The artefacts or materials have a dominant position in the design exercises, and the participants are actively encouraged to explore and move *through* them. Furthermore, play and playfulness are very important during all design activities. It provides a common ground and framing an exercise as play gives an excuse to do things differently. This often helps participants to be awkward or do things they would normally not do. Here also lies the strength of silly warm-up exercises. Having already done embarrassing or awkward things, helps them to be looser in the main design activity.

When asked what a successful MBD session looks like, the experts noted that the participants would feel relaxed, they would use up the space in different ways, and they would move in ways they were not moving before. They interact with each other more, take up more space, and explore and experiment. They look weird and awkward and come up with ideas that materialise in embodied sketches. They use their bodies and the bodies of others to exemplify concepts. Especially in the moments that something doesn't work, people are using movements to explore and keep tweaking until they reach a solution. This physically moving together creates shared experiences, a shared vocabulary which people can refer back to and anchor ideation in.

The facilitator has an important role in pushing and challenging the participants with invitations to try different things. He also has the task of reading the room and noticing who is feeling more and less comfortable. Targeted prompts can help those who need them. The facilitator can also give pushes or invitations to try new ways. They can modify the direction of the group by suggesting small changes like '*What if we do it this way, or now this way? Or what if you have to hold hands while doing this?*'. It is a constant work of feeling what's happening and providing little pushes to steer the group. P2 noted that groups perform the best if the facilitator jumps in, challenges them, and constantly pushes with suggestions. Besides, the flow of a session must be designed and taken care of through taking breaks and changing the types of activities. For example, changing the design activities from strongly physically engaging, to more self-reflection, to documenting how you feel, and back to physically engaging. This modifies the energy and engagement in the room.

P3 always uses artefacts that can be put on your body, on the body of others or out in space. The format depends on the design goal, but there are often relevant and completely irrelevant things. Some props will align with the goals, and some are out of place. P3 noted that working with props or cards requires careful selection. This makes it easier for the facilitator to handle all the cards and find specific ones.

Facilitators should also be aware that the wrong cards at the wrong time can severely disturb the process. Besides, a facilitator should be intentional about what you bring to the session, when and how. People will want to engage with whatever is brought to the session, so it could slow the pace, or transform the focus and energy in the group. Both P2 and P3 noted that participants will go read all the available cards, which interrupts the process. This means the flow of the session needs to be steered by managing who, what, when and where things are brought into the space. It was also noted that props that are heavier in technology, require even more time for the people to explore and figure it out.

The experts were also asked about their experience with promoting movement in a design session. Their answers led to a valuable new insight, that more movement is not necessarily better, but it rather asks for more meaningful, explorative movement that is related to the design process. The movement has to come from a place of investigation, exploration and curiosity. All experts noted that the facilitator has an important effect on the stimulation of this type of movement by challenging the participants to try new things. This helps to provoke new experiences or lines of thought. It was also noted that there are many different ways to modify explorative movement. Instead of it only being the cards, modifiers can be in the facilitator, the space, the environment, the artefacts. Even the participants will start to become modifiers once they feel comfortable enough. This provided a new perspective that it's not only the design cards that can modify a session since there are many more elements in the activity that can suggest changes and new perspectives.

Conclusions

Two key elements in designing movement-based design sessions are 1) the desired end goal and 2) the participants. Warm-up exercises are crucial in ensuring a participant group that feels safe, comfortable and ready to move and engage. The main activity of the session is often split into smaller scaffolding steps that progressively build up towards the end goal. This ensures that participants feel control and trust in the process. Play and playfulness are very important during all design activities since this gives people an excuse to behave silly and unusual. In a successful MBD session, the participants would feel relaxed, move freely in the environment, and show movement to explore and experiment. They feel safe enough to move weirdly and awkwardly and engage in embodied sketches. The facilitator has an important role in pushing and challenging the participants with invitations to try different things. The facilitator also has to design the flow of the session, by intentionally designing the what, when, how and why of all elements that are brought into the session. According to one expert facilitator, the participants will want to engage with everything that is in the session. She further noted that it thus requires care and full consideration of what you bring into the workshop.

3.3 User scenario

The findings from the observations and interviews are used to write a user scenario. The scenes are taken from real observed situations, as well as situations described by the experts. This aims to give more colour to the potential user, their needs and how people take part in a movement-based design workshop. We will later come back to this scenario, to sketch the context in which our designed solution will be used.

Background

Four people, Alice, Bob, Carol and Dave, take part in a lunch workshop from their university. The workshop is part of a seminar series on shaping the health care of the future. This particular workshop wants to give the participants a practical introduction to designing new and innovative healthcare solutions. It is given by a teacher from the "Embodied Interaction" course.

During 2 hours, they are tasked with designing a chair that promotes movement and active engagement for elderly people. The design activity for today's session is "Embodied Sketching", aimed at ideating and conceptualizing their chair design. As a handhold, the teacher introduces a set of Modifier design cards from the MeCaMInD card deck. The participants can use these during the design process. All the cards are placed on a table in the middle of the room.

All participants are split into teams of four, and Alice, Bob, Carol and Dave together form a group. They each have different backgrounds:

- Alice (31): A creative designer with a background in industrial design. She feels comfortable with designing and using different brainstorming methods. She also has some experience with MBD. Although she always feels a bit awkward when starting, she often loosens up over time.
- Bob (25): An engineering enthusiast interested in human-computer interaction (HCI). He is interested in design, and has a little bit of experience with traditional ideation methods, but is new to MBD. He feels a little stiff and awkward.
- Carol (28): A healthcare professional specializing in gerontology. She is new in the design field and feels unsure about using her body. She likes dancing and has no trouble moving, but she is a bit intimidated by the experienced designers in her team.
- Dave(39): An experienced HCI researcher with a focus on user-centered design. He has more experience with movement-based design than the others, and he feels like he has to set an example to make the others feel comfortable.

Motivations

Since the participants all come from different professions, they are driven by different motivators:

Alice is motivated by her passion for creative design. She seeks to come up with innovative and aesthetically pleasing solutions. She really likes the focus on 'healthcare for the future', and she wants to push the boundaries of a traditional chair design. She feels like this is really upcoming field, and is enthusiastic to dip her finger into it.

Bob is interested in improving his knowledge of design methods. Movement-based design is new to him, and he is curious, although a bit nervous, to try it out. He has less interest in designing something futuristic, in his opinion, chairs should mostly be safe and functional. He is quite realistic, and with his technical knowledge, he quickly knows whether or not a new design is feasible.

Carol is motivated to improve the well-being of the elderly. She is really interested in how new chairs can be designed, that improve comfort, mobility and quality of life of elderly users. Her background in healthcare fuels her enthusiasm for this workshop.

Dave is really interested in user-centered design principles, always looking for ways to improve his knowledge. He often follows workshops and seminars about these topics, and he is eager to participate today as well. He is happy to apply his knowledge of design to the topic of the workshop.

Context

At the start of their Embodied Sketching exercise, the group is a little hesitant to start. Dave decides to open up the discussion and picks out four Modifier Cards. He places them on the floor, in front of the three others. Alice, Bob and Carol come closer, and they all form a circle around the cards. They bend forwards, to read the small letters on the cards. 'HR-monitor', 'Feedback', 'A tree in the wind', and 'Counter', they read. They all start thinking about these design cues, both Alice and Bob are bent forwards, resting with their arms on their legs. A few minutes later, Dave takes a big pilates ball

Figure 6. Left: the team exists of Alice, Bob, Carol and Dave. Middle: Dave shows the four Modifiers he picked out. Right: the group stares at the cards, not sure how to start

from the room, holds it above his head, and says '*Come on guys, let's take some materials to explore!*'. Bob and Alice also get a robe and some fabric, before they return to their spot in the circle. While they start fidgeting with the materials in their hands, Dave starts to think out loud with his Pilates ball. He enacts a bouncy chair that softly rocks you from side to side. *'He'* shouts Carol, *'that looks like the card 'A tree in the wind"*. The conversation continues around this idea, while Bob enacts the new suggestions that come up. The others remain inactive in the circle, fidgeting with something in their hands. After a while, everyone is looking at the

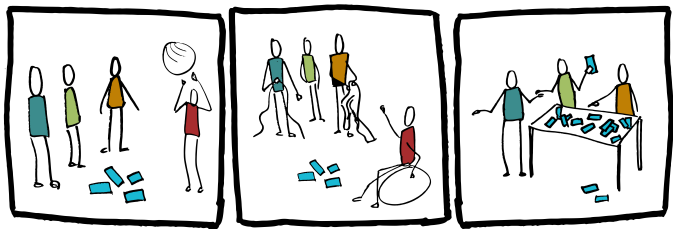


Figure 7. Left: Dave picks up a big ball. Middle: Dave starts enacting an idea with the ball, and the others start fidgeting. Left: the group is discussing which new cards to pick

cards again. Bob suggests that the group refresh the cards. Everyone walks towards the table of cards, and they start discussing the different modifier cards. 'Perhaps *'assymetric'?*' suggests Bob. *'Or gymnastics, that has to do with being active'*, offers Carol. They continue to discuss the cards until Alice suggests *'this is taking too long, let's just blindly take four new cards okay?'*. After taking the cards, and thinking about them for a bit, Bob remarks that the cards are quite difficult. He offers to exchange two of them, and he returns with the new cards 'physical play' and 'hitting'.

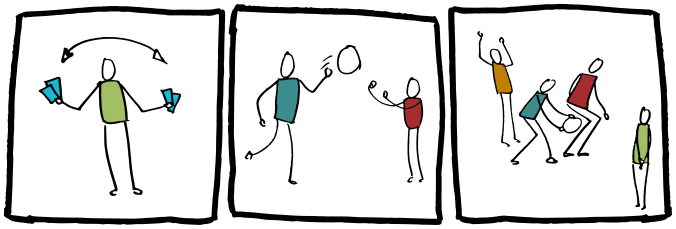


Figure 8. Left: Bob proposes to switch the cards again. Middle: Alice starts playing a ball game with Dave. Right: Alice, Carol and Dave start enacting and exploring with the ball, and Bob has trouble joining in.

Ten minutes later, Alice walks back to the materials table, she places back the rope she was fidgeting with and picks up a foam ball. She is finally starting to feel more loose in the group. She starts throwing the ball in the air, and then unexpectedly throws it to Dave. Dave has to laugh and catches it. He throws it back to Alice. After a minute, Alice gets an idea. She presses the ball underneath Dave's knees, and suggests *'What if it is an inflatable chair?*' Dave gets enthusiastic and starts enacting the solution. Carol gets enthusiastic too, and

offers them some insights into how elderly people experience difficulty standing up and getting seated. She enacts it while squatting up and down, pointing to her knees and ankles. While they are getting in the flow, Bob still feels a bit awkward. He is not used to using his body in this way, and he keeps fidgeting with the fabric in his hand.

Problems and Needs

In this scenario, the participants encounter different needs and problems. In the beginning stages, the cards didn't promote movement or exploration. It was due to Dave and his initiative to pick up a Pilates ball, that the group started discussing ideas. The cards were placed in the middle of the circle and made the participants become static. The unlimited option of modifier cards also made it difficult to decide upon which one to use. It was a good suggestion by Alice to 'just pick a few random cards' to end the discussion. However, as Bob noted, this might give the team cards that are difficult or not fitting to the design context. The unlimited supply of cards also gave an 'easy way out' of a difficult card, and Bob quickly took his chance to pick out an easier card. This might have harmed the depth and richness of their discussions. The cards also didn't offer handholds for the participants to move. The materials opened up fidgeting behaviours and pushed Alice and Dave to start exploring ideas. This started the ideation flow, and Carol was able to join in as well. However, for Bob, it was hard to start exploring with this body.

3.4 Design Guidelines

The related-work study (Section 2) and the preliminary study (Section 3) yielded insights into what is (un-)desired during a MBD session. We can now reflect upon how these insights relate to the design of an artefact. These takeaways are translated into actionable design guidelines that will be used in the design stage of this thesis (Section 4).

Takeaways from Literature

The literature review from Section 2 led to a set of qualities that are relevant to a facilitating artefact:

- The movement in a MBD session should be meaningful and related to the design process in order to serve as design knowledge. The artefact should thus stimulate deliberate, conscious and meaningful physical activity, rather than 'just' movement.
- In this thesis, the design process of developing an artefact should be enriched with doing and experiencing movements. That's why we should ourselves take part in MBD activities in the next chapters of this thesis.
- The modifier method cards are mostly used to inspire and fuel the design process. The artefact, inspired by these cards, should be used during the ideation session and have similar tasks as the modifier cards. It should also make information more tangible and provide a more hands-on experience.
- Play and playfulness are two important elements in a movement-based design session since they make room for silliness and unusual behaviour. Playfulness can be embodied in an artefact through the shape and materials of the design. Therefore the artefact should include materials and shapes that provoke a playful experience and invite different sensorial experiences. This includes different types of materials such as soft or smooth textiles.
- The influence of the artefact on the attention of the participants should be carefully managed, since this strongly influences experience and engagement. A study by Park et al. concluded that movement-based design experts were less open to immersive technologies that demand a lot of attention since these could take on a lot of attention, and restrict movement and interactions [57]. This risk should be carefully considered in the later design stage.
- The artefact should invite exploratory movement that is centred around investigation, exploration and curiosity. This can be done by making movement more tangible by breaking it down into simpler blocks (magnitude and direction). In this way, the larger concept of 'movement' is broken into more tangible elements, and the participants can use this as a handhold to start exploring movement. The artefact should thus contain interactions with these two properties while allowing for a wide variety of possible physical manipulations and motor functions.

Takeaways from Observations

The observations from different MBD workshops, described in Section 3.2, led to a set of qualities that are relevant to a facilitating artefact:

- The artefact should be relevant to the specific MBD session since this will likely affect the direction of the conversations. Meaningful conversations are more likely to flow from the right modifying prompts.
- The artefact should have an effect on and be available to all participants. This avoids that one participant is in 'charge' of the artefact and the others feel limited in their interaction with it. This will also contribute to an equal power distribution and a common ground experience.
- There should be physical materials or artefacts present in the room since these have the role of facilitating physical interaction and exploration. They have the ability to provide a framework in which the participants can move. They also allow for fidgeting behaviours.
- The design cues given by the design cards had the potential to start a new line of thinking. However, they

caused a rushed, non-iterative design process when there were too many cards present. The physical design of the cards showed to limit movement exploration due to their non-dynamic and static properties. The shape of the artefact should therefore embody movement and action potential to avoid the limitations of design cards. The artefact could also include the functionality of providing additional design cues, although this has to be intentionally designed to not overwhelm or hinder the participants in their process.
- The different physical properties (e.g. warm/cold, round, soft, stretchy) of an artefact can provoke movement exploration. Movement together with an artefact nudges reflection and discussion, and provides a starting point for the ideation process.
- The placement of the artefact influences where the people will move. The artefact should thus not limit the participants in their movement throughout the environment.
- The amount of cards or options should be carefully considered. Six cards were already enough to stimulate a variety of ideas, and more cards would only have constrained the ideation process. Similarly, a table filled with design cards was overwhelming and provided too many options for the participants. This harmed their iterative design process.

Takeaways from Interviews

The interviews with the experts, described in Section 3.2, led to a set of qualities that are relevant to a facilitating artefact:

- It should be clear what the end goal is and who the participants are, this determines the workshop activities. The activities and elements from the artefact should fit with this.
- At the start of a workshop, participants need to be prepared so that they are engaged, feel safe and secure and are comfortable to move. Therefore, a warm-up is strongly recommended. The artefact should allow for it to be implemented in different types of design activities, such as warm-up exercises. The artefact could also facilitate a way in which the participants feel safe and comfortable to explore with it. Participants should also feel control over- and have trust in the artefact.
- The artefact should allow for and stimulate play and playfulness
- Participants should be invited to use the whole space and use movement to explore and experiment
- The artefact or facilitator should constantly read the room and provide intentionally timed tweaks, pushes and suggestions. This challenges the participants to evolve their ideas.
- The what, when, how, and why of all the elements that are brought to the session should be carefully considered.

4 Design of the MoMo

The last chapters provided us with both theoretical knowledge as well as practical knowledge on movement-based design and how we can design for this. With these insights, we can now look at how to implement this in the design stage of this thesis.

The design process took an iterative approach between different design thinking steps (ideation, prototyping, and testing). This section will first go over the ideation phase, including different diverging and converging steps. It will then go over the prototyping phase, including different exploration steps and the development of a final prototype. This will lead to the final design of the MoMo.

The design process flow is visualised in Figure 9, showing the action steps throughout the design phases as well as the interim evaluations with experts. For clarity, the flow chart also includes the interviews of the preliminary study. This shows that some pre-study interviews were the same as some ideation-phase interviews (interviews 2, 3 & 4). That is because of the non-linear nature of the design process, where new discussions and interviews were used to revise the existing pre-study knowledge.

4.1 Ideation Process

The ideation phase centred around exploring solutions through iterations of diverging and converging the idea space based on expert feedback, which eventually led to a concept choice. The flow of the ideation process is visualised in Figure 3.

Diverging

First, three separate brainstorms were done to create a large number of sketches to explore possible approaches to stimulate meaningful movement in MBD sessions. The brainstorms made use of different MBD techniques, chosen from MeCaMInD's [6] MBD card deck. This was done because different studies in the MBD field highlight the importance of doing and experiencing movement while designing [38, 68]. The following method cards were selected and implemented in the brainstorming sessions: 'What can I do with this?', 'Material Props in Context', 'Daily Movements', 'Explore Movement', 'Grow Body Awareness', 'Props for Undesigning', 'Strong Prototyping', and 'Embodied Sketching'. The cards were specifically selected for their suitability for ideation by an individual since the brainstorms were done by the researcher alone. The brainstorms were combined with more traditional ideation methods, such as quick sketches and mind mapping. During this brainstorming process, input was acquired through discussions with colleagues from the HCI department at Uppsala University, the stakeholders (both supervisors are involved in the MeCaMInD project, one from Uppsala University and one from the University

[6] https://www.mecamind.eu/

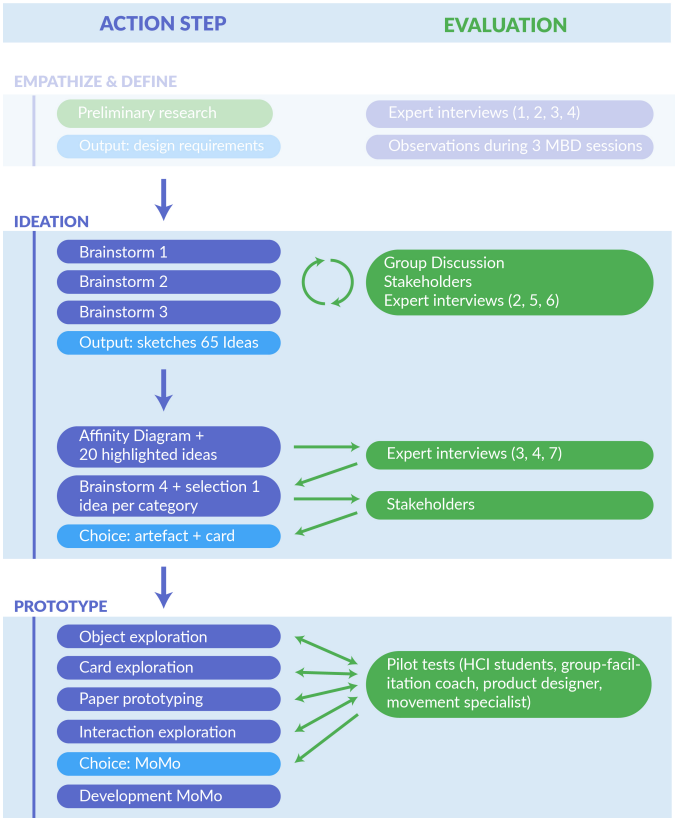


Figure 9. Overview of the Ideation and Prototyping phases, including action steps and evaluation moments. Each number in the figure corresponds to a different conversation or interview. Similar numbers across different interviews indicate that there was one interview, where different aspects were discussed. The experts: 1) MBD-expert, 2) improvisation-theatre expert, 3) MBD- & facilitation-expert, 4 & 10) two separate conversations with the same facilitator, 5 & 7) two separate conversations with the same product designer, 6) MBD-expert, 8) MBD-expert, 9) HCI PhD-candidate, 11) HCI professor, 12) HCI professor

of Twente), and three expert interviews (from the fields of improvisation-theatre, product design, and MBD). The evaluations centered around the experts' experience with movement-based design sessions, and what kind of solutions they thought would work well or not so well (question overview in Appendix B). The experts mainly highlighted their extensive use of artefacts in MBD workshops. These artefacts support the design process and provide the participants with handholds to use their bodies. The experts also noted that they have a lot of attention towards personalisation and tailored responses to the individual participant. This includes providing scaffolds to help them step by step towards the end goal. These expert evaluations mostly aimed at expanding and evaluating the design space. This resulted in a total of 65 ideas, see Figure 10 and Appendix C.

Analysis & Converging

Next, thematic analysis and affinity diagrams were used to make hierarchical groupings and themes of the sketches, using a bottom-up approach [47, 4]. These groupings were named and clustered in main categories and the sketches were placed in this map, see Figure 21 & 22 and Appendix D for more detail. The main categories are User, Environment, Artefact, and Card. Each category also has multiple sub-categories to further differentiate between the types of concepts. These categories are further elaborated upon in the next chapter, while this section continues with the narrative of the design process itself.

In a converging step, 17 ideas were highlighted to be iterated upon further (see sketches with a red/green star in Figure 22). The ideas were selected based on their agreement with previously obtained information from expert discussions and existing literature, see section 2 & 3. The concepts from the 'User' category were mainly selected based on the literature on the 'making strange' theory [50]. By changing or adding something to the body, the user might be able to look at the body in a new way. This could provoke curiosity and kick people out of normal or restricting behaviours, thus making it easier to design and explore with their bodies. For this category, both interactive and physical concepts were selected. Concepts from the 'Environment' category were selected based on the literature on behaviour change techniques, such as providing feedback, giving people control, visualising what is happening, and nudging. For this, a small literature study was done on the different ways technology can influence behaviour. However, this was not added in the main part of the thesis, since there is a relatively low focus on this aspect in the final design. Therefore, the study is added to Appendix **??**. For the 'Card' category, it was chosen to include a concept from each of the three categories: 1) changing the card for a physical translation, 2) attaching a physical element to the card to promote physical engagement, and 3) attaching an interactive property to the card. Concepts from the Artefact category were selected based on their capacity to contain movement potential. Both literature and experts in the pre-study stated that playthings such as balls, ropes, and skateboards work really well to stimulate activity in the group. It was also chosen to include an artefact that visualises the movement in the room, in a more indirect manner (inspired by the behaviour change overview, which was added to Appendix **??**).

Evaluation

The affinity diagram and the 17 highlighted ideas were evaluated by three experts (from the fields of MBD, facilitation and product design).

The interviews brought up some criticism for larger installations from the 'Environment' category. Attention steering

Figure 10. Part of the sketches from the ideation phase. The sketches can be found in more detail in the Appendix.

is a very subtle and important aspect of facilitation, and a large installation might take away the focus of the group or overwhelm and intimidate them. It was also seen as negative that a large room-sized installation would need a lot of preparation time, is harder to tailor to the individual needs of participants, and would be harder to personalise to each different workshop. Facilitators noted that they mostly make new materials for each different workshop, since the needs are so different for each design goal, but that these materials are mostly small and relatively easy to assemble. Overall, this was not the preferred concept category.

Concepts from the 'Artefact' category provoked the most positive responses and appeared most often in literature. Facilitators noted that they very often use artefacts to aid the workshop. Given that they are facilitated properly, artefacts have the power to get people started and engaged. Participants get instantly busy with the materials, especially if the materials allow for physical manipulation or movement. As a warning, it was noted that objects need to be very carefully facilitated, regarding what, when, how, who, and how long the objects are brought into the workshop. It was also noted that by designing the object, you are not just designing an artefact, but you also design the attention and focus of the participants. Overall, this category was the most preferred category by experts.

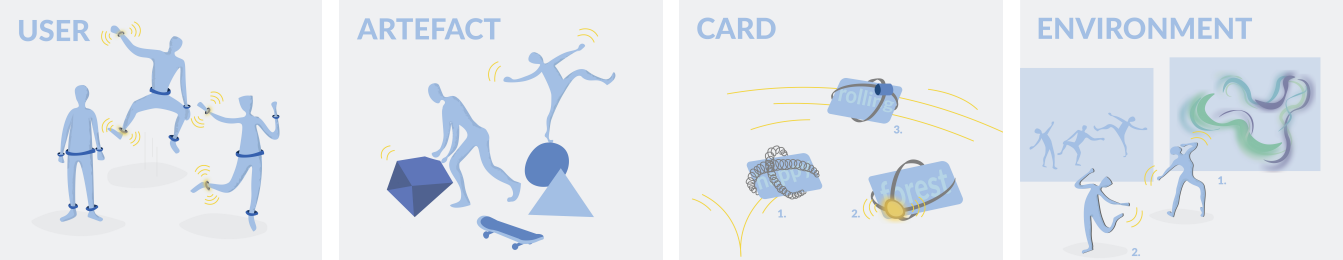
The 'User' category was not so much elaborated upon by the experts. This was more taken together with the 'artefact' category. For example, a user could explore with a cape or a foam suit, but this would stem from artefacts such as fabrics and foam materials. Therefore, this category was taken together with the artefact group.

For the 'Card' category, both the stakeholders and literature studies praised that the value of design cards lies in their ability to give a large variety of design cues. Therefore, it was chosen not to interchange the card for a physical equivalent since this would limit the number of cards that can be available. Instead, concepts were picked that added a physical or interactive property to the card itself to make them more interesting. A downside is that the cards work less well as a standalone since they need more guidance and introduction from the facilitator. It was also noted that facilitators often make new cards for their workshop, to make sure the cards fully fit their design goal.

Diverging & Concept Choice

A second brainstorm iteration was done to implement the expert feedback, iterate upon the structure of the affinity diagram, and select one idea per main category to scope down the idea space (see Figure 11). The four ideas were used in a final evaluation with the stakeholders.

For the 'Artefact' category, it was decided to go for a playful object with direct interaction with the user (although it was not specified yet what the concrete shape or function of this object should be). This was deemed the most effective



(a) Selected idea from User-category **(b)** Selected idea from Artefact-category **(c)** Selected idea from Card-category **(d)** Selected idea from Environment-category

Figure 11. Selected ideas from the 4 main categories from the Affinity Diagram

and most used by the experts. However, some downsides could be that participants will require time to get familiar with the object and that their focus might only go to the object itself, instead of using the object as part of the design process.

For the 'Card' category, it was chosen to enhance the card with an interactive sleeve to add action potential and make it less static. The sleeve could be added to any card in a click-and-play-like manner, where the strength of the endless variation of cards is maintained. A potential downside could be that the card results in a short-lived moment of 'gamification', which takes away the focus on the design process. However, the observations also showed that the cards are not used continuously throughout the process, but are used periodically. If in these moments of card-consultation, the card boosts playful movement rather than the old behaviour (see Section 1), it might not be a downside.

For the 'Environment' category, the concepts and their interactions in the room were limited to one-wall interactions, due to the concerns of implementation difficulty as well as the amount of cognitive load it would place upon the participants. Two variations were picked, both limiting the size of the interaction to only one side of the room. The first concept projects a video of actors on a wall. These actors are performing the design exercise with large and playful movements, thus providing an example of how the desired behaviour would look like. The 'real' participants could get inspired by this and it could contribute to a safe environment. This resonates with facilitators stating that they often set the bar by behaving with large, 'crazy', and outgoing movements. This makes the other participants feel safe and more comfortable to move in the same way. The second concept builds upon existing literature, by making an interactive wall that responds to movement in the room [50]. In this way, it provides feedback on the flow and activity in the room. The flow is visualised by the northern lights with their changing intensity and moving patterns, inspired by the Swedish winter.

After an evaluation with the stakeholders, the choice was made to focus on augmenting the design cards with an artefact. That is because the stakeholders showed a preference for a smaller, handhold object. It was preferred that the object would serve as an add-on to an existing MBD card deck (in their case, specifically the MeCaMInD method cards). Therefore, it should be a smaller object, able to fit in a box of design cards, so it can be conveniently used by the larger public. This artefact should be a physical object with interesting digital properties that excite curiosity and physical movement from the user. This is also in line with interviews and literature, where facilitators mostly use physical artefacts in workshops. However, a combination of a physical and digital layer is more novel and less common in artefacts for MBD facilitation.

4.2 Prototyping Process

After deciding upon the choice of a digital-physical artefact in the previous section, the prototype phase aimed to further crystallize this concept. This was done through different experimentation rounds to iterate upon the desired shape and interactions. Four parallel explorations were done. First, object explorations with existing (everyday-life) objects to explore how users respond to different shapes and the action possibilities they contain (Figure 12). Second, card explorations that take the card as a starting point and explore adding a physical property to the card, such as implementing the card into a bouncing foam ball, giving it cold/warm properties, or placing it in a frame made out of chenille thread. Third, paper prototypes to explore combining shapes with design cards (Figure 12c). Fourth, and last, interaction prototypes to explore the effect of different interactions and feedback methods (Figure 13c, 13b, 13a). The prototypes from these four explorations were tested during pilot tests, with, among others, HCI master's students, a group facilitation coach, a product designer, and a movement specialist. Written or verbal consent was received for all of the tests.

(a) A selection of the tested every day objects: balls, rope, Frisbee, balance ball, sponge.

(b) The game 'Twister' that was tested in the every-day object exploration

(c) Three paper prototypes with a design card attached

Figure 12. A selection of the objects that were tested

Object Exploration

The object exploration showed that round objects were by far preferred since these immediately provoked playful interactions between people. However, if the size became too large, people were more hesitant to pick it up. It was also found that rules or objectives gave people more guidance. For example, a rule to only throw to a ball backwards, or to have your eyes closed. This was well picked up and stimulated people to try out new things. For example, the rules from Twister helped people to 'get out there', even if they thought it was difficult or new to them. The same worked for handling other objects: a rule or cue provided a framework through which they could get started.

Card Exploration and Paper Prototypes

The card exploration showed that the card combined with a physical element started fidgeting behaviour. The card now had more action options, which could be seen back in the behaviour of people. The link to the word cue however made the object more 'serious', and less interesting to play around with. However, this might be different if it is properly implemented in a design process, where the card is given further meaning and instruction. These findings were similar to the paper prototypes. However, these prototypes provoked more physical movement since there was more emphasis on the physical property.

Interaction Exploration

The interaction explorations were done with the Adafruit Circuit Playground[7] on four different interaction dimensions (balancing, accelerating, tapping, shaking) with different feedback modalities (voice, sound, vibration, light). Overall, the added digital interaction really stimulated people to explore the meaning behind the device. The provided feedback made people repeat the movement until they 'figured it out'. The tapping and the shaking interactions resulted in smaller, limited movements where only the hand was used. The feedback modalities light and sound were very intuitive, and the direct response was helpful in keeping people engaged. The balance interaction led people to balance, they started to show exercises that were known to them, augmented with the feedback. Like a yoga pose of balancing as an 'aeroplane' and keeping their back stable. Overall, balancing and acceleration were the preferred interaction types, with voice, sound and light as preferred feedback modalities (Figure 13).

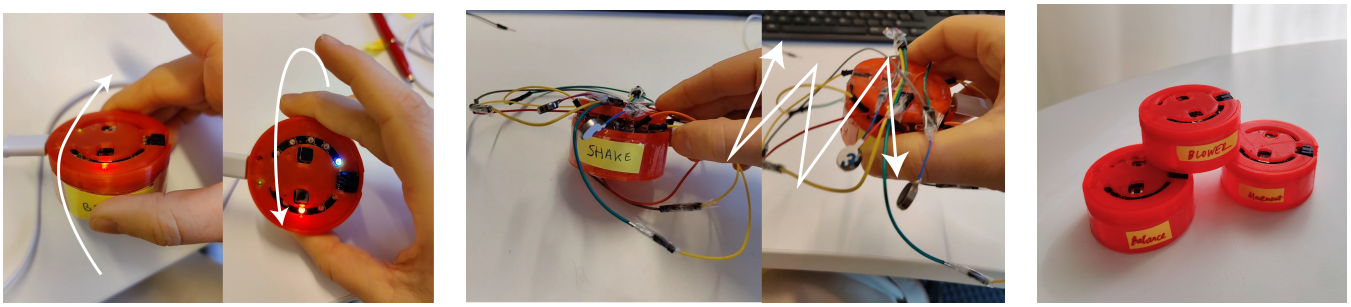
Object Choice

In the previous section, we explored different choices of shape and interactions. Overall, the pilot tests with paper prototypes and different sports materials emphasised the need for a shape with high movement potential, i.e. balls or other rounded objects (Figure 12). This led to the final design choice of the Movement-Modifier (MoMo). This shape embraces round elements into a cone-shaped appearance. A rendered model of the MoMo is shown as visualisation in Figure 15. The pilot tests also showed a preference for digital interactions focused on balancing and acceleration, with feedback modalities with voice, sound and light. The next section further explains how the findings of the pilot tests led towards the design of the MoMo.

4.3 Rational behind the Movement-Modifier (MoMo)

The pre-study observations and interviews showed that people have difficulties with explorative movement with design cards. This could be caused by feelings of discomfort or feeling unaccustomed to using the body in a design setting. Normally, it's the facilitators' job to make people feel comfortable through examples or scaffolding exercises. However, the facilitator could find this difficult for her/himself, or (s)he

[7] https://www.adafruit.com/category/965



(a) Interaction prototype: balance **(b)** Interaction prototype: shake **(c)** Interaction prototypes

Figure 13. Interaction prototypes, screenshots from Pilottest videos

could be occupied with other participants. The design cards also aim to stimulate a movement-based design process, but we previously saw that this does not always have the desired effect. It rather induces counterproductive behaviours, as explained in Section 3.

Therefore, this thesis explores if we can design an artefact that can invite people to use their bodies more in the design process. In this way, people can start moving and exploring in an approachable way. The artefact could serve as a handhold, giving people a means through which they can move. It will thus serve as an alternative to the design cards, and as an assistant to the facilitator.

The artefact that we developed, the MoMo, is designed by implementing different movement actions into the object. Movements like rolling, holding, shaking, spinning, throwing, wiggling, and stroking are embodied into a shape. These actions are amplified through digital interactions and feedback (see Figure 15). It is hypothesised that the user will be made curious or engaged to interact with the artefact, and in this way trace back the designed movement-actions. This will, hopefully, make the participants engaged with exploration and physical movement. A visualisation of what the MoMO will look like is shown in Figure 14

Shape

The shape of the MoMo is designed so that it holds unique intrinsic dynamics that are unlike many everyday objects. The bottom of the MoMo is rounded so it can wiggle, roll, spin, and doesn't stand still easily. The size is chosen so that it's easy to pick up and hold with one or two hands. It can also be packed in a box with the MeCaMInD design cards so that it can be distributed as a complete package to researchers, designers and other people who want to try out movement-based design. The hand-hold top is large enough to hold with one or both hands and is made of soft fabric to encourage users to hold it. The same soft fabric is brought back at the bottom of the MoMo, where a soft and colour full ring is added just above the yellow bottom part. The yellow colour was chosen to convey a message of enthusiasm, playfulness and movement-richness [46]. The material of the MoMo is sanded and softened for a soft tactile feeling. Overall, the shape is chosen with the criteria that it contains movement potential and allows for different movement actions and experiences.

Interactions

Section 2.7 discussed the basic principles of movement: magnitude and direction. These interactions were also preferred during the pilot tests. The digital interactions use these two building blocks to give the user feedback alongside those dimensions. This will make movement more tangible and visible to the user. Direction is used in a balancing interaction, where visual feedback is given according to the direction of the movement. A light ring shows how the artefact is orientated. Magnitude is made visible through an acceleration interaction, where audible feedback is given for different speeds. Different pitched tones are linked to different acceleration speeds. By changing up the acceleration, the different tones form a melody.

Design Prompts

The design cards are also implemented in the artefact. The paper-based cue is changed for an audible design prompt, extracted from the meCaMInD modifier cards. In this way, the design cue is already connected to a more physically engaging object compared to a small card. This might already overcome the most prominent issues that were found in the pre-study observations.

Interplay of Shape, Interaction and Design Cue

The shape, digital interactions and design cues aim to work together to increase their impact. For example, the shape is designed so that it allows for shaking behaviour. The digital layer of the artefact is designed so that it could further augment the shaking behaviour. It could provoke slow shaking (lower tones) quick shaking (higher tones), or alternations between shaking speeds (for a combination of tones, forming a melody). This allows for a higher amount of action

Figure 14. Digital Renders of the MoMo

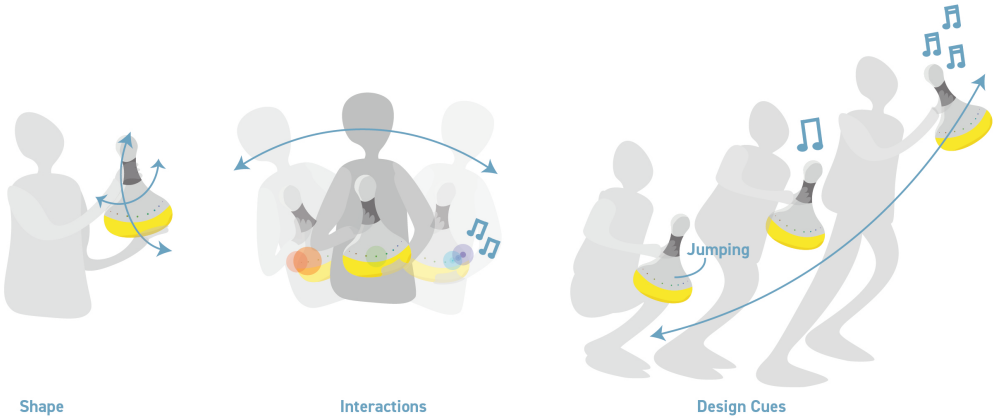


Figure 15. Intended uses with the MoMo, regarding its shape, interactions and design cues

possibilities. The shape and the digital interactions also aim to augment the modifier cues. For example, the design cue could be 'jumping'. The MoMo further augments this design cue since users can jump fast or slow (inducing different feedback), repetitively or only once, in different directions, etc. A cue such as 'Flow like lava', could stimulate different speeds for slowly moving lava or explosive movements for a lava eruption. In this way, the different aspects of the MoMo work together to create a wider repertoire of actions. See Figure 15 for a visual representation of the intended use.

In this way, we hope that the combinations of interactions and shapes allow for the exploration of a wide dimensionality of movement actions.

4.4 User scenario: follow-up with the MoMo

This user scenario repeats the written scenario from Section 3.3. The background and motivation of the four participants (Alice, Bob, Carol and Dave) are the same. However, this time, the workshop is not facilitated with the Modifier design cards, but with the MoMo. This will highlight how the MoMo could be used in a design workshop, and how this could solve the needs and problems of the participants.

Background and Motivation

The backgrounds and motivations of Alice, Bob, Carol and Dave are the same, as described in Section 3.3. The only difference: the design cards are taken away from the table in the room. Instead, the lecturer has now distributed two MoMos per participant team.

Context

At the start of their Embodied Sketching exercise, the team is a little hesitant to start. Dave decides to pick up a MoMo that was placed in front of them. This motion makes the MoMo beep in a low tone. Alice laughs, a bit startled by the sudden sound. She picks up the other MoMo. Dave got curious about the sudden beep and started sweeping the MoMo through the air, to evoke different tunes. Alice watches him and mirrors his sweeping movements. She is so caught up in it, that she almost hits Bob with the device. Bob has to laugh, he asks if he can take over the MoMo. He is very curious about what you can do with this technological device. He notices the light ring on the MoMo and points it out to Dave. Both of them get caught up in trying to hit only the red LED. Alice has to laugh: Bob and Dave actually look quite silly now. It reminds her of their exercise, their bodies almost resamble two chairs, bending forward like that. She points it out, and Dave starts bending back and forward, resulting in low-pitched beeps from the MoMo. Bob quickly mirrors him. The sounds from Bob's MoMo get higher pitched as he rotates faster. Dave mirrors the movement, and he tries to make his sounds go higher than Bobs. After their little game ends, there is a playful atmosphere in the group.

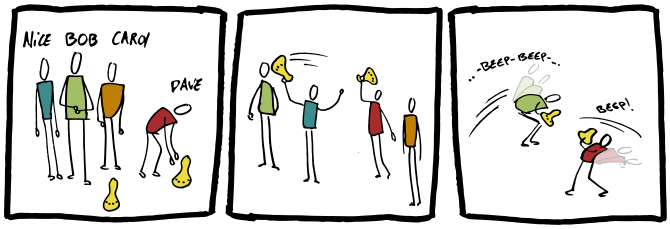


Figure 16. Left: Dave picks up the MoMo. Middle: Dave and Alice try the MoMo, almost hitting Bob. Right: Bob and Dave play a little acceleration game

The facilitator comes by and rotates the knob on their MoMo. *'A tree in the wind'*, the MoMo says. *'We just did that'*, shouts Dave, as he repeats his movements from their game. *'Actually, that bend forward position is exactly the position in which most elderly cannot move further'*, remarks Carol. *'They often have trouble with standing up from their chair, and the last bit of the movement is the most difficult.'* To illustrate this, she grabs a chair and enacts the laborious rising. Bob clamps the MoMo against his belly and mirrors her slow movements. Indeed, if he moves very slowly, he does not have enough acceleration to rise. The MoMo makes very low beeps during the movement. *'He'*, says Alice, *'How high do the beeps have to get, until we have enough acceleration to get up?'*. She takes the MoMo from Dave and tries it out on the chair. After a little trial and error, the group finds the optimal beeping composition: low-low-low, and then increasingly higher, until the acceleration allows you to stand up.

Figure 17. Left: the MoMo 'tells' a new design cue, Dave enacts his idea. Middle: Carol enacts a situation to explain to the group a problem. Right: the group explores with different accelerations.

Bob mostly watches this, while he fidgets with the MoMo. He mindlessly tries to make the LEDs on the ring light up one by one, and by doing this, he slowly rotates his torso in circles. After a while, Carol sees him doing that. She mirrors his movements, and remarks *'Oh wow, this movement actually requires more ab muscles than I toughed!'*. Everyone is now doing the rotations, mirroring Bobs initial fidgeting behaviour. This leads to a discussion on how a chair could have multiple functionalities, such as training abs or helping you stand up.

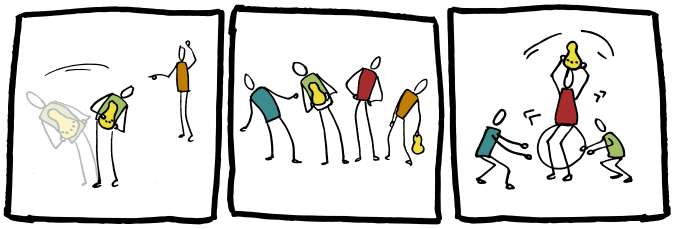


Figure 18. Left: Bob is fidgeting with the MoMo, Carol follows up on this. Middle: the group is mirroring Bob's fidgeting behaviour. Right: the group continues on their new-found balancing exploration.

After a few minutes, Dave picks up the pilates ball and sits on it, while holding the MoMo above his head and simultaneously rotating his torso. Alice decides to joke a bit and pushes the ball a little. Dave loses his balance for a second, but quickly catches himself, resulting in a few sudden beeps. Bob joins in, and he and Alice start poking the ball from two sides. Dave really has to work his abs now, trying to balance on the ball. As he gets better, the beeps get lower and lower, resulting in less sudden accelerations. Carol and Dave switch places, and they compare who could keep the beeps the lowest. Alice then comes back with a blindfold and asks Bob to put it on. All of a sudden, the beeps get another meaning, because audio is still perceivable for visually impaired people. Their discussion continues on how they can include audio cues in the chair, as Bob tells them about his experience with the blindfold.

Addressing the problems and needs

In this scenario, the MoMo tries to solve different challenges of the participants. In the beginning stage, the uniquely shaped object provokes an initial curiosity after which Dave and Alice start exploring with the device. It takes a while before they figure it out, and they mirror each other's behaviour while doing so. This strengthens their common experience and allows them to work together in a playful manner. This helps to break the ice, and all the participants have now moved and explored a bit. Even Bob, while he is normally not really used to being playful in this bodily way.

The design cue helps them to link the playful movements from earlier to the design process. This lifts them from being only fun and playful to a more focused state. Thanks to Carol's experience in the healthcare provision, she recognises a common problem among the elderly in the movements of Bob and Dave. The group further explores the problem, using the MoMo as a physical element to guide them. They take turns in holding the device, to try it out. Here, the MoMo helps them to digest the problem, by providing one dimension which they can explore. The LEDs first help them to explore one aspect of movement, namely: direction, as they move in different directions. Later, the beeps help them to focus on acceleration, and Alice uses this to ask them '*How high-pitched do we need to get, before we can solve the issue?*'. They later also use the beeps as a tool to explore the effect of vision impairment. The sounds from the MoMo give them a handhold to explore and experience.

The shape and digital elements of the MoMo also inspire fidgeting behaviours. Bob is still feeling a little more awkward to move, but he is fidgeting with the MoMo. Through this fidgeting, he is actually exploring his movements, although he is not aware of this. Luckily, Carol notices it, and the group mirrors his fidgeting movements, which starts a new discussion. In this way, the movement-rich actions of the MoMo could provoke fidgeting behaviour that is more body-focused.

4.5 Implementation Details

Three high-fidelity prototypes of the MoMo are developed to be tested later in an MBD workshop. This section provides more detail on how the MoMos were realized.

Physical

The prototype of the MoMo was modelled in Solidworks[8]. Then, multiple shells were 3D printed using the Multimaker[9], due to the low costs and ease of manufacturing. The design was iterated upon a few times before three final models were printed. The models were manually reworked through five rounds of sanding and spray filling, after which the final layers of primer and spray paint were applied. To finish the design, a handhold and ring were added from soft and colourful 'felt' fabric sheets.

For future developments, we would like to experiment further with different materials for the base shape, such as foam, soft fabrics or cold and warm materials to see how this impacts the interaction with the device. Since the choice of material is related to playfulness and engagement [77].

Hardware

The prototype needed to register movement and respond to this by means of sound and light. We used the Adafruit Playground for sensing the movements since these boards were already widely available at the workspace of Uppsala University. This board has built-in functionalities like a motion sensor, temperature sensor, sound sensor, speaker, buttons and NeoPixel lights. We connected 10 LEDs to the output pins of the Circuit Playground and incorporated these in the shell of the MoMo.

The Adafruit Playground is a great tool for quick design iterations, but we found that it is less suitable for more high-level prototyping. The audio quality from spoken design cues was too limited with the Playground's speakers, and we

[8]https://www.solidworks.com/
[9]https://ultimaker.com/

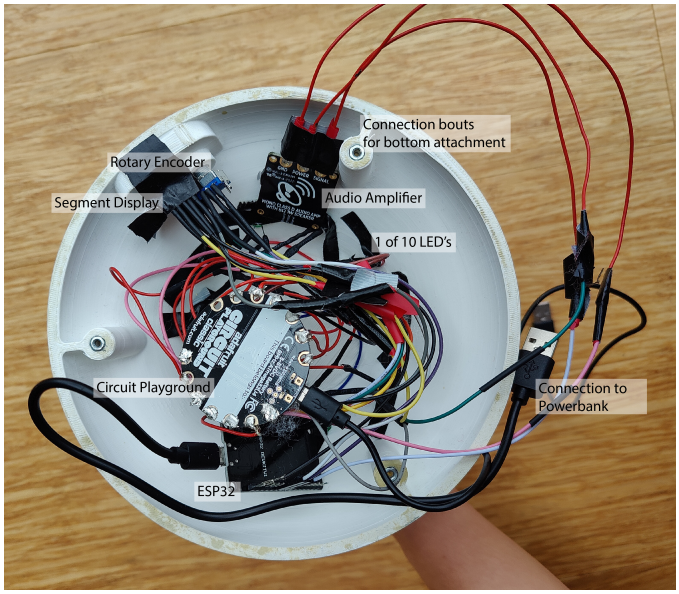


Figure 19. An overview of the implemented hardware inside the shell of the MoMo

Figure 20. Photo's of the final prototype, only one of the three MoMos pictured here.

chose to separate this functionality from the other interactions. This limited the options of integrating the design cues in movement-related interactions. Instead, we chose to include an additional board, the ESP32-WROOM with WiFi and Bluetooth modules, to handle the processing of the design cues. The ESP32 was connected to an audio amplifier with a speaker, to improve the loudness of the audio. To interact with the design cues, we included a Rotary encoder with a switch and a 9-digit segment display. In this way, people can 'scroll' through 10 design cues that are pre-programmed on the device. For future development, it would be desired to connect the design cues to the movement interactions as well and to include all 350+ modifier cards into the device. The Bluetooth and WiFi modules of the Esp32 easily allow for this. However, for now, we recorded and hard-coded the 10 pre-chosen modifier cards. Both the ESP32 and Adafruit Playground Circuit were connected to a power bank, and everything was hidden in the lower compartment of the MoMo, as shown in Figure 19.

Software

The MoMo was programmed in the Arduino IDE[10] in C++, the native Arduino language. We also made use of specific Adafruit Circuit Playground[11] libraries. The code of the prototype is added to Appendix J.

[10] https://www.arduino.cc/
[11] https://www.adafruit.com/category/965

5 Design Space

In the previous section, the choice was made to continue the research with a digital-physical artefact, after which the MoMo was developed. However, the affinity diagram that was developed during the ideation phase is a valuable research output for future studies in the MBD field (Figure 22). Therefore, this section will go over the design space of the different ways in which we can design for MBD (Figure 21). This can help researchers in the MBD field get started with designing facilitating tools for movement. The design space is born from the affinity diagram that was constructed from the collection of sketches made in the ideation phase (Figure 10). There are four main categories: the card, environment, user, or artefact.

5.1 Cards

The concepts in this category affect the modifier cards from the design card deck and are divided into three subcategories.

1. *Cards are enhanced with a physical property.* These concepts aim to give the card a physically engaging body, through which people can interact. For example, the card can be attached to a large bouncing ball, or to a long stretchy rope.
2. *Cards are enhanced with an interactive property.* This allows for people to interact with the card, in a responsive manner. The interactive property fits around the card as an 'interaction sleeve'. For example, the card could fly towards different people or move away when trying to catch it, or the card could be attached to an accelerometer and stimulate people to move the card around.
3. *Cards are interchanged for their physical counterpart.* For example, the card 'boxing' could be exchanged for boxing gloves.

These concepts are in line with the existing brainstorming technique 'random word combinations' [12], where random words are combined to spark new and refreshing ideas. In the same way, the physical property and the word on the card can lead to more ideas when combined.

Reflecting upon this category, it could be said that an interesting physical appearance might better engage people compared to an original paper card. However, this doesn't necessarily result in activity that benefits the design process. Therefore, the challenge in this category is to keep a connection to the design goal of the workshop in which the cards would be used. This can be achieved through carefully designing the physical element. For example, a workshop about rehabilitation for the elderly might need different physical 'sleeves' than a workshop on a new game for children. On the other hand, we earlier saw that the cards are only consulted at limited times throughout the process. So if the cards could provoke a playful interlude, this could also be beneficial for the workshop. Even if the interactive sleeves are not perfectly aligned with the workshop content.

[12]https://hatrabbits.com/en/random-combination/

5.2 Environment.

The concepts in this category affect the environment in which the MBD workshop takes place. Six differentiations are made.

1. *An interactive floor* is used to physically engage people. Some concepts focus on providing feedback on how people move in the environment. Through, for example, creating a light around the user with a variating size based on the amount of movement. Other concepts aim to provoke physical movement by changing the environment. For example, the floor can be tilted into an inclined plane so that people have a different sense of balance. This could create an alienating environment which might lead to new perspectives [50]. The floor could also show safe spaces to stand on, inspired by the game 'the floor is lava', to make people move throughout the space.
2. *Visuals are placed on the wall* for a *non-direct interaction.* For example, a projection could show a group of people working on a similar exercise, but with a high level of explorative movement. This could serve as an example and lower the bar to start moving.
3. *Interactive lights* are used to nudge people to use the full environment. This could encourage people to open up to the full space and increase the size of their movements. This was named by the facilitators as a problem they often encountered. For example, lights around the corners of the room can reflect where people are in the room, and nudge them to break apart from small circles.
4. The *flow in the room is visualised* and responses to the activity by the participants. This can be done through music (changing musical parameters, e.g. tempo, volume, layers), a water stream that moves faster or slower, or a projection of lights (e.g. the northern lights that flow with more/fewer colours, with higher/lower intensity). By providing indirect feedback on the activity in the room, people might become curious and motivated to play around with it.
5. People can *directly interact with a visual projection* on the wall. For example, people could imitate artworks or shapes with their bodies, or they could replicate a projected moving pattern. This could provide an 'excuse' for people to start using their bodies in new ways, which could be particularly useful in the first stages of a workshop where people might feel awkward or uncomfortable.

CARDS

- Card enhanced with **physical property**
- Card enhanced with **inter-active property**
- Card changed for **physical object**

ENVIRONMENT

- Interactive **floor**
- **Other** (non-) direct **interactions** in the workshop space
- **Visual** on wall for **non-direct interaction**
- Interactive **lights**
- Visualisation of **flow**
- **Visual** on wall for **direct interaction**

USER

- User **augmented** with **physical** property
- User **augmented** with **inter-active** property

ARTEFACT

- **Artefact** for non-direct interaction
- **Interactive artefact** for direct interaction
- **Artefact** for direct interaction

Figure 21. Overview of the (sub-) categories of the Affinity Diagram. See Appendix C & D for the overview including the sketches, and for the separate categories with sketches in more detail.

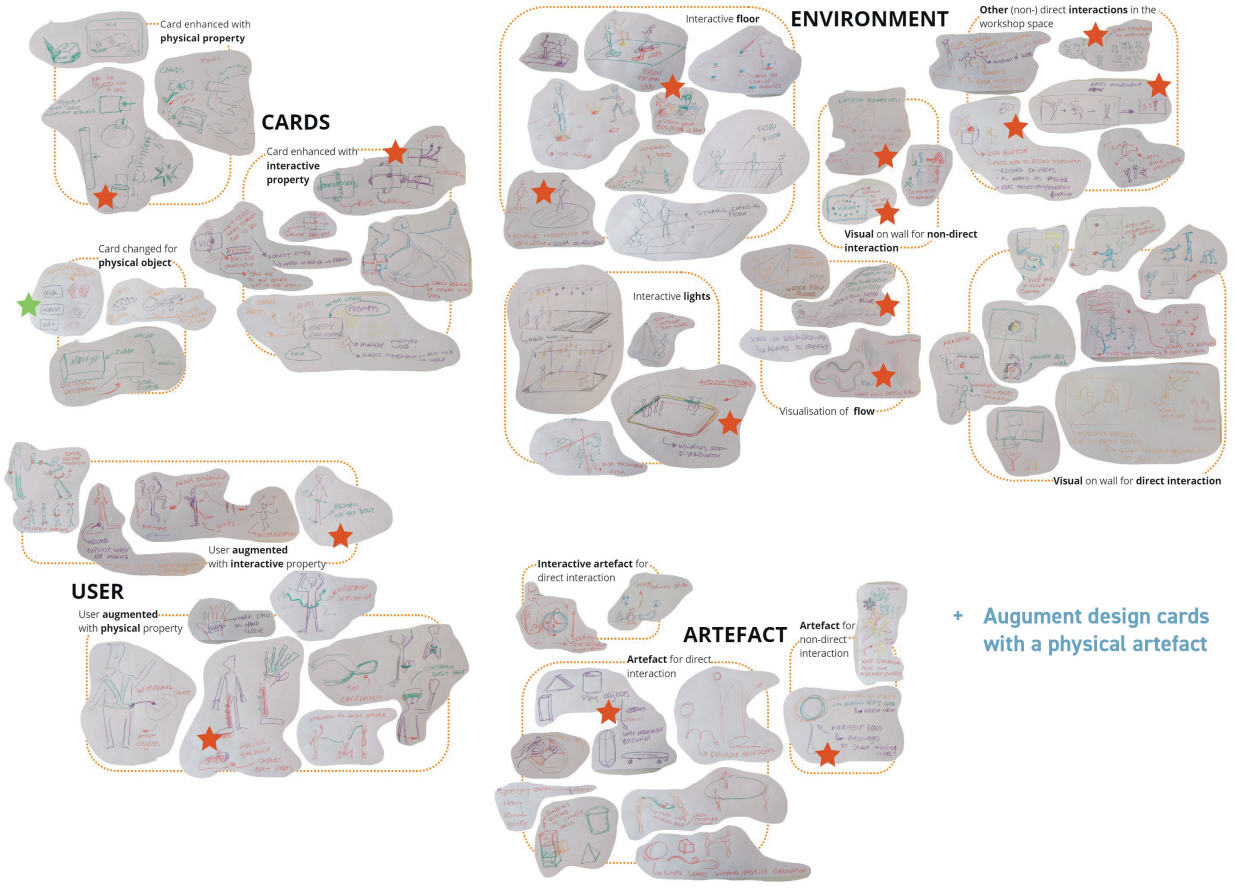


Figure 22. Overview of the Affinity Diagram, including the sketches. See Appendix C & D for the separate categories with sketches in more detail.

6. The last group is a collection of ideas that do not fit into a particular category. This contains an 'idea button' for people to easily record their physical ideas, a tool

that rates the movements, or a way for people to set a goal for their desired amount of movement.

By reflecting upon the concepts in the 'environment' category, we can see that placing something in the environment might make the interaction quite obtrusive. This could have the benefit that people start moving more easily, resulting in larger and more spacious movements. However, ultimately you want people to be fully engaged in the design process where they are in a state of flow. It was noted by different facilitators that sometimes a group 'just flows really well' and that it is then better to not disturb them. At other times, a group might need a bit more attention and stimulation. This brings up two challenges: 1) a large installation might interrupt the flow state of participants, and 2) different groups might need different types of simulations at different times, whereas an environment-wide interaction is harder to personalise in-the-moment.

5.3 User.

The concepts in this category are worn by the user. Two categorisations are made.

1. The user is *augmented with a physical property*. For example, the user wears a Velcro suit, to which different objects can be attached. The user can also be restricted or enabled by objects, such as a blindfold or extra long fingers. The participants can also be attached to each other by ropes or other objects. These concepts build on the 'making strange' theory by Loke to provoke curiosity and new perspectives [50].
2. The user is *augmented with an interactive property*. This category is similar to the previous category, except that the objects are interactive. They are able to provide feedback and prompts to which the user can respond. For example, body sensors can prompt the user to move a certain body part, or for multiple people to match their body sensors.

The concepts from the user category build upon the making strange theory, which can help the user to step away from how they 'normally' move and constraints they might experience [50]. This can pave the way for curious exploration of the body. The interactive concepts have an extra layer, through which they can actively nudge the user to move in certain ways. The challenge for this category is to provide meaningful interactions, that benefit the design process.

5.4 Artefact.

The concepts from this category add something new to the workshop. They are divided into three categories.

1. *An interactive artefact for direct interaction.* These concepts record the movement of the user and provide feedback. They can also use gamification to further stimulate the user to be active. For example, an artefact might ask for e.g. horizontal, circular, or explosive movements, thus nudging the user to perform certain actions.
2. *An artefact for non-direct interaction.* These objects are present in the room and visualise a message, rather than they can be directly manipulated. For example, they can visualise the activity in the room through colours and thus provide people with feedback on how well they are doing. Another concept is a flower or other living object, that has to be kept alive by activity in the room.
3. *An artefact for direct interaction.* These types of artefacts are play objects with different types of characteristics such as bouncing, stretchy, long, sticky, large, small, heavy, stackable, etc. These objects have movement potential, through which people can move and interact.

Similarly to the card category, the physicality of an artefact has the ability to engage people with physical exploration. The pre-study showed that facilitators (from Uppsala University) often make use of a large variety of artefacts in their MBD workshops. The object can be designed in such a way that it contains movement potential, such as a ball can be thrown, rolled, squeezed, passed along, kicked, etc. Besides, shapes like this can serve as a million other things. Through imagination and acting out, a ball can become a chair, a world globe, a head, a poisonous berry, etc. In this way, a handhold physical thing can assist the user in exploring and trying out. However, this doesn't necessarily mean that people will also perform these actions. Perhaps, interactive nudging could assist in getting the user started, by providing cues which the user can follow.

6 Method

To investigate the potential of the MoMo in a movement-based design setting, we designed a workshop in which we recorded the design process of students. It took place on the 17th of May, 2023. A between-subjects study design was used where the students either used the modifier cards or the MoMo. In the card-based group, the students were given design cards with cues by the facilitator during their design process. In the MoMo group, the facilitator still provided facilitation support towards the participants but didn't intervene with the MoMo. However, later in the workshop, the audio function of the MoMo deteriorated so the design cues were transmitted verbally by the facilitator. The workshop was recorded with GoPro cameras and the video data was analysed through annotation and reflexive thematic analysis [7, 8, 6]. After the workshop, multiple expert discussions were held to further reflect upon the MoMo. The design process steps are visualised in Figure 23

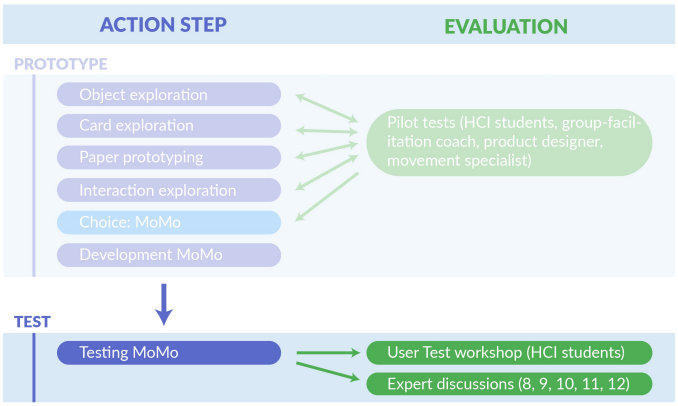


Figure 23. Overview of the Testing phase of the study, including a design workshop and interviews

6.1 Participants

A total of seventeen students from the HCI Master's program at Uppsala University participated in the design workshop. The students were all part of the Embodied Interaction course. It was emphasised that their participation in the workshop would not influence their course performance. Data collection took place during a single movement-based design workshop at Uppsala University and lasted 3 hours. The students were inexperienced with movement-based design or other embodied design methods. The study was reviewed by the ethical committee of the faculty of Electrical Engineering Mathematics and Computer Science of the University of Twente. All participants received an information brochure and signed an informed consent form. Both of these were reviewed and accepted by the ethics committee of the University of Twente. They are also included in Appendix I.

6.2 Session Design

This study has a between-subject design. The experimental group used the MoMo in their design process. The control group used the design cards in their design process. The participants were organized into five teams, each from three to four students. Within the experimental group, there were three student teams, whereas the control group consisted of two student teams. All teams were provided with the same design objective and were situated within the same, shared classroom. The set-up of the classroom is shown in Figure 24.

The session went through different design stages, including a warm-up phase, a problem-focused design block, a 20-minute break, and a solution-focused design block. Both groups received the same information and went through the same design phases. The problem-focused design block, design block 1, provided the goal: 'Explore a problem with managing time and things that are important to you". Including things like procrastination, planning, or habit tracking. It has to be said that the topic of the workshop was a requirement of the Embodied Interaction program. The students were asked to make use of the 'Daily movement' method card, from the MeCaMInD card deck. They were asked to capture the problem in a movement and make use of the available sports materials. The solution-focused design block, design block 2, provided the goal: 'Explore solutions to your discovered problem. Think of embodied things/movements/-solutions that solve your bodily problem". Again, they were encouraged to use sports materials, as well as a variety of craft materials. For this exercise, we asked the students to use the Embodied Sketching MBD method. The PowerPoint slides are added to Appendix F.

To guide and facilitate the session, both groups received assistance from a team of three facilitators, consisting of two professors and educators, and the primary researcher. The facilitators offered guidance by enhancing the design process and fostering movement exploration. The MoMo group did not receive additional facilitation tailored specifically to the MoMo. This decision was made to minimize external influences on the interaction dynamics between the students and the MoMo, thus preserving its inherent behaviours.

To assess participants' experiences after the session, a custom-made survey was conducted. This survey included 15 questions, using a Likert scale for ordered responses, and finished with three additional open-ended questions. The survey questions were categorized into two primary subjects: one focused on participants' experiences with movement activities during the workshop, and the other centred around their experience with either the MoMo (experimental group) or the design cards (control group). The survey questions are included in Appendix E.

6.3 Procedure

Before the start of the session, the participants were informed about the objective of the design workshop. They were told what a movement-based design workshop entails and how this translated to their workshop. It was explained that the first design block centred around finding bodily problems with managing time (e.g. procrastination, habit tracking, planning). The choice of the topic was made in discussion with the teacher of the course, based on the requirement that it fits with the course theme 'temporalities'. The second design block centred around finding embodied solutions for the explored problems and translating this into a physical prototype. It was emphasised to use the body and embodied experiences in the design process. At the end of the workshop, participants were asked about their experiences in a survey (see Appendix E).

The workshop structure was as follows:
9:15 - 9:30 Introduction to movement-based design
9:30 - 9:45 Warm-up
9:45 - 10:30 Design block 1
10:30 - 10:45 Break

10:45 - 11:30 Design block 2
11:30 - 12:00 Demo round & closing

After the workshop, five expert discussions or interviews were conducted with a movement-based design expert, three HCI researchers, and a facilitator. These interviews reflected upon the potential of the MoMo and its role in movement-based design.

6.4 Data Analysis

We will split the data analysis into three parts: video analysis, survey analysis, and expert interview analysis. These three are then combined in a Reflexive Thematic Analysis.

The workshop was video recorded, and the analysis of this data had two main outcome goals. First, observing whether participants would wield the MoMo as intended, and second, observing the interaction between the MoMo and the design process. The video data was recorded by 7 Go-Pros and imported to Elan[13], an annotation tool for audio and video recordings. Next, the video data from the Go-Pros was reorganised per student team, and manually annotated. Research conducted by Saldaña emphasizes that 'A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data.' [64]. In line with this view, we manually assigned descriptive codes to participants' movements and interactions throughout video clips. This resulted in a list of short, descriptive annotations per team, from both the MoMo group and card group. The codes were then organised into different categories: codes relevant to the MoMo (e.g. 'throwing a rope around the MoMo'), codes describing physical activity (e.g. 'trying balloon (prototype) on the body'), or codes describing fidgeting (e.g. 'passing ball around in hands'). Besides, the moments at which a facilitator intervened with a group were also annotated.

The post-workshop survey outcomes were analysed and summarised to further examine the experience of the participants. The outcomes were compared with a statistical T-test. Additionally, the key findings from the expert interviews were summarised directly after each meeting.

Reflexive Thematic Analysis

The findings from the video recordings, surveys, and interview summaries were further analysed with Reflexive Thematic Analysis (Reflexive TA) [52, 6, 10].

Reflexive TA is a research method used to 'identify and make sense of patterns of meaning across a dataset'[8]. This includes analysing and interpreting different types of data, such as video recordings, observations or text. It provides a systematic approach to engage with the data, identify patterns and themes, and produce a robust analysis[14]. Reflexive TA is done according to the following six phases: 1) data familiarisation, 2) initial data coding, 3) generating themes, 4) reviewing themes, 5) redefining and naming themes, and 6) report production/or writing up [9, 52]. Although these six phases provide structure and are advised to follow sequentially, they are not intended as a rigid structure. Instead, according to research by Braun and Clarke, '(...) these six phases can blend together somewhat, and the analytic process necessarily becomes increasingly recursive.' [8]. It is noted that "codes (in RTA) are understood to represent the researcher's interpretations of patterns of meaning across the dataset," and are thus influenced by the subjectivity of the researcher [12].

In this thesis, the outcomes of the video recordings, post-workshop survey, and expert discussions were all considered in the reflexive thematic analysis for triangulation. It was chosen to analyse them with reflexive TA because of its ability to derive meaning and patterns from diverse types of information and data sets.

7 Results

This section goes over the results of the workshop, including the video and survey data. These findings are then interpreted by means of Reflexive Thematic Analysis, and written up into four themes.

7.1 Workshop Movement Analysis

The video data was first re-watched and general notes were made to discover variables that might say something about the MBD process. It was found that movements of the participants could be categorised as movements that were observed to be directly related to the design process (e.g. exploring materials, students that physically depict examples, mirroring movements in discussions), physical fidgeting or idle movements (e.g. fidgeting with a ball), and movements with the MoMo. Movements were classified as fidgeting if the participants made continuous, small movements, with no observed particular purpose, resulting from a state of idleness. Movements were classified as MoMo-behaviours if the participant directly interacted with the MoMo through their own body or through another material. Movements were classified as relevant to the design process if they seemed to contribute to an active exploration of movement in the group. Some examples of movements that were classified as MoMo-behaviours or explorative movements are shown in Figure 25 26. It was also marked when a facilitator would intervene with each participant group. The times at which the facilitator came in are marked with horizontal lines in the graphs, see Figure 27.

[13]https://archive.mpi.nl/tla/elan

[14]https://www.thematicanalysis.net/doing-reflexive-ta/

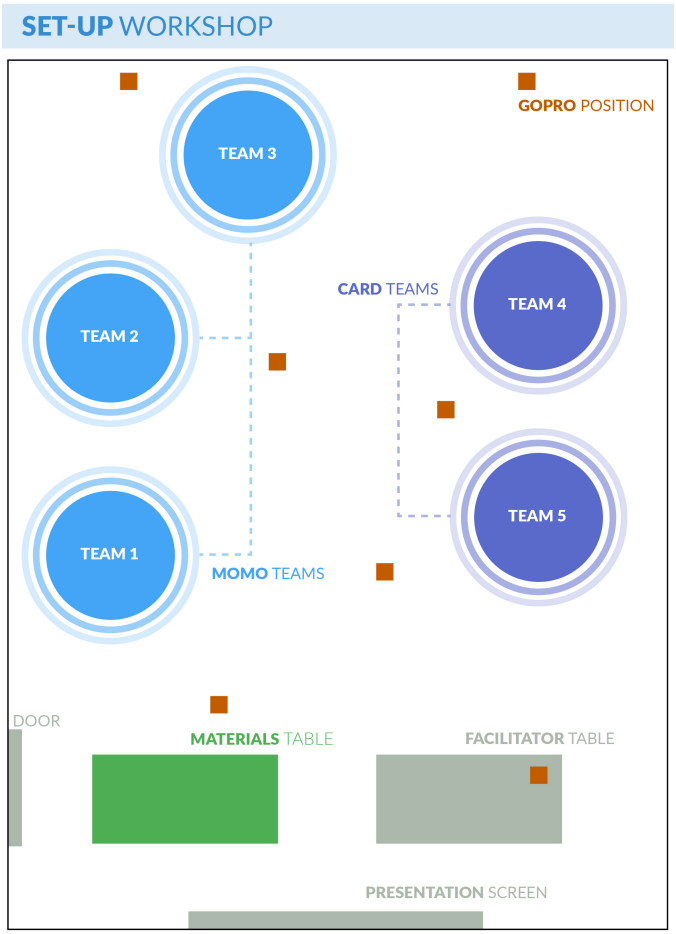


Figure 24. The set-up of the workshop in a classroom at Uppsala University.

(a) Movement with the MoMo1 **(b)** Movement with the MoMo2 **(c)** Movement with the MoMo3

Figure 25. Snapshots fromt the workshop with activity regarding the MoMo

The variables were determined during an iterative process. After watching the first videos, the variables were shaped and updated when the analysis progressed. The video data was analysed by manual annotation of the behaviours and interactions that related to the variables. The annotations were counted and their length was determined. This was used to plot the changes in types of movement over time, which is shown in Figure 27. This shows how the different types of movements change during the course of a MBD process. For each team, the video recording was split into batches

(a) Snapshots from the workshop regarding explorative movement

(b) Snapshots from the workshop regarding explorative movement

Figure 26. Impressions from the design workshop

from 10 to 20 minutes (depending on the camera). Each data point in the graphs represents the amount of movement for that batch, meaning that the first data point in Figure 27a represents the amount of movement that took place during the first 3 minutes. Figures 27a - 27c visualise the movement of the MoMo-teams and it shows that the MoMo-related interactions decrease to zero after the first 35 to 45 minutes. Figures 27d and 27e show the movement of the teams that used the Modifier Cards. The vertical lines in the graphs show the points at which facilitator intervention took place.

The first aim of the analysis was to observe whether or not participants would wield the MoMo as intended. It shows that the participants could indeed explore the movements that the MoMo incites, as described in the design rationale in Section 4.3. Participants moved alongside the digital dimension: shaking, swinging in large circles, placing it to their ears to listen, and moving their bodies sideways with MoMo. They also interacted with the physical dimension: holding it in different places (top, side, bottom, handhold), rotating it in their hands, touching and patting the soft elements, and placing it on the floor to spin in fast and slow circles. Participants also interacted together on the MoMo, by listening together, passing it along, pointing and talking towards it, and discussing it. Participants also exposed the MoMo to external materials, as they tried to touch and wiggle it with a rope. Besides, the MoMo didn't result in the earlier described negative behaviours of the design cards. Overall, this shows that the participants were able to explore the various directions and magnitudes of movement, interact with its materiality, and explore its physical shape. This is an important finding since it shows that people can recognize the affordances of such a digital-physical artefact, and that we are able to design for that.

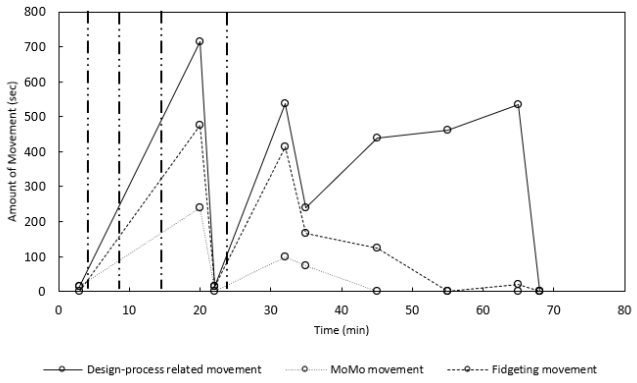
The second aim of the analysis was to see the interaction between MoMo and the design process. The observations suggest that the explorative behaviours with the MoMo were only executed in isolation and for a limited amount of time. The video data showed no clear signs that the movements of MoMo influenced other movements related to the design process. However, the analysis process that was chosen is limited to the subjective view of the researcher and this influences our ability to say something about the occurrences in the recordings.

Another unexpected finding is the amount of fidgeting that took place. Fidgeting movements increased at the start of the workshop. Later in the workshop, that the graphs in Figure 27 show that the amount of fidgeting movement decreases over time for all teams, whereas the trend of the design-process-related movement does not follow this exact decline. This could suggest that fidgeting movement influences process-related movement.

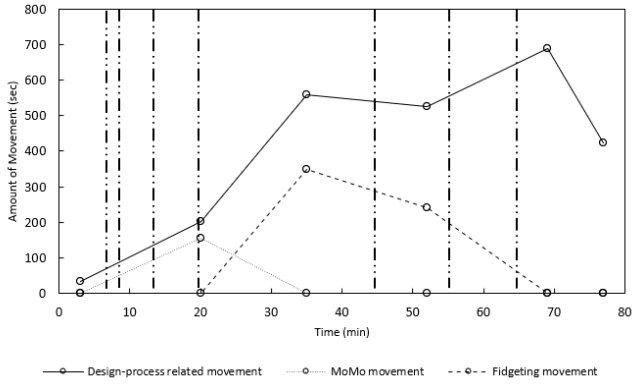
7.2 Survey analysis

Surveys were conducted to examine what the participants thought of their exploration and movement during the design process, as well as their experience with the intervention (design cards or MoMo). The results were compared for the MoMo-group and the card-group with an independent T-test. However, no significant differences were found among the groups. This means that we are unable to state a significant difference in the mean survey scores between the two conditions.

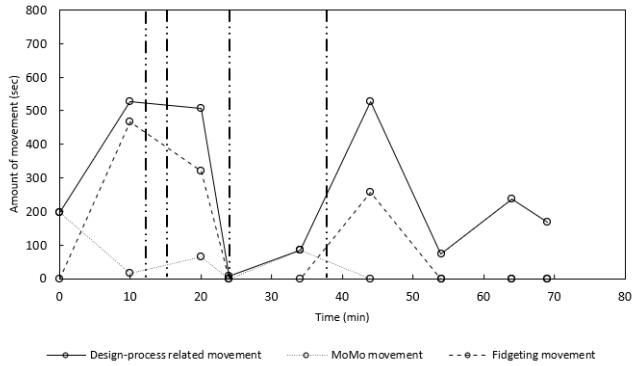
Although no significant results were found, it is interesting to look at the descriptive statistics of the individual items, see Table G. The questionnaire was structured in two sections: questions about explorative movement during the session, and the influence of the intervention (MoMo or cards).



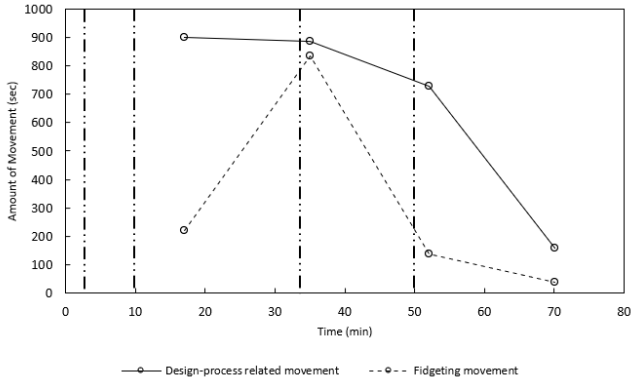
(a) Group 1's movement during the MBD session



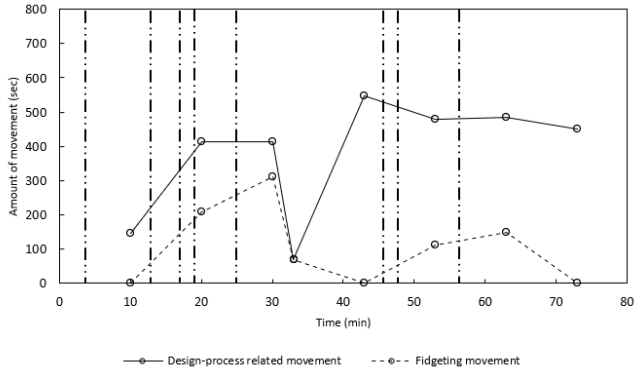
(b) Group 2's movement during the MBD session



(c) Group 3's movement during the MBD session



(d) Group 4's movement during the MBD session



(e) Group 5's movement during the MBD session

Figure 27. General movement, passive movement and MoMo-related movement plotted over the duration of the design workshop, with facilitator interventions at the vertical markers

First, we look at the differences between the two groups regarding the movement in the design process. The MoMo condition reported a more positive agreement for *Comfort to use movement, playfulness in movement*, and *perceived meaningfulness of their movements*. For these survey items, the MoMo showed higher mean values than the Cards condition (see extended Table in Appendix G). The MoMo condition also showed a more peaked distribution for both the first two survey items, suggesting the responses were less varied with a higher level of agreement among the participants. For the *limitedness of movement* and the *impact of the movement on the perceived design knowledge and insights*, the Cards group reported better results. With a lower mean on the perceived limitedness of movement, and a higher mean on the perceived design knowledge. However, both medians

and the mode for perceived design knowledge, are similar for the two conditions.

Second, we look specifically at the perceived influence of the intervention (MoMo or cards) by the participants. The Cards condition reported a more positive response for *Perceived value of the intervention on the design process*, *ability of the intervention to inspire and spark new ideas*, and the interventions' *limited the movements*. For these survey items, the Cards yielded a higher mean value, compared to the MoMo condition. However, for these survey items, both cards and MoMo scored a relatively low agreement (neutral or disagree), looking at the median and mode. The MoMo also showed higher variability in responses compared to the Cards condition, suggesting a more varied response.

7.3 Reflexive Thematic Analysis

We used reflexive TA to 'make sense of the data' and structure the findings into patterns and themes. As explained in Section 6.4, reflexive TA makes use of six phases. Below, we will document the last step of the recursive reflexive TA process: the write-up. The write-up is organised in four themes: body exploration, participant interaction, fidgeting behaviour, and material exploration. These themes emerged from the data, and we can use them to say something about the types of movement and exploration that take place in a MBD session. We can also see to what extent the MoMo influenced these.

Theme 1: Body Exploration

The MoMo encouraged body exploration through its shape and digital interactions: a participant pressed the MoMo to her chest and rotated her upper body from right to left at alternating speeds [Team 3]. However, most explorations with the MoMo resulted in no profound body explorations, but it was rather seen as material exploration (further discussed in theme 4). The survey showed that participants saw no particular value in body exploration through the MoMo: '*We had the MoMo, but we didn't use it as we didn't understood the point of it*' and '*It didn't affect my movement, apart from rocking back and forth a bit*'.

Some participant groups were comfortable with body exploration from the start. For example, a group explored posture by trying postures out themselves, adjusting each other's posture, and using balls to stimulate muscle relaxation [Team 5]. This group used the design cards, and they helped the group to start a new exploration trail after which the group started to use their bodies. Other groups, however, tended to stay static and turned towards vocal discussions rather than bodily explorations [Team 2 (MoMo), Team 3 (MoMo), Team 4 (Cards)]. The MoMo didn't show to help the participants to get out of this vocal discussion. However, they did show fidgeting behaviour with the MoMo [Team 2, Team 3]. In these cases, the facilitator had a larger influence in encouraging participants to use their bodies. A student from this group remarked afterwards that the facilitator's input really helped her to get started with body explorations.

During the expert interviews with, among others, HCI professors and facilitators, it was suggested that the difficulties with bodily expression could be deeper embedded into society, with roots leading back to mind-body dualism and its consequences on the way that the body is perceived. One of the experts noted that this thought still holds sway in psychiatry and medicine, where the mind is seen as superior to the, separated, body. And that this perhaps also affects how fluent participants are in bodily expression and how well they can tap into this knowledge. The experts saw potential in a digital-physical artefact as a handhold for participants to overcome this mind-body blockade since it could make physical exploration more tangible and approachable.

Theme 2: Participant Interaction

Students mostly interacted with the MoMo individually, although the audio functionality seemed to encourage interactions. Students listened together at the MoMo, or they passed it around for all to listen. The surveys however showed that the audio was perceived as not loud enough and it didn't always seem to respond. It was supposed to respond to changes from the rotational knob on the MoMo after which an audio file would be played loud enough for the whole group to hear. The facilitator would control the knob to provide them with an appropriate design cue. The sound was unfortunately in most cases not loud enough, therefore the facilitator would verbally provide the group with the design cue.

Although the participants didn't interact simultaneously on the shape and materiality dimensions of the MoMo, they did show delayed mirroring behaviour [Team 1, Team 3]. Two participants would mirror each other's behaviour with the MoMo, alternating who was using the MoMo. These behaviours seemed to be explorations with the MoMo, rather than part of the design process.

Overall, the design process was influenced by different participant interactions: discussion, mirroring, interaction in exploration, interaction in activity, interactions through a common goal, reflection on game/activity, reflection on movement, and reflection on materials. The MoMo was mostly not so involved in these shared participant interactions. Mirroring behaviour often occurred when students explored movement or materials [Team 2, Team 1, Team 5]. This happened mostly with props such as balls and ropes, and sometimes with the MoMo. It must be said that all groups only had one MoMo, while there were many balls and ropes. This could have influenced the mirroring behaviour with sports materials, compared to the MoMo. Overall, mirroring seemed to strengthen the common ground experience, and it was observed that participants would start new discussions or explorations after all parties had experienced the same movement. For example, team five was exploring with posture. One participant enacted a bent posture, after which the other

participants mirrored the enacted posture. This provoked laughter and a playful moment, after which they continued to examine the posture.

Theme 3: Fidgeting Behaviour

Fidgeting behaviours were observed as continuous, repetitive movements that had no direct observable relation to the design process. Although seemingly non-related, research suggests that fidgeting can be very interesting, showing that it can facilitate problem-solving and creativity (see Section 2.5). For this theme, it must be said that fidgeting is difficult to interpret and observe by an external researcher. There is no direct relation between movement and cognition that can be 'read of' by an external observer. Rather, people engage in a personal process of sensorimotor coupling that underlies their sensemaking experience. This includes movement and perception, affect and emotion, and the context [19]. It also includes the social context since this type of sense-making is a social activity, which is coordinated with the other participants. Therefore, these findings are exposed to the subjective judgment of the researcher.

Fidgeting behaviour increased over time at the beginning of the session. Participants started from a state of relatively little movement, and discomfort. The facilitators would distribute materials, which caused a majority of the participants to start fidgeting with materials. Over time, the fidgeting movements became larger (from touching a ball in their hands to catching and bouncing the ball against the wall). Participants would also more regularly get their own materials. In the second half of the workshop, fidgeting movements decreased again, whereas design-process-related movements increased. This could tentatively suggest that fidgeting has the potential to bridge the gap between non-movement and explorative, design-related movements. However, as earlier stated, it is hard for an external observer to give meaning to the relation between movement and cognition.

The MoMo was mostly subject to fidgeting behaviours. Students would, for example, rotate the MoMo in their hands, continuously spin it on the floor, or wiggle it from right to left. They would also have it in their hands for a longer time, without clear movements. Sports materials such as balls and ropes were used the majority of the time.

The facilitator often initiated fidgeting behaviour by distributing materials like clay, ropes, balls, hola-hoops and other sports materials. This kick-started fidgeting behaviours like kneading, juggling, throwing balls, rolling balls, bouncing balls, wiggling rope, and passing materials through their hands. Some teams cycled back and forth between fidgeting and design-process-related movement, where the facilitator was an important catalyst in this step. Facilitator intervention simulated exploration and reflection which led to renewed design process-related movement. From the facilitator's perspective, it was perceived easier to stimulate design exploration, if the groups were already fidgeting. Whereas, if groups were not actively fidgeting with materials, it was harder to stimulate a design process that included materials and movement. Looking at the MoMo, MoMo-related movements mostly stayed fidgeting and didn't grow out in design process-related movements. However, it must be noted that the facilitators did not mediate the MoMo in the same way as the sports materials. The choice was made to observe the natural response to the MoMo in a MBD setting, without steering from the facilitator. This could explain the limited amount of design-process-related movement born from fidgeting with the MoMo.

Theme 4: Material Exploration

The MoMo was subject to material exploration, as participants investigated its functionality. This resulted in behaviours such as tilting, rotating, spinning, listening, touching, shaking, passing it along, holding, etc. These behaviours were sustained for some time, after which they turned into fidgeting behaviour or the MoMo was put aside again. Material exploration was observed both as an individual activity and as a group activity.

Overall, it was observed that participants regularly explored materials, which seemed to assist movement exploration. The facilitator oftentimes introduced materials to the participants. After a familiarisation phase with the materials, these interactions often turned into fidgeting behaviours. This happened both for the sports materials and for the MoMo. The facilitator had an influence on material exploration since suggestions by the facilitator invited the participants to use the materials in new ways. This led to further material or bodily exploration, causing new iterations in their design process. However, these facilitator suggestions were only applied to the sports materials and not to the MoMo. This leaves the question of how the MoMo could have supported the design process with similar facilitation support.

8 Discussion

After documenting the findings from the workshop and organising them in the reflexive TA write-up, it is valuable to further discuss the insights we can abstract from this. In this section, we will discuss the process of this thesis, the workshop results, the next steps for the MoMo, and the established design space. We will also go over the contributions, implications for the MBD field, the limitations of this study and future work recommendations.

8.1 Retracing the Design Process: Where Did We Came From?

This thesis started in the context of MeCaMInD, a project that aims to make movement-based design practical for researchers and designers. To do so, they developed design cards, specifically including 'modifier cards' that work as

design cues or guides to stimulate movement during the design exercise of a movement-based design session. These 'modifier cards' formed the starting point of this thesis. Preliminary research, through observations, interviews and participation in MBD workshops made it clear that the cards didn't successfully promote physical exploration, and that the paper format was hindering the effectiveness of a MBD session. At the same time, the pre-study showed that implementing physical exploration in the design process forms valuable knowledge for the MBD process, and is therefore wished for. This led to the question of how we can design for the stimulation of physical exploration in the context of a movement-based design session. With a later focus on artefacts, this was concretized into the following research question: *What is the potential of a digital-physical artefact to stimulate physical exploration in Movement-Based Design Sessions?*

After potential solutions were explored and summarised in a design space, a choice was made to focus specifically on artefacts. The preliminary study had shown there was a preference for an artefact, together with an early stated wish from both MeCaMInD stakeholders and an expert facilitator that 'the cards shouldn't be cards, but they should be objects'. It was envisioned that the object could neatly fit in a box with the design cards, to package it like a complete MBD kit. This was also in line with common practice at Uppsala University to include a rich amount of artefacts and materials in design workshops.

Leading from there, it was explored how an object could facilitate people to take part in bodily explorations during a MBD session. It was decided to implement movement actions into an object. By interacting with the device, people could recognise the designed movements and start experimenting with them. This theory was put into practice and implemented in the MoMo, and tested with students from the HCI master's program at Uppsala University. The results of this workshop are already summarised in the previous section, but the further implications of these results are reflected upon below. As well as the lessons we learned regarding the design space and the MBD field in general.

8.2 Discussion of the Workshop Results

The reflexive thematic analysis provided a more abstract view of the MoMo and its context in a MBD workshop setting. We hypothesised that the device would stimulate the exploration of rich movements that are embedded in the design process. The shape, interactions and design cues were designed to facilitate movement actions and explorations. Unfortunately, the outcomes of the study have failed to fully align with these initial expectations.

On a positive note, the participants did exhibit the designed behaviours with the MoMo. They showed an understanding of the rationale behind the movements, materiality and shape. This shows that people are able to extract these actions and movements from an artefact. Furthermore, the MoMo did not give rise to the negative aspects of the design cards. We could also see moments in which the MoMo was used in all of the four MBD themes of the Reflexive TA: participant interaction, fidgeting behaviour, and explorative body and material movement. This is a promising finding since it shows that digital-physical modifiers have the potential to convey certain actions and behaviours. Additionally, it underscores that researchers have the ability to deliberately design for this.

That being said, however, the results with the MoMo showed that the device didn't lead to extensive, explorative movement. The cases in which the MoMo was used in participant interaction, fidgeting behaviour and explorative body and material movements were too limited for a self-standing facilitation object. The MoMo was also not adopted into the design process, as it mostly provoked short bursts of material exploration or fidgeting. This stood in contrast to how e.g. ropes, fabrics or balls were implemented in the design process. This lack of including the MoMo in the design process could, partially, be explained by the fact that facilitators have a strong influence on stimulating deeper exploration by challenging the participants to use the materials in new ways. In the workshop, the participants received facilitation with the materials, but not with the MoMo. The reason is that we wanted to see the natural response to the MoMo in a MBD setting.

Overall, looking at the MoMo, it didn't result in the negative behaviours of the cards, but it also didn't lead to extensive movement exploration in the design process. After an initial exploration phase, the MoMo was often placed to the side. The facilitators didn't intervene with the MoMo to be able to observe its inherent effect on the group. However, the literature study showed the importance and influential effect scaffolding and fidgeting can have on the design process. With this in mind, it raises the question if the MoMo could have had more impact if it was facilitated too. So in conclusion, the MoMo didn't result in the desired movement on its own, however, we didn't study its effect with active promotion by the facilitator. More research is needed to fully show the potential of a digital-physical modifier when it is facilitated and built into scaffolding exercises.

8.3 Next Steps with the MoMo

Now that we have discussed the results of the workshop and the effectiveness of the MoMo, it is valuable to translate this into actionable next steps. This thesis had an iterative Research-through-Design approach, where the design evolved over time. The design of the MoMo marks the end of the first RtD cycle. However, if we were to continue this design process, we would adopt different design lessons from the MoMo and implement these in a future design. After reflecting upon the performance of the MoMo, we've listed the

Positive Aspects	Negative Aspects
Fidgeting	Material hard & vulnerable
Movement feedback	Shape not like sports-material
Design cues	Small interactions and explorations
Shape allows for different actions	Output unclear
Size good for 1 and 2 hands	Stimulates limited senses
	Limited support with design flow

Table 1. The current positive and negative aspects of the MoMo

observed positive and negative aspects in Table 1. In future design iterations, we would try keeping the positive aspects, while finding alternatives for the negative aspects.

Positive Aspects
First, the physical property of the MoMo allowed for fidgeting behaviours. These seemed to help the participants in their creative process and it seemed to comfort them in the early stages of the workshop. The facilitator also marked that it was easier to stimulate design-related exploration for groups that were already fidgeting. The positive effects of fidgeting are also reported in the literature, see Section 2.5. Second, the workshop tentatively suggested that digital feedback on physical movements might provide valuable insights for the participants' design process. This can be further explored in a future design of the MoMo. Third, the design cues were valuable in framing the space of the design process. The audio format kept participants from getting caught up in the negative influences of a paper-format design cue. Next, the shape of the MoMo was found to result in different actions, as we hoped for: swinging, rotating, gliding, holding, etc. And related, the size was perfect for people to hold it in either one or two hands. This allowed for different hand positions and ways to handle the MoMo. These aspects are found positive since the shape doesn't limit the user to only one configuration.

Negative Aspects
First, the material of the MoMo was hard and vulnerable 3D-printed plastic. It is understandable that the participants were hesitant to throw or exuberantly play with the hard-shelled object. In the future, we could instead make the shape from foam or from a bouncy material. Second, the shape didn't resemble a sports material. It is common at Uppsala University to include a variety of sports materials in a MBD workshop, with whom the participants will explore. The MoMo didn't look so much like a ball, frisbee or other sports material. Instead, we could experiment with other shapes, such as a ball or a rugby, and see how this would influence the types of participant-MoMo interactions. Third, the MoMo led to subdued movements, while we would be interested in provoking larger, more spacious movements that stretch to the full environment. Perhaps, we could include additional elements in the environment that can interact with the MoMo. As an example, we could create different zones in the environment where the MoMo behaves differently. Or we could experiment with attaching the MoMo to the user. As an example, the user could wear a Velcro suit on which the MoMo can be stuck. And thus combining different categories from the design space into the concept. Next, the output that the MoMo produced was often unclear to the participants. This was mostly due to the low intensity of the sound and the limited brightness of the LEDs. By increasing the intensity of those, the interactions might become more clear to the participants. Next, the MoMo only stimulated the senses through its shape, sounds and lights. It might be interesting to explore other dimensions such as heat, cold, or vibrations. Last of all, the MoMo was limited in its ability to contribute to the design flow of the participants. Ultimately, we would like the MoMo to provide feedback and stimulations in such a way that it enables a movement-rich design process, while not distracting or hindering. We could further research how the shape and digital interactions of the MoMo can contribute to this. Perhaps by including more ways in which the MoMo can provide feedback on specific movement actions, which can be included as knowledge in the design process.

More generally, we would also like to further research how the MoMo can provide scaffolded steps in the design process, e.g. by increasing the difficulty of the exercise or by provoking reflection or discussion. And how the object can be better embedded into the design exercise. As well as how the MoMo can be better facilitated by the facilitator of the MBD workshop. These elements showed to be important in the facilitation review from Section 2.3.

8.4 Reflecting upon the Design Space

The design space was developed based on the thematic analysis from the ideation sketches. It contains four categories: cards, environment, user and artefact (see Figure 21). In this thesis, we mostly focused on the MoMo, which is placed in the Artefact group and in the subgroup 'interactive artefacts for direct interaction'.

After testing the MoMo, we can now make some suggestions on this corner of the design space. In the workshop,

fidgeting showed to be really interesting. The workshop showed that there is power in fidgeting since these inherent movements *are already there*. Fidgeting often occurs after an initial material-exploration phase. The facilitator was able to catalyse fidgeting into design-related movement. This led to an increase in movement exploration and the scaffolded suggestions caused step-by-step developments in the design process. It took more facilitation effort to get participants to explore with materials in groups that were not fidgeting. This fidgeting behaviour was caused by the materials that were placed in the workshop. This is therefore a promising characteristic from the Artefact group. However, the digital interactions of the MoMo didn't add enough substantial value to make it usable as an effective facilitator object. Because the participants were hesitant to start moving and seemed to feel uncomfortable, it required ongoing facilitator encouragement to scaffold their experience. An interactive artefact did not offer the needed handholds for the participants.

So, overall, the Artefact category shows potential through the occurrence of fidgeting and material exploration that could lead to design-related exploration. The disadvantages are that a relatively small, handheld device led to smaller movements, and the interactions did not remove the discomfort and resistance to physically explore.

Looking at the other categories, we can make tentative suggestions as to what we expect. We suspect that the User category would face similar issues as the MoMo. The participants of a workshop could be hesitant and uncomfortable to start moving. Therefore, augmenting the user with (interactive)-properties might work counterproductive. However, this could really depend on the participant group you are working with. It might also work really well for outgoing participants who feel comfortable, and an augmenting property could very well lead to playfulness and explorations. The cards category might, like the MoMo, result in small actions and limited interactions, and thus not have a substantial impact on the design process. The environment category is a larger installation, and could thus result in a larger impact. All participants would also be exposed to a similar experience, which could provide comfort and a common ground, which are two important aspects in MBD.

In a future cycle of the RtD process, it would be interesting to test other types of concepts from the design space. The Environment category is recommended as a starting point for further research since this could potentially overcome one of the biggest issues with the MoMo. Namely, the lack of spacious, explorative interactions and connecting these to the design process. But it would also be recommended to further iterate upon the MoMo, to further research the potential with digital-physical artefacts.

8.5 Contributions

The findings of this thesis are already discussed in the previous sections of this report. However, there are three important contributions to the field that are worthy of brief mention.

First, this thesis took the MeCaMInD modifier cards as a starting point and developed them into a digital-physical modifier (the MoMo). This device aimed to stimulate explorative movement through its physical shape, digital interactions, and design cues. The results from the user study showed that people are able to pick up the design rationale behind such an object. More generally, this translates to the broader design thinking field since it shows that design cards, an often used tool in (movement-based) design sessions, can be augmented with an interactive physical property. This opens up new possibilities for designing interactive, facilitating materials in design workshops. However, it must be noted that the MoMo still needs further development iterations to solve the current limitations. The user study also brought to light a resistance among the participants to take part in bodily-centred ideation. Awareness towards these challenges might help other researchers to better design solutions. Therefore, the insights gathered in this thesis can serve as a foundation for future research in designing for movement in MBD.

Second, we developed a design space for the different ways in which we can design for movement in MBD. The design space includes a rich overview of different types of concepts that could stimulate explorative movement. The space is built up by means of a Thematic Analysis approach from a large amount of sketches. This led to four main categories (cards, environment, user, and artefact) with different subcategories. The concepts, as well as the categorisations, can be used by other researchers that aim to design for the stimulation of movement in MBD. However, the categories are not limited to the MBD field and can be applied more generic in other disciplines. For example, it could provide new perspectives to researchers in the fields of e.g. rehabilitation, health care (as we saw in the user scenario), design thinking, or sports technology.

Third, the research topics in this thesis aimed to provide a profound overview of the different facets of facilitation. In this report, we stretched these findings further towards facilitating *objects*. We reflected upon the possibilities and challenges for an artefact to take on facilitating characteristics (described in the Related Work Section 2.3). We have also developed a real-world example of such an facilitating object; the MoMo. In the user test, we've tested if the MoMo can indeed perform such facilitating roles. This thesis therefore contributes to the future of movement-facilitating objects, through its literature review on facilitation and the projection of these findings upon facilitating-objects. Together

with the testing of the MoMo, we hope to provide valuable insights and a starting point for future research.

8.6 Implications for Movement Based Design

The results of this thesis have various implications for the current practices in movement-based design. Since the development of this modifier also opened up the state of the movement-based design field. We found that participants had difficulties with using their bodies as a tool to brainstorm. They seemed hesitant and uncomfortable to explore movement. This relates to the concept of mind-body dualism, which builds upon the belief that mind and body are two different substances. Research by Harré on this topic states that 'the indubitable truth must be mental' and that a person is a thinking thing that is separated from the material, spatial and temporal body [31]. This philosophical theory has set foot in society and led to far-reaching consequences in our understanding of mind and body. Research noted that this 'took our focus away from the dynamic nature of human beings, their relationship with the environment' [53, 33]. It was also noted that this body-mind dualism perspective is still dominant in the West, and body and mind are still often treated as separate entities [33]. This concern was also brought up during one of the interviews with an HCI professor.

This could have consequences for MBD practices since participants might have difficulty tapping into the experiences of the mind and body. During the workshop of this thesis, participants noted that they 'didn't see the point in moving' or thought that the movement exercises were not useful. The teacher confirmed that students had no practical experience, but were more used to theoretical approaches. In this study, a digital-physical modifier aimed to assist the participants in bridging this mind-body gap and gave them a handhold to design with their bodies instead of their minds. The resistance to moving with the MoMo emphasises these challenges for the MBD field. This raises the question of how a different context with participants who are more fluent in body expression could potentially lead to different results.

This also invites a reevaluation of the original MeCaMInD method cards. Perhaps these cards stimulated a more 'mind-centred' design process, with whom the participants felt more comfortable (which could explain the static behaviour during MBD sessions with the cards). Having this in mind, perhaps we should have designed with more empathy and understanding towards this hesitance with bodily exploration. This thesis took the design cards as a starting point, but instead, we could do a step back to understand where the movement problem originates from. This would also help to better align the designed solution with the problem participants face.

Last of all, in this thesis, we made the decision to not facilitate the participants' interactions with the MoMo. Although this was made as a considered decision, the lack of facilitation may have influenced the results. This suggests that the facilitator could have an influential role in how an object performs in a design session. More generally, research in HCI regularly uses methods that include a design process with participants, like co-design or pilot studies, that oftentimes include a facilitator to guide the session. However, research also suggested that facilitation is often treated as a black box in HCI research [81]. This means that studies don't go into detail on who, how, what, etc. was facilitated. This limited transparency may make it hard to understand if the results of a design session are influenced by the behaviour of the facilitator. For example, if the researcher of the study is the same as the facilitator, this might influence the process and the design outcomes. This may have implications for HCI research that is dependent on the outcomes of design workshops.

8.7 Limitations

This study took a RtD approach where we took part in an iterative design process through which the prototype evolved. However, we recognise that the RtD process was limited by the short duration of this thesis. In its current form, the MoMo still faces different limitations and challenges that can benefit from additional design cycles. Therefore, the time duration of this thesis formed a main limitation of the current design of the MoMo. However, we do hope that the exploration of the physical-digital artefact in this study is successfully portrayed and documented. So that it provides value for future research. Besides, there are some other limitations to the study and the developed artefact.

One limitation of the study is that the design pilot test during the ideation phase was performed with participants from the HCI field. The different pilot tests were also repeated with the same participants. There might be more variation in response when the pilot tests included more participants from variating disciplines. This could have made the design process richer.

Another limitation is the functionality of the digital-physical artefact. Due to time constraints in combination with a lack of possibility to fool-proof test the high-fidelity prototypes, the MoMo didn't perform optimally during the user test workshop. The hardware was shown to be vulnerable, and this decreased the quality of the digital outputs of the MoMo (sounds and lights). This may have influenced the interactions between the MoMo and the participants, and thus the outcomes of this study.

Besides, the test workshop was performed with a limited amount of seventeen participants. However, due to limited time and resources, it was not possible to execute the workshop a second time. The participants were also all from the same discipline and had no previous knowledge of MBD. These demographics might have influenced the workshop, and different results may have been obtained with different

participants. For example, participants that are more fluent in body exploration, e.g. dancers, or actors. Besides, the study had a between-subject design where each participant was exposed to one variable. However since the comfort and willingness to move differ strongly among participants, a within-subjects design may have been better. However, this could have caused carryover effects or time-related effects, such as growth into the topic.

Another limitation is that the MoMo was not facilitated during the user test workshop. This decision was made because we wanted to observe the natural response towards a digital-physical object in a MBD workshop context. Optimally, we would have also carried out an additional test workshop in which the MoMo was also facilitated, but due to time restrictions, this was outside the scope of this thesis. However, looking at the facilitator, the results showed that facilitation had a considerable influence on the design process. Scaffolds and facilitation intervention guided the participants further in their process. This determined the focus of their design process and thus the outcome. In this thesis, the facilitators chose to not influence the natural interactions with MoMo. This may have impacted the comparison with the modifier cards, and thus the results of this study. Research in facilitation also emphasises the importance of being aware of this facilitation effect (see Section 2).

8.8 Future Work

A variety of 'next steps' and possibilities for future work have already been discussed in the previous sections. This section will go over some unexplored opportunities for future research that need some more detail.

First of all, for future research, we are interested in continuing the Research through Design process with the MoMo. The points discussed in Section 8.3 form a good starting point for the next design iteration upon the MoMo. We would also be interested in doing more research on the different types of feedback and movement interactions we can design into an artefact. Besides continuations with the MoMo, it is also interesting to research other areas of the proposed design space. Especially the 'environment' category seems to have potential to influence movement-exploration. Section 8.4 provides a good starting point for these future developments.

Second, for a future study, we are interested in taking a different starting approach. In this thesis, the modifier cards were taken as a starting point and problem statement. However, in the future, we could perhaps focus on seeing how we can optimise the design practice itself. This would require taking one extra step back to discover potential issues and troubles that exist in movement-based design. This could potentially open up the context of MBD and reveal underlying interactions and places of resistance. During the last interviews, one of the experts noted the issue participants may have with listening to their bodily experiences since there is still a present mind-body separation present in society. This might be one of the problems that could come up during more in-depth research on potential problems in MBD. The designed solution could then also differ, because it wouldn't take the design cards as the starting problem. The design would then rather aim to support people, as embodied beings, and empower them to take part in movement-based design activities, through their continuous interactions with the artefact. For this, future research might include co-design sessions with participants that find MBD challenging, and include them in the process of designing a solution.

Additionally, there is a recent rise in AI and creative art generation[15]. This might also be interesting for research in digital-physical artefacts. There could be possibilities to include creative, facilitating suggestions into the artefact, which could assist the design process. Another interesting area for future research is the way chatbots or robots interact with people. Findings from this field could perhaps make the artefact more sensitizing towards the environment and the participants so that it better fits with the design process of the group. It is interesting to see if he can then better assist the current facilitator.

9 Conclusion

With the MoMo, we aimed to stimulate meaningful movement exploration in movement-based design sessions. We designed a digital-physical modifier and tested its potential during a design workshop with HCI students. Although the modifier didn't lead to extensive movement exploration, the participants could pick up upon the designed movement actions. More research is needed to see if additional support through the facilitation of the artefact further impacts the effectiveness of a digital-physical artefact.

The study also revealed that participants have difficulty tapping into their bodily experiences and seeing this as a source of knowledge. Further research could be done in a context where participants are more experienced with body expression, to see if this changes the effects of digital-physical modifiers and their relation to the design process. Future research could also take a step back to look closer at why these participants feel uncomfortable and not ready to indulge in physical exploration. What are the problems they face, and what exactly would help their needs. With these insights, we could then look at the design space again and see how we can best facilitate these issues.

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A Research Topics On Facilitation

The full literature review on facilitation is added here, starting on the next page.

Research Topics

EXPLORING THE ROLE AND INFLUENCE OF FACILITATION ON THE DESIGN PROCESS

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Contents

1 Introduction

The field of Human-Computer Interaction (HCI) often makes use of (participatory) design sessions, where participants are involved in the design activities. Groups of users and other stakeholders collaborate to discuss, explore and work out design-related challenges. These sessions are typically led by a *facilitator*, who performs tasks that guide the participants from A to B: from design challenge to design outcome. Research in this field showed that a competent facilitator is essential for a successful outcome of a design workshop, since it has such a strong impact on the process and, therefore, the design outcomes [35, 33, 28, 14, 20, 11]. Despite its importance, the influence of facilitation in design is hardly recognised in HCI literature. This leaves the facilitator to be a 'black box' that is taken for granted in design research, despite its potential (negative or positive) influence [8, 42, 20].

Since design sessions are oftentimes guided by facilitators, there is a need for recognition of facilitation as an influential force that shapes the outcomes of a design session. Uncovering the influence of facilitation helps to understand how this impact manifests. Thus, this calls for 1) understanding the role of the facilitator to better understand the potential impact of the facilitator, either implicitly or explicitly, on the design process, and 2) empowering facilitators to make conscious decisions about their practice.

This literature review aims to answer the following research questions: 'What is the role of facilitation in design sessions?' The term 'role' covers the general function of facilitation in design, as well as the factors that the individual facilitator needs to balance. By sketching the broader context in which facilitation takes place, facilitators can become aware of their 'play field' and make conscious decisions about their practice. This review also discusses which factors are most influential. In this way, it tries to detangle the 'black box' and shine a light on the facilitation factors that need more attention in HCI research.

This review is structured as follows. Section 2 will describe the methods that were used to collect and analyse the data for this review. Section 3 will present a high-level overview of the different factors that influence facilitation, after which all the factors are discussed in more detail. These findings are summarised in a final overview, which is presented in Section **??**.

2 Method

2.1 Define

A systematic review of the literature was conducted to identify which factors are related to facilitation in design sessions. First, the inclusion criteria were determined. Accordingly, this study only included articles from the field of Human-Computer Interaction (HCI), or fields related to design thinking. This showed the number of times a facilitator is included in Design Thinking studies and which roles they play. The literature search was done in three phases, starting with a broad search of articles from the HCI field. After that, the field was narrowed to specifically include HCI in combination with movement-based design thinking. Then, the field was specified further to facilitation in the HCI and movement-based design field. A query of (a combination of) the search words, denoted in Table 1, was used on the databases ACM Digital Library, ResearchGate, Google Scholar, and WorldCat.

2.2 Data Collection and Selection

During the collection of data, the search words and outlets, as described in Section 2.1, were iterated upon.

For the selection of the data, first, duplicates in papers were removed from the set. Then, only the articles related to the field of Human-Computer Interaction or fields related to design thinking were included in the data set. This was done by scanning their title and abstract, after which the full articles were then scanned for their context relevance. Forward and backward search was done to find

design thinking and/or methods	movement-based design thinking	design thinking and facilitation
Embodied Design Methods	Movement-based (interaction) design	Participation
Design methods	body movement	Facilitation
interaction design	body-storming	Role
Human-computer interaction		leadership
method cards		
design tools		
interaction design process		
research through design		

Table 1: Search words for the three search phases

relevant related studies, and to enrich the quality of the data set.

Two additional sources of data were used in this study: expert discussions and observational data. The expert input on facilitation and grounded theory was directly used in the data analyses, see Section 2.3. The observations were done during a facilitated movement-based design workshop, which took place at the University of Twente with students from the master´s Interaction Technology.

2.3 Data Analysis

The literature studies were analysed according to the principles of Grounded Theory, using open coding, axial coding and selective coding in an iterative manner. The book 'Constructing Grounded Theory' by Charmaz [6] was mainly used as reference, in combination with a more practical Grounded Theory approach from Wolfswinkel, Furtmueller, and Wilderom [41]. In this study, the data used in the Grounded Theory was in the form of published papers, observational notes and discussions.

Each article was scanned again, and relevant findings and insights on 'facilitation' were highlighted. The selected text, either words, sentences or whole paragraphs, served as excerpts that were later used in the coding process. During this stage, concepts and insights were starting to form mentally. The highlighted 'excerpts' were then re-read and coded using the line-by-line approach [6].

Each line was coded, using the open coding principle. Besides, additional comments or broader insights, called 'memos', were noted. In this way, the 'hidden' meaning was articulated and labelled into concepts. In an iterative matter, axial coding was used to identify themes, relations, broader concepts and categories from the open codes. This uncovered categories and relationships between the data excerpts and the codes.

The iterative character of grounded theory allowed for identifying and relabeling the set of concepts once more excerpts were analysed. This caused the theory to become more stable over time. Once half of the data was analysed, the codes were transferred to a large brainstorm map. This mapped out the codes, their overarching categories and the relationships between them. Then, in an iterative process, the codes from newly analysed articles were added to the map and the structure of the map evolved accordingly. Selective coding was used to identify relationships between the main categories. Comparative analysis, as described by Charmaz [6], was used to engage with the data and the codes, by comparing codes with other codes, codes with other data, and data with other data. These new findings and higher-level insights were also used to refine the word map.

The observation notes from the facilitated session were first transcribed and complemented by memory. Then, the transcript undertook the same analysis process as the research articles and it was line-by-line coded and analysed. The codes were added to the map. The discussions with facilitation experts lead directly to alterations of the map and were not coded.

Once the literature from the initial search was analysed, the gaps in the map were identified. A second literature search was performed to fill these gaps to reach saturation. This was done by backward and forward searches with the most relevant papers. Each new article was directly analysed using Grounded Theory and the findings were integrated into the map. This iterative process altered the categories and codes until theoretical saturation was reached, meaning that no new concepts,

categories or interesting links appeared [6, 41].

2.4 Theory Building

The word map iteratively evolved while more codes were integrated. Once the categories appeared stable, the map was analysed using thematic analysis. Main themes were abstracted by engaging in interpretation and sense-making of the map. According to Maguire and Delahunt, thematic analysis makes use of six phases: becoming familiar with the data, generating initial codes, searching for themes, reviewing themes, defining themes, and writing up [24]. Step one to three were already performed during the Grounded Theory analysis. The initial themes from the first version of the map were reviewed and further grouped according to their overlap and relevance. This involved critically asking whether the themes made sense, if the codes were placed underneath the correct themes, if there was overlap, whether there were sub-themes visible within themes, etc. This process was repeated for the second and third versions of the word map. During this stage, there were still articles added to the data set when more 'substance' was needed in a certain corner of the map. After the completion of the third version of the map, an abstraction was made from the main themes of the map which served as the 'backbone' of the remainder of this literature review. This literature study was built by reviewing the codes and excerpts that were involved with each specific theme. A more general theory was shaped from the selection of papers related to the different themes.

3 The Findings

3.1 Literature Search

The first literature search resulted in a total of 65 papers. From this list, 9 papers did not met the inclusion criteria and were excluded. All papers were first analysed according to three categories: they either 1) didn't specify a facilitation role, 2) did not specify, but briefly noted the presence of a facilitator, or 3) specified that there was a facilitator. Table 2 shows the distribution of these categories over the three search domains. In the later stages of the Grounded Theory approach, a second literature search was performed to reach data saturation and fill 'gaps' in the map. This resulted in an additional 20 papers, which makes an overall total of 74 articles.

Design thinking and/or methods	**movement-based design thinking**	**design thinking and facilitation**
Not Specified: 11	Not Specified: 10	Not Specified: 0
Described: 5	Described: 4	Described: 0
Specified: 5	Specified: 5	Specified: 16
Total: 21	Total: 20	Total: 16

Table 2: Results of the initial literature search regarding the occurrence of a facilitator

3.2 A High-level Overview of Facilitation

Three iterations of the facilitation map were made in the online brainstorming environment 'Miro', which can be seen in Figure 1 and in the online Miro environment[1].

In the first version of the map, the codes were placed in clusters and categories were made between them. These categories were linked to higher-level categories, which formed the main theme of the map, as shown in Figure 1. After that, thematic analysis was used to iterate upon the map and evolve the sub-themes. In the second and third (final) versions of the map, the categories were critically analysed and reshaped according to the steps described in Section 2.4. Additional discussions and a design session were included in this process.

An abstraction from the final version led to a high-level overview of the different factors that play a role in the facilitation of a design session, shown in Figure 2. The main themes are Practicum, Facilitator as an individual, Social dynamics, Experience, and Support. The remainder of this study

[1] https://miro.com/app/board/uXjVPN-sFbc=/?share_link_id=877758937769

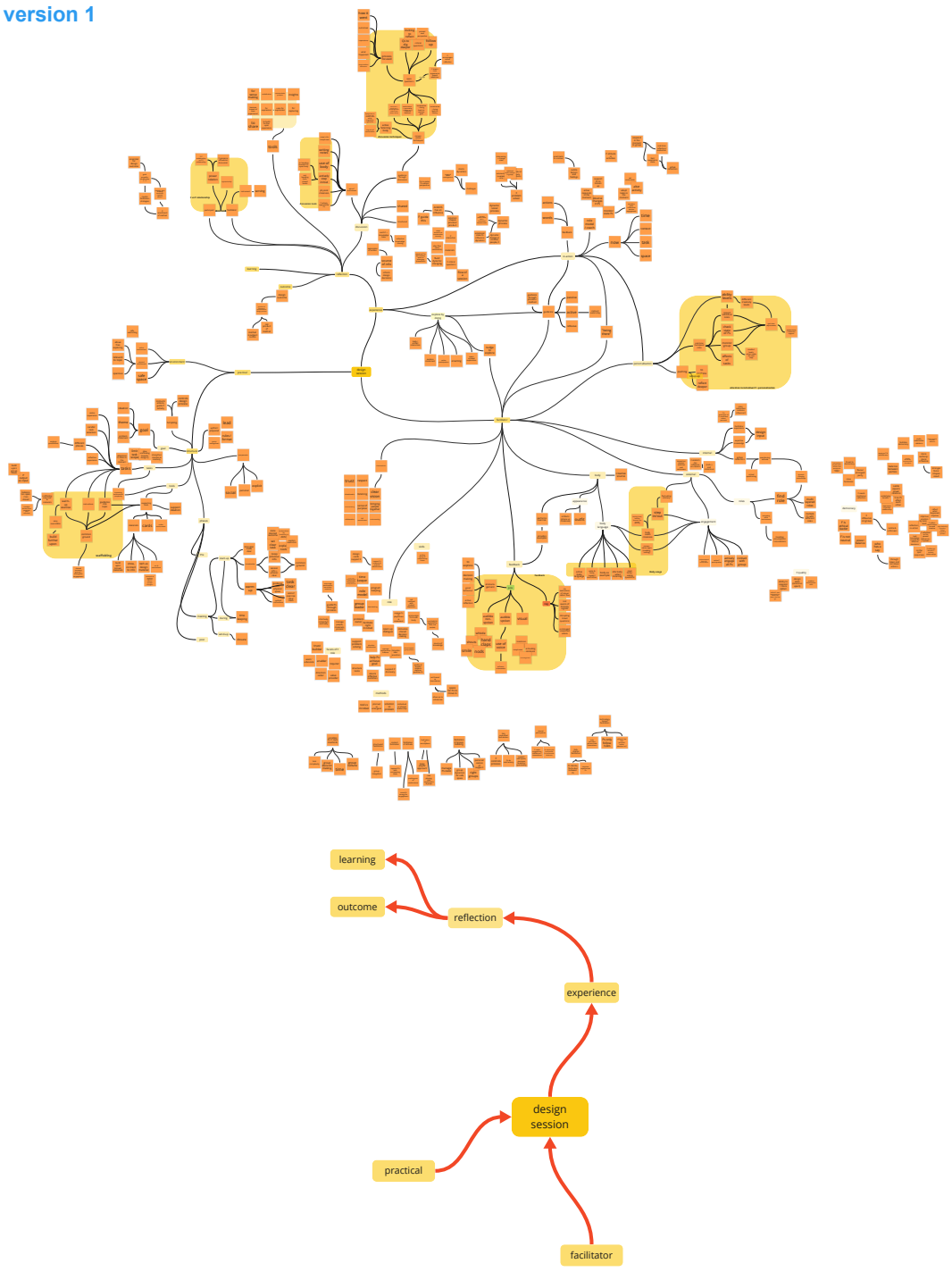

Figure 1: Mapping the Facilitation: version 1 of the word map (top) and the main theme (bottom).

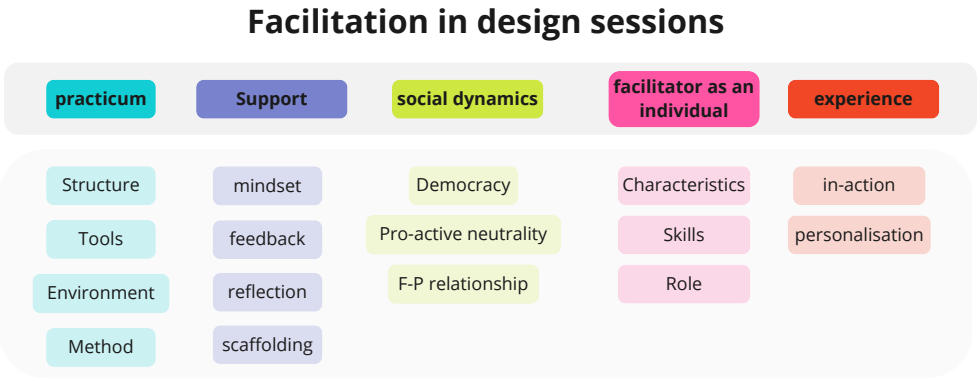

Figure 2: High-level overview of Facilitation

will go over these themes and their interrelations in more depth.

3.2.1 A three-layer facilitation figure

These main themes are structured in a three-layers figure of the facilitation factors that influence the design session, see Figure 3. From outside to inside the factors that influence the design session become more ambiguous and abstract.

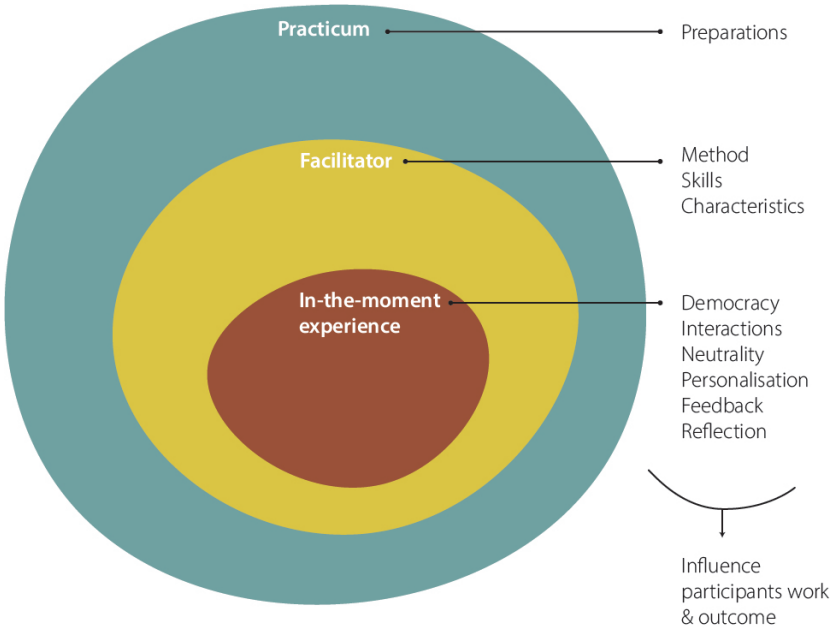

Figure 3: Model of the facilitation factors

The outer shell represents the practicalities of the 'Practicum', discussed in Section 3.5. These are all the elements that need to be carefully prepared and thought out. This involves preparations such as the structure, the tasks, the tools, the logistics, and the environment. But also preparing different personalisation scenario's for potential differences in skills and creativity. The preparation responsibilities stretch over all the phases of the session, from the first client contact to wrapping up the session. The elements of this shell need to be taken care of in order to have a successful design [52]

session. However, they are relatively easy to implement and are independent on the characteristics of the facilitator. Awareness to these elements can already help facilitators to consciously design a fitting design session.

The second shell discusses the elements that the facilitator brings to the session, discussed in Section 3.5.4, 3.6.2 and 3.6.1. It was discussed earlier that the facilitator as an individual, brings his own preferences, skills and characteristics to a session. Section 3.6 discusses multiple characteristics that are related to competent facilitators, some of which are inherent qualities, whereas others can be learned. This section also discussed the three different characteristics of a facilitator: interpersonal, process management, and personal. Although these qualities might come easier to some, they still can be improved when the facilitator actively works and reflects on them. This is the same for the skills of providing guidance and feedback. The facilitation method is also the result the personal preferences of a facilitator. Active reflection on the facilitator's influence and the effect this has on the process and the participants is a valuable way to improve facilitation practice.

The factors in the third layer are taking place *in-the-moment*, all at the same time whilst interacting with each other, discussed in Section 3.7.1, 3.7.3, 3.7.2, 3.8.2, 3.9.2 and 3.9.3. The facilitator has the role of 'juggling' all these balls. High-performing facilitators have the ability to handle all these factors with ease at the same time. The literature often recognised that the facilitator needs excellent social engagement and awareness to work with the social complexities of the group in a respectful, structured and flexible way [4]. The most competent facilitators can pick up the subtle things that are happening in the group and directly respond to them in an intuitive matter. These social abilities, as well as the ability for instant and intuitive response, show to be the most influential factors in distinguishing between novice and expert facilitators.

3.3 Main Findings on Facilitation

It became clear from the literature that facilitation is a subtle art. During a design session, participants move from a design challenge to a design outcome. Along this journey they might interact with each other, perform all kinds of activities, learn, experiment, explore, and experience. It also became apparent that there is often someone (although this is not always clearly noted in design research) that owns or presents the design problem and guides the participants on their journey towards the solution. A facilitator nudges and guides the participants on the path towards the solution. This asks for a delicately tuned facilitator that can bring the right amount of support for the best design circumstances. If this is done well, the session will be more effective and the results more successful [35, 14, 33].

However, this literature review found that the presence of a facilitator is barely acknowledged in design-related research. The reviewed articles in the 'Design Thinking methods' category only acknowledged the presence of a facilitator in 5 out of 21 studies. In the other 16 studies, facilitation was not noted at all, or only briefly mentioned. This was similar for the articles on movement-based design thinking. Even *if* there was a facilitator involved in the design process, his specific roles were not or very briefly described. However, research by Stewart, which specifically focused on facilitation, emphasised the importance of a facilitator [35]. The study stated that a competent facilitator is essential for a successful outcome of a design workshop.

Many of the analysed articles on facilitation suggest that there are different factors that play a role in facilitation [34, 13, 3, 35, 42, 28, 2, 25, 36, 8, 1, 11, 23, 9, 33, 5, 19]. However, most studies focus on a selection of factors in isolation, while a review of all these factors together is missing. Since most of these factors appear to influence the facilitation practice, the design thinking field can benefit from a more zoomed-out approach where all factors are considered. This will also shine a light on the potential interrelations between the factors. Therefore, this study aims to collect all the factors together in order to paint a more comprehensive picture of facilitation.

3.4 Facilitation in context

The larger context in which facilitation takes place is often not mentioned throughout the reviewed literature. Only researched by Stewart went into detail on how the group structure and the larger organizational context might influence the design process [35]. However, a closer look into the larger picture can help the facilitator to make conscious decisions on where his influence reaches. Stewart [35] concluded that the power of influence of the facilitator only stretches to the group process itself. Group process on its own is also discussed in other studies [34, 14, 19, 20, 3], and includes elements such as problem-solving [35, 14, 9, 26, 28], decision-making [35, 10, 31, 28, 14], communication [35, 19, 40, 31, 15, 14, 20, 9], boundary management [35, 15, 14, 20], and conflict management [35, 4, 10, 31]. According to Stewart, these are the elements for which the facilitator is responsible. Other factors that have to do with the group structure, the group effectiveness or the organizational context, lie beyond the influence of the facilitator [35]. The study also argued that an effective facilitator should understand and minimize these factors, but has no responsibility for them. However, the facilitator can support the participants in managing these factors, but according to Stewart, this is dependent on the competencies of the facilitator [35]. The remainder of this review will focus on these competencies and the factors that are in the facilitator's circle of influence. However, it is important for the facilitator to stay aware of the external influences that can intervene with the session.

After zooming in one step closer, research by Azadegan and Kolfschoten sketched the facilitation process during a single design session [3]. Their research shows the relationship between some of the competencies of the facilitator and the quality of the participant's work, however, they don't go into detail on the individual qualities. From their work, it becomes clear that the facilitator is responsible for setting up a structure so that the participants can collaborate efficiently and effectively. This was supported by other studies, who also stress the importance of providing a guiding structure [12, 19, 33, 10, 28, 14, 20, 9]. The facilitator also influences the motivation by managing the energy in the group through exercises [3, 28], which has an impact on the effort that the participants make [3, 19, 28, 20]. However, participant motivation is also partly intrinsic and influenced by other factors such as the external factors discussed in the previous section [35, 14, 38]. Azadegan and Kolfschoten expect an interaction effect between the group motivation and the quality of the facilitation service [3].

These results show that the facilitator has an important role in stimulating the right mindset and energy, as well as the process. However, the study by Azadegan and Kolfschoten does not specify what is needed to achieve this and which qualities are required from a facilitator. But since the overview includes elements that are related to social dynamics, such as motivation, energy and effort, it suggests a need for strong social and communicative skills from the facilitator. In the next sections, this work aims to review a large selection of papers in order to provide an overview of these qualities and the way they impact the facilitation practice.

3.5 Practicum

This section discusses the practicalities that involve facilitation. Most of the aspects that contribute to a successful session mainly require thoughtful preparation, planning and critical thinking upfront. That suggests that these elements are easier to implement since they don't necessarily depend on the personal characteristics of the facilitator. These individual skills relate, for example, to the facilitator´s ability to handle social dynamics, design skills, or his experience in facilitation [31, 26, 20]. This section will go over the different practicalities that were abstracted from the reviewed literature: Structure (3.5.1), Tools (3.5.2), Environment (3.5.3), and Method (3.5.4).

3.5.1 Structure

The timeline of design facilitation stretches both before and after the session. As a facilitator, it is important to understand the context in which the session takes place in order to steer towards relevant outcomes. This includes an understanding of the design challenge, the client, the different stakeholders, the overarching project, previous sessions, etc.

There are different studies on how the timeline of session preparations can be structured [3, 35, 14].

Hayne note that the division into stages serves as a loose guideline and shouldn't be used as a rigorous structure [14]. However, they suggested that design problems of higher complexity require a more structured approach, whereas this is less necessary for simpler design problems. Overall, the literature has an agreement upon the phases: an initiation, pre-workshop, workshop, and post-workshop phase.

These findings are summarized and the following 4-stage model is proposed:

1) Initial Client contact This stage describes the initial workshop request and information meeting with the client. There are different facilitator tasks in this stage that might influence the design session later on. First, the facilitator has the task of gathering a first understanding of the design problem and situation, since this might influence his ability to intuitively guide the design session. This might include the workshop topic, practicalities, and potential challenges and opportunities [35]. Another factor that might influence the group dynamic later, is how the facilitator understands which stakeholders are involved and what their requirements are. A last factor is how the facilitator diagnosed the design problem: is a design session suitable or could alternatives, such as a presentation or training, be considered? Picking the most suitable format might affect the effectiveness of the session [35].

2) Pre-workshop preparation This planning and preparation stage occurs around five to ten days before the design session. In this stage, the way different preparations are carried out might influence the design process later on. This includes the facilitator's cultural- and contextual awareness, preparations of the logistics (such as participants, venue, documentation, and equipment), a design of the workshop process and a decision on the tools that will be used in the design session [35, 14]. This has a large influence on how the space, tasks and participants will come together in the session later on. Other factors that influence the session, are which participants are invited and how they are briefed on beforehand. Designing the appropriate tasks is dependent on how the facilitator assessed the participant´s familiarity with the tasks and materials [9]. Last, the design session might be influenced by how the facilitator reviewed the previous meetings to understand the overall process and prepared the meeting goal, key documents and agenda, and anticipated the risks [14].

3) Workshop Facilitation Activities This phase describes the design workshop itself and it contains managing the process, objectives, and participants. Although the facilitator has the end responsibility to meet the session deliverable, he will not be involved with the content itself, but rather with the process [28, 14] The competencies of a facilitator become most evident during this phase since he has to manage all the elements in real-time [35]. The factors that are of influence *during* the session are discussed in more detail in the next sections.

The workshop activities can be further fragmented into a Start-Up, During, and Wind-Up phase [14]. The *Start-Up* phase aims to create a common ground between all participants and prepare the right mindset. The *During* phase contains the actual design tasks and activities that are earlier prepared by the facilitator. The *Wind-Up* phase recaps and summarizes the session and ensures that the participants have a common understanding of the accomplishments [14]. The influential factors that come into play during the design session will be discussed in depth in the next chapters.

4) Post-workshop Activities The post-workshop activities contain the finalisation of documentation, such as project plans, summaries, or business models. Although the session itself has already been completed, the facilitator can still influence its effectiveness by tying up the loose ends in a responsible matter. This includes tasks such as distributing the right materials to the participants and stakeholders afterwards, as well as communicating the next steps and potential forthcoming sessions. [35]. This also includes a moment for reflection, so that the facilitator might improve his own practice for future design sessions. As well as a meeting with the client to review whether the objectives and outputs met the expectations [35].

3.5.2 Tools

Different types of materials are used during design sessions, such as technologies, craft materials, or design tools (such as design cards). These tools are used as media to explore, express, discuss, reflect

or transfer thoughts [30, 12, 9, 10, 40]. It is *through* these materials that the participants are able to channel their thoughts and creativity [10, 26, 19, 28, 20]. To facilitate this as effectively as possible, the facilitator should show and introduce the tools clearly so that the participants are able to 'master' them [15, 10, 26, 19]. Especially if there is a tool abstraction, where a tool substitutes for an abstract concept, it could cause difficulties for some participants [9]. A selection of conventional and unconventional materials can encourage participant exploration [40].

Hutchinson et al. gave their participants 'low-tech prototyping art materials (coloured paper, string, clay, etc.) to use to design technology solutions´ [16]. Low-technology materials can substitute for complex materials, while the design goal can still be reached. Similarly, Lee, Lim, and Shusterman asked their participants to design an interactive product, but they provided only 'various materials for sketch drawing and low-fidelity prototyping´ [19]. In a study by Oulasvirta, Kurvinen, and Kankainen, materials were used to explain the design scenario, where 'drawings and written text were used as a media for scenarios' [26]. This served as a source to transfer thoughts, and provoke expression and discussion.

The facilitator can also make the decision to design with more complex technologies. Wilde[1] et al. encouraged the participants to experiment with technological materials, such as body-mounted sensors and other recording devices [40]. [10]. Hsueh, Alaoui, and Mackay asked their participants to interact with high-technological materials [15]. They were instructed to dance and move their bodies in reaction to adaptive visualisations on a larger screen. The visualisations could be altered with different visual parameters, such as springiness, fluidity, or speed. In this case, the participants interacted with the technology in a more one-sided interaction, where the technology only gave the prompts to which the participants reacted.

A combination of high-tech and low-tech materials is also possible. Frauenberger, Makhaeva, and Spiel used a combination of high- and low-technological materials to design quick but interactive prototypes [10]. These types of click-and-play technologies lend themselves perfectly to quick, low-fidelity prototyping since they can often be combined with craft materials such as cardboard. The technological materials used by [10] were 'Little Bits' [2], which is described as 'an open source library of modular electronics, which snap together with small magnets for prototyping and learning' [7]. After the participant became comfortable with the technological material, low-tech materials were introduced to create hybrid prototypes that were semi-functional.

Design cards

Design cards are a physical tool that can facilitate ideation and creativity [5, 18, 32]. Cards are able to digest abstract frameworks or theory into a more operational and tangible form through keywords, pictures, cues and questions. This can serve as a stimulus for new contextual perspectives. In a review of 18 design cards by Bornoe, Bruun, and Stage, it was highlighted that cards can 'facilitate a design process, support design dialogues, make the design process visible and less abstract, provide structure in the process and are easy to use and manipulate' [5]. It is therefore a useful tool to shape common ground among participants and stimulate concrete discussions. Bornoe, Bruun, and Stage make a division between general or open-ended design situations, context-specific situations, or participatory design situations (where designers and users are both engaged). They further divide the usage of cards into 'no methodology', 'suggestions for use', and 'specific instructions'[5].

3.5.3 Environment

The environment is the space where the design session takes place. The environment entails the physical setting itself, a more subtle atmosphere in this physical space, and possibly an online environment for extra support [28]. However, COVID-19 showed that the physical space itself can, although with certain limitations, also be brought to an online environment [27].

The physical space should mostly be big enough to and allow for free exploration [33, 10, 19, 14, 27]. Reidsma et al. note that 'An essential role of a facilitator in Movement-based Design is to create a safe and welcoming space where the design activities can take place. People may feel exposed and embarrassed performing movement activities.' [28]. In line with this, Lee, Lim, and Shusterman stated

[2] https://sphero.com/collections/design-build-systems

that 'The physical space should allow for the design activities to take place, the space for designers to freely move around, and work either at the table or on the floor.'[19]. Frauenberger, Makhaeva, and Spiel add that the environment should allow for free exploring of possibilities regarding the design materials and space [10]. And Body, Terrey & Tarags add that 'A good space will have good natural light, space to move around and plenty of horizontal or vertical surfaces on which to develop or display emerging thinking' (Body, Terrey & Tarags, 2010). Choosing certain environmental stimuli can influence to the facilitation of the participant's mindset, according to Reidsma et al.[28]. However, the facilitator should be aware to 'protect the group from the external environment' and potential hindering, external threats or distractions [14, 38].

The more subtle atmosphere is largely influenced by the setting, but also by the group dynamics and the facilitator himself. The mood and energy in the room should be facilitated for the best possible participant commitment and engagement [28]. Reidsma et al. noted that mindset is an important factor and that it can be scary for participants to engage with full commitment. They state that when 'acting out (in often new environments with new people) is scarier, the group dynamics also become more critical.' This asks for active facilitation to guide the participants in their stage engagement. However, it is a fine balance of pushing certain participants a bit harder, while other participants might need to be left alone more [28]. The initiation of more restricting exercises, such as warm-up exercises, can help to 'support building a safe and friendly movement environment, but probably takes away some flexibility and spontaneity' [28]. Overall, the facilitator should be very mindful towards the atmosphere of the group, since it can greatly impact the group dynamics and participant behaviour. It asks for careful 'feeling' of the group´s doing and which support is needed.

3.5.4 Method

Different variables can influence the facilitation approach, such as group culture, task complexity, group decision-making, and time [14]. Hayne stated that there are different processes that the facilitator can influence. The task activities themselves are mostly content-driven which means that they are in the hands of the participants. However, the structure and the process are in the facilitator's control. The facilitator can thus actively decide upon the structure of the session or how much influential control he gives to the participants.

A range of facilitation methods

This framework visualises how facilitation approaches can differ from each other, by distinguishing between four parameters.

Starostka et al. discussed four parameters that characterize the different facilitation methods, see Figure 4 [34]. Each of these parameters is a continuum on which a facilitator's approach can change, either voluntarily (by adjusting to the group) or involuntarily (by social pressure or preferences). The first parameter is understanding Design Thinking from a Tool vs. Mindset perspective. This ranges from participants focusing on the tool itself and using it as-it-is to achieve a goal, to the participants understanding the mindset behind the tool and being free to explore and experiment with it. The second parameter is focusing on solutions vs. on problems. this ranges from a focus on the creation of a solution or prototype and working towards this, to a focus on identifying the full problem, whereas the solution itself comes secondary. The third parameter is a planned vs. emergent process. This ranges from having a defined and well-prepared plan, which is presented to the group as a ´given´, to having many prepared materials, but no predefined plan. Instead, there is room for consensus and co-developing with all participants. The last parameter is individual vs. shared leadership. The left side of the continuum describes a process that is led and steered by the facilitator, with two extremes that are either 'I facilitate', or 'I delegate facilitation responsibilities to you´ [34]. Whereas the right side describes a process where the responsibilities are shared with the group and the facilitation will provide guidance to teach and engage, but the participants take co-responsibilities and the overall process is co-created. Each approach has its own strengths and weaknesses, and the appropriate method should be adjusted to the context of a project and to the group´s development and expectations. To illustrate this continuum, Starostka et al. did two case studies, where one facilitator practiced on the left side of the continuum. Participants stated that they really disliked the rigid structure and the unpleasant way the facilitator took authority. They had no room to follow unexpected leads or explore a certain area more. The facilitator from the second case study was found on the right side

of the spectrum. Although the participants liked the freedom and co-sharing of responsibilities, they noted that they felt very lost in the possibilities. More guidance and restrictions would have been very beneficial. This shows that the extremes both have their own consequences, and the facilitator should make a deliberate decision on which side fits better to the session.

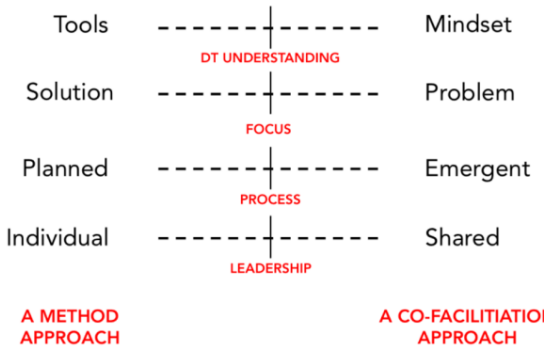

Figure 4: The four facilitation method parameters on a continuum extracted from [34]

Facilitator control

This framework describes four different approaches in which the facilitator can exert control over the participant group.

Reidsma et al. mapped facilitation approaches along four facets [28]. The first is fully controlled facilitation, where the facilitator controls the complete process and participants only focus on their tasks or activities. This limits flexibility and spontaneity but adds to a safer and more friendly movement environment. The second is shared participation, where participants can explicitly suggest methods or influence the process. This requires a smoother session where participants feel comfortable, but it has the risk of a unbalance in participant dominance. Thirdly, fully shared facilitation, where the session runs between the participants, without a fixed facilitator. This requires an experienced group that is aligned in their goal, path and timeline. Last is technology-based facilitation, where a technological tool steers the process and provides structure and rules. This increases the efficiency of the session but lacks adaptiveness and personalisation to individual participants.

Types of facilitation

This framework summerizes the different elements that can be facilitated.

Reidsma et al. also introduced a theory on the different elements that can be facilitated. Their seven focus points are: 1) structure facilitation, which ensures that the group stays on the right path, regarding order and time [28]. 2) content facilitation, which helps to identify interesting or 'unheard' ideas from all group members. 3) mood and energy facilitation, so that commitment and engagement stay high. 5) facilitation of maintaining a playful attitude, since this is hard to do on commando and needs some steering with examples, tasks, props, or task constraints. 6) group-building facilitation, which handles the group dynamics and involves monitoring individual participant engagement, setting up the right groups, and the personalisation of support. 7) Facilitating of stage-engagement, to help participants step-in-and-out of the centre point of the group.

3.6 Facilitator as an Individual

Facilitation methods and techniques cannot exist on their own, instead, they are carried out and embodied by the facilitator [20, 39, 9]. Light and Akama stated that 'it is not meaningful to separate the designer from the method since we cannot know participative methods without the person or people enacting them. Methods and techniques require embodiment [9]. We must also look at how this relates to practitioner characteristics, their worldview, purpose and decisions on the day.' [20]. The study by Light and Akama urged researchers to pay attention to the way in which designers practice facilitation, rather than merely looking at the methods themselves. They further stated that the characteristics

of the facilitator are relevant since they influence how the method will be carried out, which was also found in other research [38, 31, 9].

Stewart stated that the 'competency' of a facilitator can be split into five parts: motives, traits, self-concept, knowledge, and skill [35]. Motives describe the drive and behaviour that steers facilitators towards certain actions. Traits are the personal characteristics and nature of the responses to situations. Self-concept contains the facilitator's values, self-image and attitudes. Knowledge describes how much the facilitator knows about a certain area [28]. Skills describe the facilitator's ability to perform a certain task, either physically or mentally [30]. Skills and knowledge are relatively easy to learn with time and training. On the other hand, motives and traits are difficult to learn and are more dependent on the innate characteristics of the facilitator [31, 20, 9]. This requires a selection process to ensure that the facilitator has the essential characteristics in order to effectively facilitate a design session. A larger difference in these factors will distinguish an average facilitator from a superior one [35]. These factors are further discussed in the three sections below, focusing on characteristics, skills and facilitator role in design sessions.

3.6.1 Characteristics

The facilitator is the enactment of his own worldview, values and personal characteristics [20]. This means that the inter-subjective nuances of an individual facilitator will have an influence on the session [9]. Schweitzer, Sobel, and Groeger named the following characteristics that make a competent facilitator: trustworthy [28], respectful [9, 38], charismatic, understanding [27, 14, 20, 9], having a clear vision, sense of purpose, full commitment, bringing people together [9], collaborative [12, 27, 28, 20], and strong in communication [31, 40, 14].

Stewart proposed a set of competencies that are essential to high-performing facilitators. Their competency model stretches over five categories: Interpersonal competencies (communication skills, and other skills), management process competencies, personal characteristics, and knowledge competencies. High-performing facilitators stand out because they 'can do it all at once' [35, 33]. They also show greater abilities of sensitivity, intuitiveness and empathy [35, 9, 20].

Interpersonal characteristics
The interpersonal skills of a facilitator mostly contain the ability to participate in an effective conversation. Stewart concluded that high-performing facilitators have exceptional communication skills. These skills were summarised in 'LEAPS': Listen, Empathize, Ask, Paraphrase, and Summarize. Their verbal, non-verbal, and written communication skills are also high, in combination with an attitude of good questioning, active listening, and perceptive listening.

Besides communication skills, other essential interpersonal skills were flexibility, sensitivity and modelling neutrality. However, almost all interpersonal skills were evaluated as important by Stewart. This includes cultural awareness, leadership, and building relationships. Interestingly, leadership was evaluated as the ability to 'shepherding', where the facilitator 'leads from behind' instead of a hierarchical way of leading.

Process-Management characteristics
The competency model by Stewart showed that managing time, planning and organizing, managing the physical environment, and managing feedback were evaluated as the most important process-management skills.

Personal characteristics
Adaptability and emotional resilience are two personal characteristics that were evaluated as most important. However, there was no large difference between the other personal characteristics from the model, such as trustworthiness, self-awareness, objectivity, or intellectual agility.

3.6.2 Skills

Novice facilitators do not have the same skill set as expert facilitators [20]. The largest difference lies in their ability to identify problems. Light and Akkma suggest that engineering tools can support the

Design Thinking Types	Design Expertise Levels	Problem Level	Problem Level Approach & Description
Result-Focused	Naïve	Simple	**Direct** Complete a task
Convention-Based	Novice	Simple	**Change Work Processes** Modify process to facilitate self-direction
Situation-Based	Advanced Beginner	Complicated	**Modify Structure** Modify approach, information & connection
Strategy-Based	Competent	Complicated	**Convene & Intervene** Compare approaches with and without goals
Experience-Based	Expert	Complex	**Convene** Bring together components of complex adaptive systems
Developing New Schema	Master	Complex	**Examine, Describe Patterns** Observe interactions between complex and adaptive systems
Redefining the Field	Visionary	Chaos	**Seek Patterns** Scanning chaotic systems for emerging patterns

Figure 5: Design expertise compared to design thinking types, extracted from [25]

novice facilitators, which can 'improve reliability and quality of problem identification' [20]. They note that design cards can serve as a helpful tool to support novice facilitators. Their study also suggested that an ongoing reflective approach to their own facilitation practice can improve the quality and skills. Besides, facilitators can improve their level of design expertise with repetitive practice, 'skill acquisition, learning declarative knowledge and developing relevant experiences', which will help in their facilitation practice [25].

Different studies explored the influence of design expertise on the quality of facilitation [25, 28, 20]. The success of a design session is for some part dependent upon the facilitator's guidance and feedback [25, 33, 14, 12, 19, 30, 10]. However, a certain design expertise level is required so that the design thinking methods can be successfully instructed and provided with feedback.

A model of seven layers of design expertise was proposed, ranging from naive to visionary [25]. These seven layers are mapped against design thinking types, as shown in Figure 5. The lower levels of design expertise have a problem-focused approach. This means that naive designers tend to take on a problem-focused strategy where they spend all their attention on analysing the problem in order to get to a solution. On the other hand, facilitators with higher levels of expertise apply novel, unexpected solutions. Design experts tend to use solution-focused problem-solving techniques, where they focus on the generation of solutions [28].

Another differentiator between novices and experts is the facilitator's ability to perform reflection-in-action [33, 9, 20, 12, 27, 39], which, according to Mosely, Wright, and Wrigley 'helps them to deal well with situations of uncertainty, instability, uniqueness and conflicting values that are inherent in ill-structured problems' [25, 27, 20]. Advanced designers also apply a focus on the 'methods, skill set, modes of reflection, mindset or mind-shifts needed to practice design thinking' during the design session [25, 31, 28, 27, 20]. This is in contrast to the naive facilitator, who focuses on surface-based issues, such as workshop structure and the stages that are often associated with design thinking.

This suggests that facilitators can be differentiated by their ability to approach problems [25]. However, Mosely, Wright, and Wrigley added that the ability to solve problems is not only influenced by design expertise, but it's also greatly influenced by creativity [25]. Their study recommended facilitators to have a minimum level of 'Advanced Beginner' or (preferably) 'Competent', which corresponds to a finished undergraduate study in design. Facilitators with a lower level will have trouble guiding the participants through complex problems. This will impact the participants' ability to fully comprehend and address the design challenge of the session. Mosely, Wright, and Wrigley advised mindfulness towards the complexity of the design problem so that it fits the design expertise level of the facilitator.

Sanders and Stappers discussed that facilitators can bring domain-specific skills into their practice since they are often also active in other fields [30]. For example, a facilitator that is also a social psychologist can bring in knowledge of interviewing skills, as well as knowledge of social interaction patterns. This expertise can be valuable in the facilitation process. It is also argued that the expert

knowledge of the facilitator, as well as their facilitation experience itself, can serve as additional design input [27, 30]. However, this is a debated topic since other studies suggest that facilitators should stay away from the content of the design session [28, 14]. But perhaps this asks for subtlety from the facilitator's side, to balance his influence on the design session while making use of his valuable insights.

Another highlighted skill is to provide guidance, although the body of literature suggests different ways of doing so [30, 19, 39, 40, 37, 28]. Lee, Lim, and Shusterman discussed guiding the participants in reaching the appropriate mindset or reflecting on experiences [19]. Wilde, Vallgårda, and Tomico proposed guidance to help participants through a method and in the discussion phase [39]. Sanders and Stappers noted how the facilitator can guide participants on different levels of creativity, ranging between leading, guiding, providing scaffolds and offering a clean slate [30]. Wilde[1] et al. discussed guiding the participants during the experimentation and discussion phase [40]. Hsueh, Alaoui, and Mackay discussed an example where a participant was 'stuck' in the task and the facilitator 'stepped in and helped guide her in relating to the visuals', which shows that the facilitator has a role of actively stepping in- and out in order to assist participants at critical moments in their process [15]. Light and Akama summarized that a facilitator guides 'people through processes to agreed-upon objectives in a manner that encourages participation, ownership and creativity from all' [20]. And last, Reidsma et al. added that 'a facilitator is skilled in guiding a group in co-operative processes, including shared decision-making to full its purpose in the best manner — focusing on managing design activities, unlike managing the content' [28].

Wakeford and Pimbert criticise that facilitators often apply a ready-made method without much elegance. Rather, facilitation should be seen as a craft that requires 'a comprehensive apprenticeship rather than a handful of brief lessons' [38]. They proposed that a facilitator has a toolbox ready, which they can tap from according to the situation. In addition to this, Light and Akama stated that there is a consensus in research that facilitation cannot be done by a handbook [20]. It asks for a subtlety to feel, experience and think about what is going on. Especially what is happening *now* in the moment with the participants and the atmosphere in the group. It asks the facilitators to respond in-the-moment to the situation in an intuitive matter, although this (often) stems from a method or theoretical skill. There is a need for subtle 'feeling' of the room [20]. Their research further described this as 'The facilitator is required to juggle personnel, materials and processes in intuitive ways (Light and Miskelly 2008), often instantly or reactively and we detail the interaction that influences the decisions made – often intuitively and often in response to unexpected incidents'. This indicates that an important part of being a facilitator is managing the group in an intuitive manner. This asks for quick responses that come from an intuitive grounding, and are not always fully thought through on the spot.

3.6.3 Facilitator role

Facilitators can have different roles in relation to the session or to the participants. The facilitator is challenged to find their role in the group, while there can be one facilitator with a multi-layered role, or multiple facilitators with different roles [27]. Research by Harvey described this as the 'multifaceted role' of facilitation, which contains enabling reflective learning, identifying the participant's needs, guiding the group process, encouraging critical thinking behaviour, and helping achieve the design goals [13]. Facilitators have to navigate this social environment while handling assumptions and associations from the participants [27]. In this dynamic environment where the relationships are constantly changing, it asks for a critical questioning attitude with active reflection and constant adaptation [27, 38, 19, 13].

The different roles of a facilitator can be roughly categorised in process or practicalities related.

Process. Regarding the process, the facilitator role can be further divided into group dynamics, reflection and exploration. Hayne stresses the importance of this role: 'process guidance, process restrictiveness, and communication mode directly impact decision quality', where decision quality describes the ownership of the participants over their design problem and their ability to tackle it.

Facilitators assist group dynamics by supporting problem solving or, as Hayne concludes, ´help the group face, access, and deal with unpleasant realities' [14, 9]. Hayne further differentiates between

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problems that are ‘(1) *substantive*, limitations in information available or use of information, (2) *procedural*, the best way to sequence activities, and (3) *relational*, relationships among the group members´ [14]. Facilitators also support the group dynamics by helping the group reach a consensus [14, 9], by encouraging and stimulating decision-making and collaboration among participants [10, 28, 14], encouraging a collaborative mindset that embraces diversity [31, 27, 28, 20], and encourage active participation [19, 28, 20]. Facilitators also have an important role in equalising the power relations that might be present among different stakeholders or participants. This will be discussed more in section 3.7.

A second element of the facilitator's role in the process is reflection. Facilitators have the role to open up the dialogue [33, 28, 38], assist participants to express their view [9], or support communication to create understanding between participants [14, 20, 9].

A third facilitation role in the process is regarding exploration. This entails facilitating the right mindset, stimulating playfulness and movement [28], supporting participant discovery [14], stimulating idea generation [28], and encouraging ownership and creativity [31, 20]. Especially regarding movement-based design, the facilitator also has the role to encourage the participants to use their bodies to experience, feel and use their senses [28]. This is important since participants' bodily knowledge serves as design input in the process.

Practicalities. Regarding the practicalities, the facilitator has a role in managing, leading, and taking care of the content. This contains management of the program, the time, the people, the materials, processes, the planning and the results [10, 26, 14, 16, 12, 28, 20, 9]. The facilitator has a main role as group leader [26], problem owner, guide [30, 20], or role model [33]. The facilitator also has a role in taking care of the content by structuring the tasks [14, 33, 10, 15], managing the balance between tasks and process [14], documenting [40, 26], and assuring effective outcomes of the session [14]. Besides, the facilitator has the job to set the boundaries in which the participants can move. Hayne described this as: ‘to provide a picture frame, or boundaries, within which the group can be creative‘ [14]. The use of boundaries or constraints is confirmed to help with creativity, collaboration and stimulation of the right mindset [22, 28, 20, 9].

Dahl and Sharma mapped the roles of a facilitator in ‘six facets of facilitation’: 1) Trust builder, 2) enabler, 3)inquirer, 4) direction setter, 5) value provider, and 6) users' advocate [8, 28]. The ‘trust builder’ creates an open setting which allows for idea and perspective exchange. The ‘enabler’ helps participants to express themselves with their ideas, needs or perspectives. The ‘Inquirer’ aims to understand the participants and their values. The ‘Direction setter’ steers the direction of the session so that the outcomes are most effective. The ‘value provider’ ensures a valuable outcome for the participants. The ‘users' advocate´ takes the role to represent their perspective during external decision moments.

Harvey concluded that there is no *one* best approach to being a facilitator [13]. Rather, it is a holistic approach with a continuum of roles and skills. The facilitator has the job to move along this continuum according to the situation and its dynamic changes. This requires flexibility to adapt and understand the needs on-the-spot. This was summarised in their research, where the facilitation role is placed on a continuum with on the left ‘doing it for others’ and on the right ‘enabling others’. Doing it for others means that there is a didactic, traditional way of teaching, with a lot of technical help. Enabling others means a more developmental way of learning, with a sustained partnership relation. The skills that fit on this continuum stretch from being very technical and clinical, to co-counselling, authenticity, and critical reflection.

3.7 Social Dynamics

The atmosphere in the group is very important for creative processes and part of this are the social dynamics between the facilitator and/or the participants. Asymmetries in the social dynamics can disturb its effectiveness since the strongest party has the potential to take over [9]. Besides, a ‘naive’ facilitator, who is not aware of the social dynamics, can form a threat to the democratic and empowering characteristics of a design session [9, 33]. These characteristics explain how all parties cooperate and take part in the decision-making process (see Section 3.7.1) [28]. This requires balanced equality between all parties. However, according to Dahl and Svanæs, this is not the default in a design session

[9]. It is dependent on the skill set of the facilitator and their active involvement to keep the social dynamics in balance. This section reviews the facilitator´s role in the social dynamic environment.

3.7.1 Democracy

Dahl and Svanæs noted that democracy is a fundamental principle of designing with participants, such as participatory design [9]. However, according to their research, it is not a 'given' inherent property of design sessions. Awareness by the facilitator is required for an active approach to potential asymmetric relations in the group. Research by Dahl and Svanæs described the facilitator as an ethical leader, who has an influence on who has a say in the session [9]. The effect of imbalances was illustrated by Dahl and Svanæs. The facilitators realised after the design session that they were not aware of the authority of the strongest party [9]. In this case, a doctor and a nurse from their design session had a discussion and the facilitators caught themselves favouring the doctor's opinion without second questioning. This might be similar when the participants are from the same party since there can still be differences in authority. A fruitful design session requires a participant group where everyone feels free to share and contribute. In other words, there is a need for an evenly distributed power balance. This gets more challenging when there are multi-stakeholder relations. When there are asymmetries in the power relations, it's the facilitator's job to equalise this. The power distribution is influenced both by the action that the facilitator takes, as well as the action he *doesn't* takes. These non-actions influence what, whose, and how perspectives result in the design output of the design session. This means that in an unbalanced group, the design outcome will likely be more influenced by the participants with the highest authority. Dahl and Svanæs's research further states that, besides the influence of participants on the social dynamics, the facilitator himself also has an influence [9]. They warn that the facilitator has a subtle and unforeseen influence on the group, but that mindfulness and continuous reflection can be applied to make more conscious decisions in order to limit this influence [9]. However, Wróbel, Cash, and Lomberg note that a certain amount of power is still required in order to keep a grasp on the process and the participants. This power might fluctuate over the course of the project. In one of their case studies, it showed that more power and authority from the facilitator was needed at the beginning of a facilitation process, but once respect and authority were established to a certain degree, there was less need for this [42].

Balancing parties asks for awareness of the relationships between participants and the underlying dynamics. The way in which participants affect each other can be subtle and easy to miss. This is 'tacit knowledge', which allows the facilitator to make immediate and effective decisions when a disruption in power balance occurs. The ability to provide an on-the-spot response can be improved by reflection. Research by Slovak, Frauenberger, and Fitzpatrick distinguish between reflection-upon-action and reflection-in-action [33]. Reflection-in-action is continuous reflection during the session, whereas reflection-upon-action is *looking back* upon the practice and improving this by reflecting on what happened. The facilitator can reflect on himself, on the actions of the participants, and on the underlying relationships. the facilitator can also reflect on his own practice, the design outcome and process, his power and control, and the amount of influence that he had on the session.

3.7.2 Pro-active neutrality

Research by Dahl and Svanæs showed that the facilitator is often labelled as neutral in design studies [9]. However, this fails to recognise how the facilitator might influence participation. Dahl and Svanæs stated that the facilitator is an influential force that has an impact on the session outcome [9]. Facilitation will *always* have an influence on the group, either subconsciously or consciously. This was illustrated during two case studies by Light and Akama[20]. The first study had a very involved facilitator, whereas the second study had a facilitator that was very distant from the group. In both studies, the facilitator influenced the process, which suggests that a facilitator is not neutral. The facilitator should handle this power with care, and reflect upon its influence. Dahl and Svanæs suggested reflection-on-action as the ultimate tool to stay aware of the interaction interplay in the group, which also contains the neutrality of the facilitator [9].

Neutrality contains, according to Wróbel, Cash, and Lomberg, three main elements that collectively contribute to the neutrality of the facilitator: impartiality, equidistance, and fairness [42]. *Impartiality*

deals with the distance that the facilitator takes from the content, refraining from judgement and treating the participants as equals. In practice, this would mean that the facilitator takes on a role of an 'external party' and limits its influence on the ideas or solutions of the participants.

Equidistance deals with the equal distribution of attention among the participants, such as actively giving people a turn and paying attention to the quieter participants [42, 38]. Wróbel, Cash, and Lomberg noted that an equidistant facilitator actively uses body language or speech to encourage participants to speak up, asks appropriate questions and pushes participants when needed [42]. Looking back at a previous example by Dahl and Svanæs of a design session with a nurse and a doctor (see Section 3.7.1), a more equidistant facilitator might have influenced the power balance between the two parties [9]. In this case, it could also be questionable whether or not strict equidistance is desirable. Perhaps, it might be better to spend more attention on a quieter participant, in this case, the nurse. This could affect the involvement of all participants.

Fairness has to do with the consistency and transparency of the process, tasks or rules from the facilitator. This also includes openness to feedback and actively implementing participants' feedback. In practice, this takes the form of clear two-way communication, where participants have room to reflect and suggest changes to the process [42]. In two case studies by Light and Akama, the effect of different amounts of fairness was illustrated [20]. One facilitator applied a strong two-way communication style, whereas the other facilitator did not. This had a strong influence on the process of the design session, suggesting that it is an important facilitation factor to be aware of.

There are three main facilitation outcomes on which the facilitator has an impact: people, process, and content [42, 30, 28, 14, 20]. The three elements of neutrality (impartiality, equidistance, and fairness) interact with these facilitation outcomes. The facilitator has the task of balancing the elements of neutrality over the course of the project so that neutrality can be achieved over time. Pihkala and Karasti noted that the facilitator's tasks change over time, as relationships and interactions also change over the course of the project [27]. This fits with the neutrality model of Wróbel, Cash, and Lomberg, where they suggest that the impartiality increases over time, which means that the participants become freer in deciding how they perform their tasks over time [42]. On the other hand, equidistance decreases over time, which means that the facilitator is less and less involved in the process. Fairness is expected to stay unaffected over time since the facilitator's attempts to provoke communication or reflection by the participants didn't change over time.

3.7.3 Facilitator-Participant relationship

There is an interaction between the participants and the facilitator. Different research noted that the facilitator should serve as an 'instrument' or 'servant' to the participants in order to guide them through the process [14], whereas other research described this as an 'apprenticeship' relationship [33]. The relationship between the facilitator and the participants should be of trust and transparency in order to create the optimal design settings [31, 20, 28]. But regardless of the nature of the relationship, research showed that the presence of a facilitator influences the discussions or the freedom of behaviour of the participants [28]. Research by Reidsma et al. suggested that the facilitator should adapt his involvement towards different participants since some participants might need guidance or a push from the facilitator to improve engagement, whereas other participants might need to be left alone to feel comfortable [28]. Finding this balance requires active reflection and awareness of the group dynamics to respond in the appropriate way [33].

3.8 Experience

This chapter focuses on the factors that contribute to how the participants experience the design session, i.e. the factors that are important *during* the design session. This is strongly influenced by the work of Schön, as discussed in research by Slovak, Frauenberger, and Fitzpatrick [33]. They state that the facilitator and the practicum work together to provide a (learning) experience for the participant. The design outcome flows out of this experience. This chapter will go over the in-action characteristic of the experience, as well as the real-time personalisation provided by the facilitator.

3.8.1 In-action

The 'in-action' or in-the-moment setting describes how participants perform certain design tasks in a set context. According to Slovak, Frauenberger, and Fitzpatrick, the facilitator should support the participant with in-action feedback: 'whatever the coach may choose to say, it is important that he says it, for the most part, in the context of the students doing. He must talk to the student while she is in the midst of a task (and perhaps stuck in it)' [33]. In this way, the feedback comes at the exact right time, so that the participants can reflect upon and implement this. This is called 'reflection-in-action', where the students use reflection in order to learn [33]. Slovak, Frauenberger, and Fitzpatrick further noted that expertise cannot just be learned but needs to be experienced through a scaffolded practicum (Scaffolding is further discussed in Section 3.9.1). The practicum should provide the appropriate tasks to enable the experience, as well as a reflection that guides the participants to 'grasp' the experience so that learning can take place.

Another aspect of the 'in-action' element is exploring-by-doing, such as design practices that involve enactment or role-play [19, 28]. This asks for an open-minded exploration, where participants are open to unexpected outcomes. It requires active participation, from both the participants and the facilitator. An example of in-action exploration is movement-based design, where the body is used as a source of knowledge. This is seen in research by Lee, Lim, and Shusterman, where the participants explored design ideas by 'doing', meaning that the participants explored the kinesthetic and emotional dimensions of bodily movement. Verbalising and reflecting upon this experience helped the participants to make sense of their experience so it could be used in the design process. The facilitator has the job of providing guidance during this 'exploration by doing'. Especially when this explorative state doesn't come easy, the facilitator should nudge the participants to explore. This is especially important in movement-based design since the open exploration might feel uneasy or embarrassing. A good example of exploring by doing, is using techniques from theatrical performance, such as enactment or role-playing [21]. This lively experience can uncover tacit feelings or thoughts that are hard to verbalise. Loke pointed out that facilitators can make on-the-fly adaptions to these kinds of in-action performances, which allows them to explore different factors in the design process [21].

The real-time flow of the session is another part of the 'in-action' aspect. This pictures the dynamic process over time and includes the dynamic changes in the social context [14, 27]. The facilitator has the task of managing the people, the task, the technology, and the interactions between them. The flow of a session changes over time and Hayne noted that 'tasks are started and stopped and the flow of the meeting is maintained through adhering to or adjusting the time constraints, the participants' interaction, the tools used, the technology and/or the agenda'. The facilitator's role is to make instantaneous adjustments of, for example 'questioning the group or individuals on their behaviour, changing the sequence or structure, adjusting the pace of communication, challenging the vigilance of the group, or even focusing on the content for adherence to the task.' [14]. Emotional state is another important influencer of the flow of a session. Light and Akama stated that the emotional state of the participants always influences the dynamics [20]. These changes are fluid and thus require the facilitator to be intuitive and open to emerging changes or interactions [20].

3.8.2 Personalisation

Slovak, Frauenberger, and Fitzpatrick described it as the facilitator and practicum's role to 'arrange the right sorts of experiences for the students' [33]. This means that the experiences need to be altered to the appropriate level of the students so that they are able to learn most effectively. This asks for 'specifically designed curricular components to scaffold experiences (..) and reflection' [33]. This means that a 'practicum' should be carefully designed so that it provides the appropriate experience to the individual participant so it allows for reflection and learning [33]. Another example is found in the research by Sanders and Stappers, which stated that participants are the 'expert of their experiences, but that they need the right tools to be able to express this' [30]. This might be different for each participant since there exist different levels of creativity Sanders and Stappers. This means that the facilitation should focus on the expression of creativity on all kinds of levels. This asks for personalisation to support individual needs. 65

Personalisation starts with an observation of the real-time participant state. The facilitator has the role of monitoring the state of the individual participants, of the group, their attitude in activities, and observing changes over time [10, 29, 26, 14]. The emotional state is important since it influences the engagement and thus outcome of the session [28]. Besides, the facilitator should be mindful of differences in ability levels and individual limits of the participants [29]. Research by Sanders and Stappers described that different levels of creativity exist. This asks for facilitation with the right leading, guiding and scaffolds that fit to the variety of creativity levels among participants. The facilitator can, according to Sanders and Stappers, take on four different approaches: '1) lead people who are on the 'doing' level of creativity, 2) guide those who are at the 'adapting' level, 3) provide scaffolds that support and serve peoples' need for creative expression at the 'making' level, and 4) offer a clean slate for those at the 'creating' level.' [30].

After close observation and monitoring of the group, the facilitator can intuitively 'feel' when the group is comfortable or not. The next step in personalisation is making a change to the session design. These are real-time adjustments on feedback, experiences, methods or support [33, 21, 28, 14]. This response should be a direct response *in the moment* of the session. After that, active real-time reflection or evaluation can uncover how the state of the group changed. A response could, for example, introduce a warming-up exercise to decrease the tension, or set up a group discussion to reflect on a finished activity [28, 26].

3.9 Support

As noted throughout this review, the facilitator has the main role of providing guidance and support to the participants. In this chapter, this supporting role is further dividied into scaffolding, feedback and reflection.

3.9.1 Scaffolding

Scaffolding was already shortly discussed in Section 3.5.1, which discussed warm-up exercises as an example of scaffolding. Scaffolding is described as a process 'through which a more knowledgeable person adds supports for students in order to move them progressively toward stronger understanding and ultimately greater independence in learning' [17]. The facilitator should control the elements to which the novice is exposed so that he or she can only concentrate on the elements that are within his or her competence range. By introducing scaffolds and guidance, the novice will be able to expand their skills or knowledge. Research by K Govindasamy and Moi Kwe further proposed that tools (either visual or verbal), such as graphic overviews, question cards, or concept maps, can support the scaffolding experience [17]. Besides, multiple scaffolds might be needed to make a bridge between the needed skills and their current abilities.

Frauenberger, Makhaeva, and Spiel applied the principle of Scaffolding in their study [10]. They anticipated the fact that an introduction of all design materials at once could be too overwhelming for the participant. Instead, they first let the participant explore the possibilities of a smaller subset of the materials. Then, they provided an overview of the materials and let the participant choose any of them. After that, they increased the complexity by asking the participant to combine two materials from the subset. They made sure that the participant felt comfortable with this. After that, the complexity and amount of materials further slowly increased. When the participant was fully comfortable with all high-technological materials, different low-technological materials (such as cardboard) were introduced. In this study, the facilitators carefully observed the state of the participant, after which they decided to adapt the tasks or the materials. Another example of scaffolding can be found in a study by Oulasvirta, Kurvinen, and Kankainen, where 'one design question at a time was introduced to participants', so that the participants were step-by-step introduced to new design problems [26].

As noted in Section 3.5.1, a common scaffolding activity is warm-up exercises [28]. Reidsma et al. suggested that participants might feel uncomfortable at the start of a design activity, especially if it involves body-based design methods [28]. They noted that it is essential for the facilitator to initiate warm-up exercises, such as ice-breakers, to strengthen the participant's mindset and participation. In

this sense, ice-breakers can be seen as scaffolding activities that step-by-step create the right mindset for a fruitful design session. This doesn't only apply to the warm-up phase, but a scaffold of mood and energy can also be very useful later in the process when participants feel scared or hesitant to fully participate in body-related exercises [28]. Hayne adds that it is the facilitator's responsibility to offer the appropriate sequence of activities, and adjust the right tools, tasks and technologies [14]. The task sequence and offered materials need to be sequenced in such a way that they scaffold the right experiences.

To apply scaffolding, the reviewed literature discussed the following important take-aways: 1) apply the appropriate increase in the task or material complexity [10], 2) provide guidance into the topic of the session and the tools that will be used [19, 39, 14, 9], 3) initiate a warm-up exercise that is easy executable so that all participants can follow [19, 28], 4) build further upon exercises to scaffold towards the design problem/question. It is also recommended to combine previously known knowledge with new unknown knowledge, however, a balance must be kept between tasks that are too open or too closed off [10, 15]. Participant output of previous exercises can also be used as input in the new exercises [26, 19]. This aims to lower the threshold so that everyone can participate, as well as build a common ground among the group, which will strengthen the engagement of the group[14, 20].

Research showed that posing questions is an effective scaffolding method [17]. Research by K Govindasamy and Moi Kwe stated that 'Posing questions pertinent to a specific scope of knowledge works as a thinking stimulant and facilitates the learning process. (...) Guided questioning as a form of the scaffold has been recorded as enabling students to elicit critical thinking (Coffey, 2014) and improving the depth of written reflection' [17]. Besides, they noted that posing question serves as a handhold to organise, conceptualise and communicate abstract thoughts. This can bring out the knowledge that the participants already possess. This scaffolding tool will be further discussed in Section 3.9.3 on Reflection.

3.9.2 Feedback

As noted by Slovak, Frauenberger, and Fitzpatrick, feedback from the facilitator is very important for a successful practicum. Most literature on facilitation described that the facilitator provided encouragement and examples as feedback. Examples were especially useful in sessions that included movement or enactments that required physical participant involvement. Examples by the facilitator could help to explain a task, lower the pressure felt by the participants, or explain possibilities. In a discussion with a facilitator, the facilitator described that she often 'makes a fool out of herself´ in order to ease the tension among the participants, and open up the way for them to start exploring as well. Encouragements aim to nudge and push participants in the right direction. For example, to encourage the decision-making process, or to encourage them to explore and reflect. Encouragements can also serve as positive feedback after desirable behaviour.

The observational study showed that feedback can also be wrongly applied. In this case, the facilitator was very willing to give feedback but had no awareness of the conversation flow. The questions disrupted the natural discussion of the participants, and prolonged unwanted advice hindered them to continue. A lack of awareness of the body signals of the participants also caused the facilitator to apply wrongly timed feedback.

The observational study showed that feedback was often given through non-spoken cues (such as a whistle, hand-claps or shouts), spoken cues (variations in the use of voice, 'hmm hmm', compliments, encouragements, or activation sentences), or visual cues (smiles, nods, and other facial expressions).

3.9.3 Reflection

Reflection is an important step to transform experience into hands-on knowledge that can be used as design input. This is important for the sense-making of the experience, especially in movement-based design. Reflection can help to get insights out of the experience, and besides, once it is put into words it can be expressed and shared among the group of participants. This can serve as a source of information that can inform design decisions. It also allows the participants to build further upon the experiences. A reflection upon tacit experiences will also help make the participants the 'experts of

their own experience'. This makes each participant a 'knowledge base' with a valuable set of knowledge, which can be used in collective knowledge sharing.

The facilitator has an important role in encouraging reflection among the participants. He opens up the shared discussion and allows the participants to communicate about their experiences. Research by Light and Akama noted that emotions always have an influence on how the process or product is shaped [20]. The facilitator can steer and guide this by means of reflection and open discussion. The study by Slovak, Frauenberger, and Fitzpatrick places three requirements upon the support of the facilitator: 1) it is in the context of their immediate experience (also see Section 3.8.1) it is delivered through both words and actions, 3) both facilitator and participants should participate in a reciprocal reflection-in-action [33].

Besides, the facilitator also has the task to reflect upon his own practice and the influence it has on the session. Light and Akama added that facilitators should also apply reflection-in-action to be aware of the dynamic changes in the participants and the context [20]. Reflection-in-action 'refers to the capacity to momentarily use one's tacit knowledge to make effective decisions in response to immediate events. This capacity is characteristic of on-the-spot responses executed by trained professionals' [9]. As an example of reflection-in-action, a skilled facilitator might notice a participant respond negatively towards a design idea and immediately take this event as a possibility to dig deeper and not let the incident pass. Another form of reflection is reflection-on-action, which describes reflection *after* the session has occurred. Facilitators can improve their practice by this reflection-on-action to understand how the practice can be improved, or what can be changed the next time [9].

Encouraging participant reflection requires active facilitator involvement. The facilitator should actively step in and out of the discussion. For example, the observations showed that the facilitator quickly jumped in for a compliment to stimulate the participants in their discussion. During the 'stepping-in', the facilitator physically bent towards the participants with an open, relaxed body posture. There was physical closeness, although at an appropriate distance so all participants felt comfortable. When the facilitator stepped out, the body posture bent back, while the hands closed in front of the body. These kinds of body language are important in getting across the message. Besides body posture, the facilitator also used a physical notebook to write notes, while still staying in contact with the participants. The observational study showed that the use of a digital device, such as a phone, had an adverse effect since it portrayed an image of an uninterested facilitator.

4 Conclusions

The analysis in Section 3.3 showed that a limited amount of design studies in the Human-Computer Interaction acknowledge the involvement of a facilitator. However, research that is especially focused on facilitation shows that a facilitator has a large impact on the people, the process and the end product of a design session. This means that there is a gap between research practice in reality and what is recommended.

This paper reviewed a large selection of literature to map out the facilitation space. Grounded Theory was applied to analyse all the articles in a bottom-up approach. The results are summarized into a set of factors that play a role in facilitation. In order to provide practical benefits to facilitators, it is important to know which of those elements influence the facilitation, and thus the design practice.

This section will go over each of the aforementioned sections, and provide a conclusion on the most prominent factors that influence the facilitator's impact on the design process.

4.1 Practicum

The elements that influence the practicum are divided into structure, tools, environment and method. The main factor relating to Structure that is under the facilitator's control is careful preparation of each of the four design session stages. For a better preparation, the facilitator can examine and decide upon all elements that are needed in the specific design workshop, such as the tasks, settings, problem, environment, participants, artifacts, etc. [68]

The Tool related factors that influence the design process are the type of tools and how well the participants can use them. For the type of tools, the facilitator can reflect upon how the tools should enable the participants to explore, express, discuss or reflect upon their thoughts. This will inform the facilitator's decision upon whether design cards, low-tech, high-tech or a combination of high- and low-tech materials are most suiting. The facilitator can prepare the participants through personalisation, planning activities, scaffolds, and management during the session.

The factors relating to Environment that influence the design process are the physical space itself and the atmosphere of the group. The facilitator can influence the physical space by ensuring a safe and welcoming space that is big enough and allows for free exploration. The atmosphere can be influenced by facilitation of the mood and energy, through the initiation of exercises and guidance into movement and stage engagement. Active awareness of the group dynamics and atmosphere allow the facilitator to make personalised adaptions.

Factors related to the Method are influenced by the choice of facilitation methods and the elements that can be facilitated. The facilitator can influence the design session by deliberately choosing between the different parameters of the facilitation method continuum that fit with the specific design session. The facilitator can also influence the session through distinguishing what elements need to be facilitated, e.g. the energy, attitude, or group dynamics.

4.2 Facilitator as an Individual

There are different types of characteristics, skills and roles that influence the impact of the facilitator on the design process. Factors relating to Characteristics that most prominently influence the session are interpersonal abilities (exceptional communication skills, applying the LEAPS method, and showing flexibility, sensitivity and neutrality), managing the process (time, planning, and organisation), and certain personal characteristics (adaptability and emotional resilience).

Skills of the facilitator that are influencing the design session are the ability to identify problems, perform reflection-in-action, the level of design expertise, and the facilitator's ability to act intuitively. Advanced facilitators apply solution-focused problem-solving techniques with a focus on generating solutions instead of analysing the problem. Reflection-in-action can assist the facilitator in approaching uncertainty, instability and conflicts which influences the design process. An adequate level of design expertise enables the facilitator to instruct design thinking methods and provide feedback. For an intuitive approach, the facilitator can 'feel' the room, act reactively to unexpected incidents, and balance the different session elements.

Factors that relate to the facilitator's Role are related to the process and to the practicalities of the design session. The facilitator's role in the process is influenced by managing the group dynamics, encouraging reflection, and simulating exploration. This is affected by a focus on processes such as group creativity, mindset, reflection on experiences, discussion, experimentation, participation, ownership, cooperation, and shared-decision making.

4.3 Social Dynamics

The atmosphere of the design session is strongly influenced by the social dynamics in the group. Factors that relate to the social dynamics are the power distribution between parties and the neutrality of the facilitator. The facilitator can influence the power distribution by taking active action to equalise asymmetric power relations between participants and perform reflection-on-action to form awareness of his actions and non-actions. The facilitator can influence neutrality by adapting equidistance, fairness and impartiality in order to balance the people, process and content over the course of the session. The social dynamics are influenced mostly by the actions that happen *in the moment*, as a result of the immediate responses of the facilitator. This can be trained by applying active reflection.

4.4 Experience

There are two main factors that the facilitator can balance that influence how the participants experience the design session: in-action and personalisation. The in-action characteristic can be stimulated by the in-action feedback of the facilitator (this is applied in the context of the participants doing), by the promotion of in-action reflection (reflection-in-action upon the participant's experiences), the

encouragement of exploration by doing (exploring open-minded, unexpected outcomes), and the facilitator's ability to manage the flow of the session (by managing the dynamic changes in the people, the tasks, technology and interactions).

Factors relating to personalization that are under the control of the facilitator that influences the design process are observation of the real-time participant state and adapting the session to the specific needs of the group. The observations of the participant state can be done by looking at the emotional state of the individual participants, their attitudes and changes over time, and differences in skills and creativity levels. Adaptions can be made by intuitively feeling when the group is ready for adjustments on feedback, experiences, methods or support. The facilitator can also adjust the communication pace, the structure, the activities, the critical questions that are asked, etc. The facilitator can also apply different types of scaffolds to meet the ability or creativity levels of the participants.

4.5 Support

The most prominent factors that influence the impact of the facilitator on the design process are the ability to provide support and guidance to the participants. The factors that influence this supporting role are scaffolding, feedback, and reflection.

The facilitator can apply scaffolding by progressively exposing the participants to more complex materials or tasks to close the gap between their current and needed abilities. The scaffolding process can take place through activities, materials, technologies or questions. The facilitator can influence the session through means of feedback and awareness of the participant's needs and thus applying the appropriate response, e.g. encouragement, examples, or reflective questions. This can be delivered through the use of non-spoken, spoken or visual cues. The facilitator can encourage reflection through questions and initiating discussions. This might help the participants to reflect upon their experiences and use this as design knowledge. The ability to stimulate reflection is influenced by active facilitator involvement, the ability to step in and out, and his body posture. It is also influenced by the facilitator's ability to reflect upon what is needed, provide an appropriate response, and reflect upon the effect of the response.

5 Discussion

This study provided the HCI community with an overview of the facilitation factors that influence the design process. It provides a handhold and practical focus points for facilitators to critically evaluate their own practice and implement improvements. Starting with the outer-shell of Figure 3 and moving inwards to implement the practical focus points as discussed in Sections 4.1-4.5.

It also gives researchers a way to record the specifics of the facilitator in their design sessions. The facilitator is no longer a 'black box', but can be described on basis of the themes described in this study. Since the results of a design study are so heavily influenced by the facilitator, this allows for more transparency on how the design study was carried out. This will also positively affect the replicability of the study, so that other researchers can make use of similar facilitators factors.

This study provided the facilitator with focus points that influence the design session. However, the current body of literature does not go in depth on how specific factors, such as facilitator intuition or reflection-in-action, can be learned. Since there are so many ways of facilitation, more research could be done on developing an even more practical toolkit for the wide variety of facilitator preferences, based on the literature findings from this study. Besides, it could be useful to develop a framework to assess the quality of the facilitator, based on the themes and facilitation factors discussed in this study.

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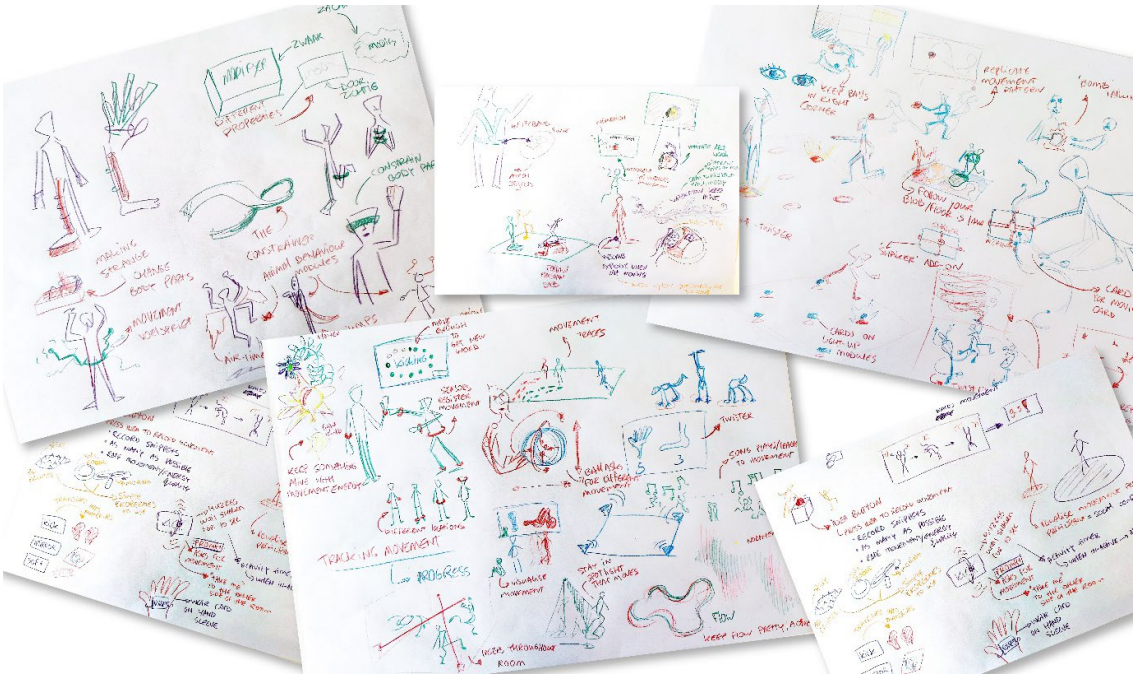
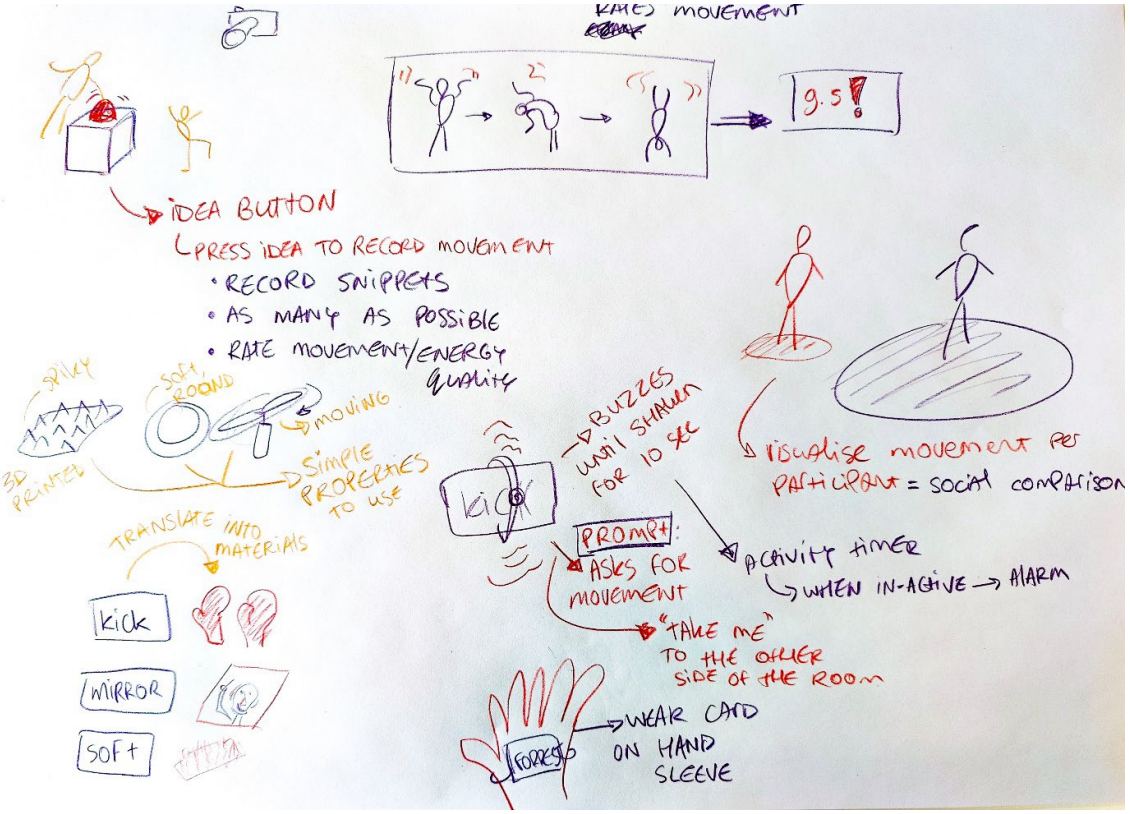
B Interview Questions Facilitators

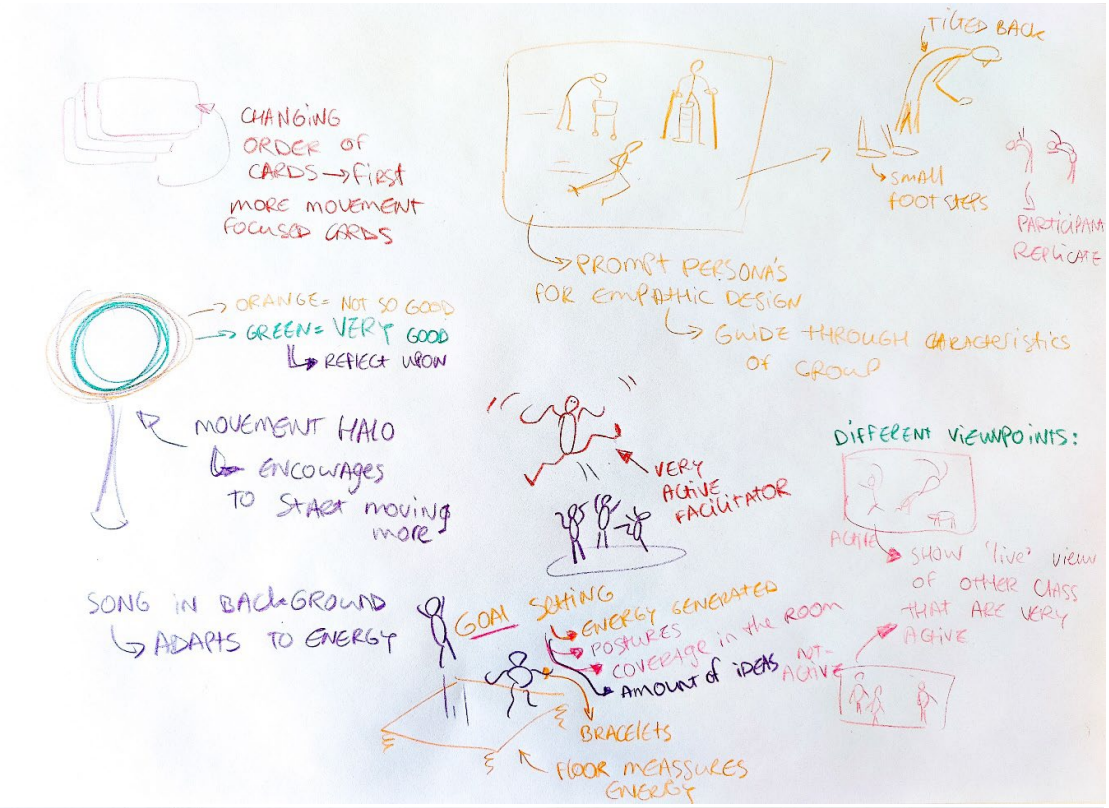
- About your experience with stimulating movement and exploration during a deign session. How do you stimulate participants to explore and move?
- Do you use certain tools or artefacts?
- If a group is really stiff/not moving, how do you approach that? How to get them out of their shell?
- Do participants move like you want them to? In your eyes, how would the perfect participant behave? How is their attitude towards movement?
- Could you describe meaningful movement? What are the characteristics of it? What is included in it? Things like reflection, or discussion, etc. Are there other ingredients needed for good ideation outcomes?
- How do you transform movement into insightful design lessons?
- Did you do design sessions with (the mecamind) design cards? How would you describe that experience? Are their challenges you encountered?
- What happens if you use the cards in a workshop? How do the participants engage with them?
- What was the effect of this on the group? How did it influence movement?
- How do you think technology or artefacts can be used to stimulate meaningful movement? What to look out for?
- What is your experience with having a technological tool in the design sessions?
- Are the cards on their own enough to get participants to explore and move?
- What obstacles did you find with using design cards in a session? //
  In my thesis: explore alternatives for the modifier cards. Keep the aspect of prompting a new idea stream with new focus points. But different format: stimulate physical movement. Looking at the four categories from the design space. What are your thoughts with these four categories?
- For each one, what are the strengths of the categories? What do you think won't works so well?
- Do you have a most and least favorite idea?

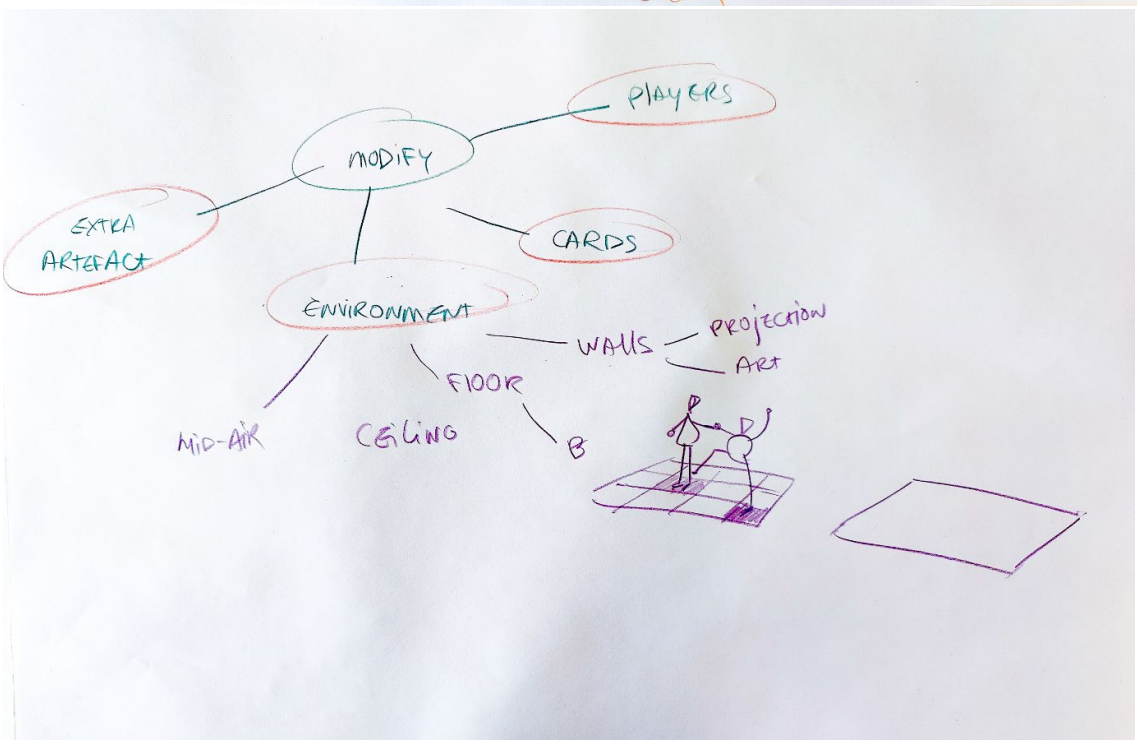
C Ideation Sketches

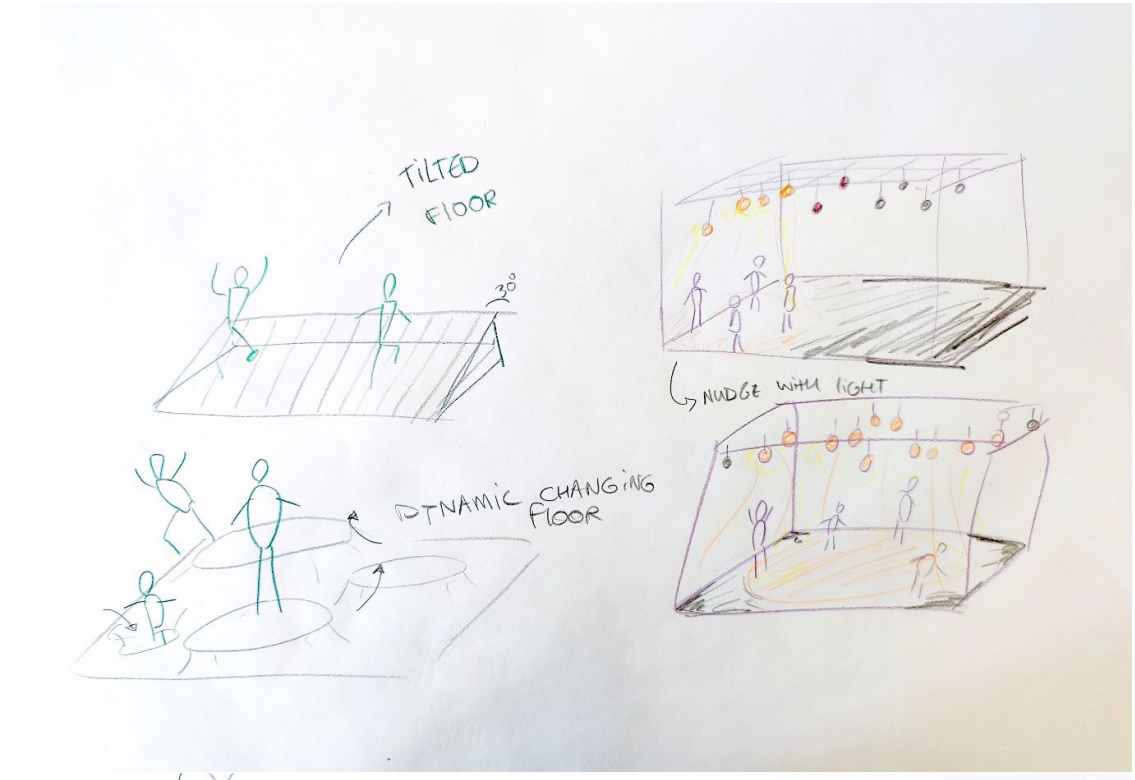
A selection of 10 sketch papers are included in the Appendix.



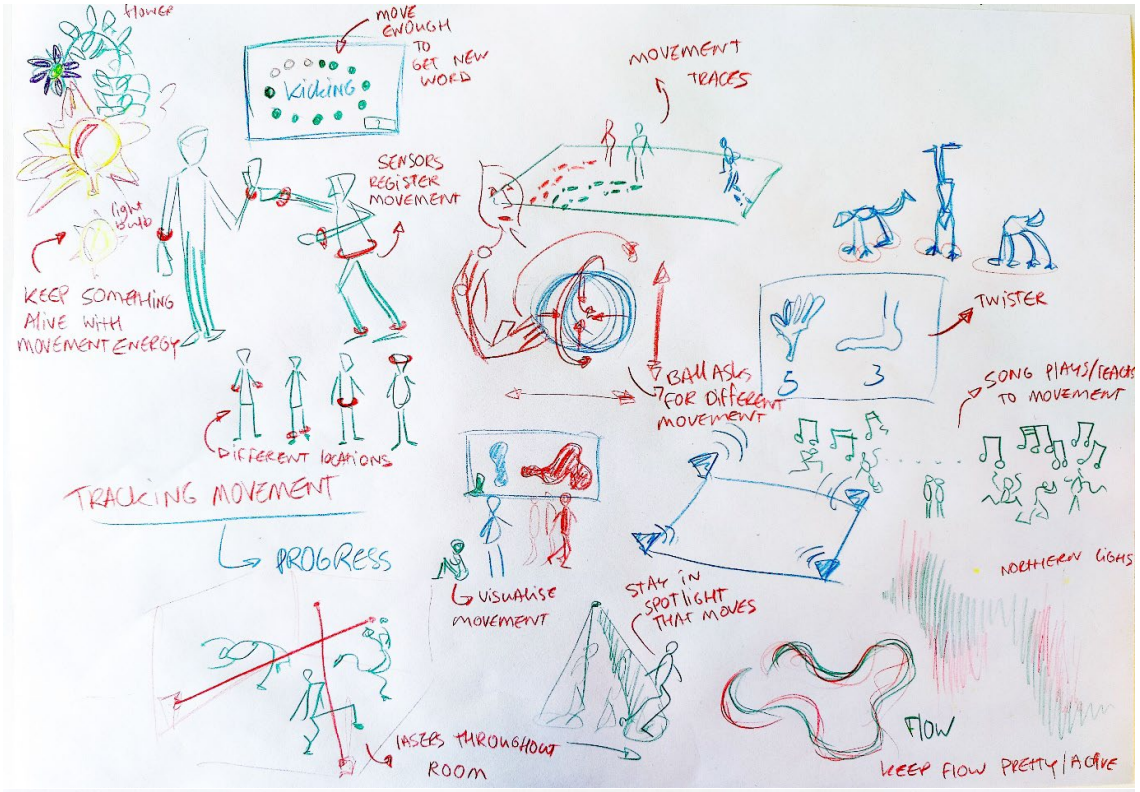

RATE MOVEMENT
9.5
IDEA BUTTON
PRESS IDEA TO RECORD MOVEMENT
• RECORD SNIPPETS
• AS MANY AS POSSIBLE
• RATE MOVEMENT/ENERGY
QUALITY
SPIKY
SOFT, ROUND
MOVING
3D PRINTED
SIMPLE PROPERTIES TO USE
TRANSLATE INTO MATERIALS
KICK
MIRROR
SOFT
BUZZES UNTIL SHAKEN FOR IO SEC
KICK
PROMPT:
ASKS FOR MOVEMENT
"TAKE ME" TO THE OTHER SIDE OF THE ROOM
FORCES
WEAR CARD ON HAND SLEEVE
VISUALISE MOVEMENT PER PARTICIPANT = SOCIAL COMPARISON
ACTIVITY TIMER
WHEN IN-ACTIVE → ALARM

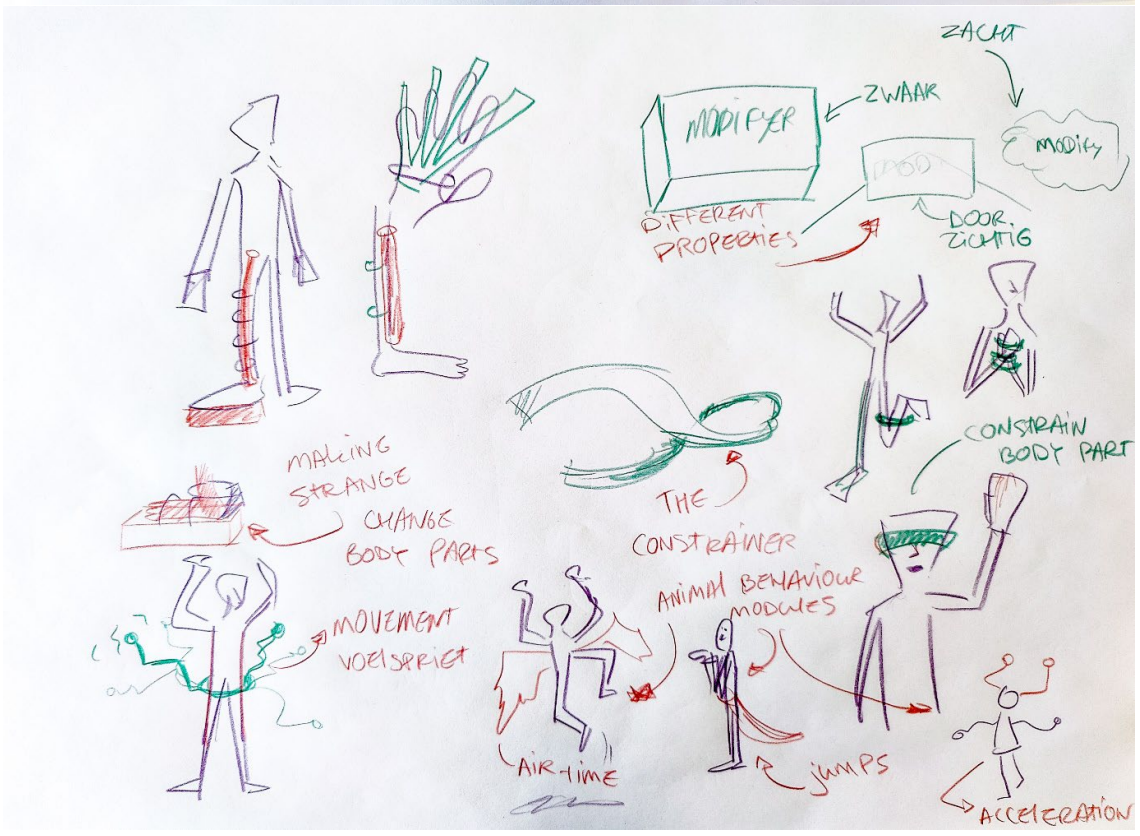

CHANGING ORDER OF CARDS → first MORE MOVEMENT FOCUSED CARDS
TIED BACK
small FOOT STEPS
PARTICIPANT REPLICATE
PROMPT PERSONA'S FOR EMPATHIC DESIGN
GUIDE THROUGH CHARACTERISTICS OF GROUP
ORANGE = NOT SO GOOD
GREEN = VERY GOOD
REFLECT UPON
MOVEMENT HALO
ENCOURAGES TO START moving more
VERY ACTIVE FACILITATOR
DIFFERENT VIEWPOINTS:
ACTIVE
SHOW 'live' view OF OTHER CLASS THAT ARE VERY ACTIVE
NOT-ACTIVE
SONG IN BACKGROUND
ADAPTS TO ENERGY
GOAL SETTING
ENERGY GENERATED
POSTURES
COVERAGE in the ROOM
AMOUNT of IDEAS
BRACELETS
FLOOR MEASURES ENERGY

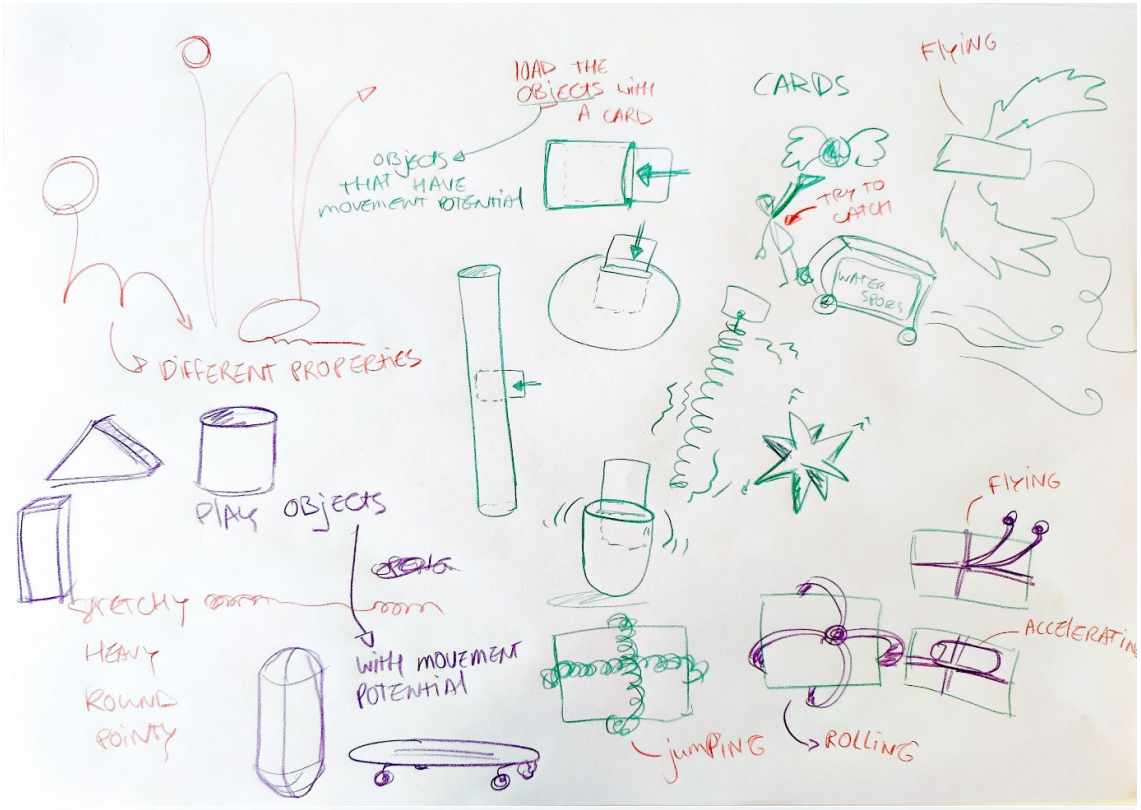

PLAYERS
MODIFY
EXTRA ARTEFACT
CARDS
ENVIRONMENT
WALLS
PROJECTION
ART
FLOOR
MID-AIR
CEILING
B

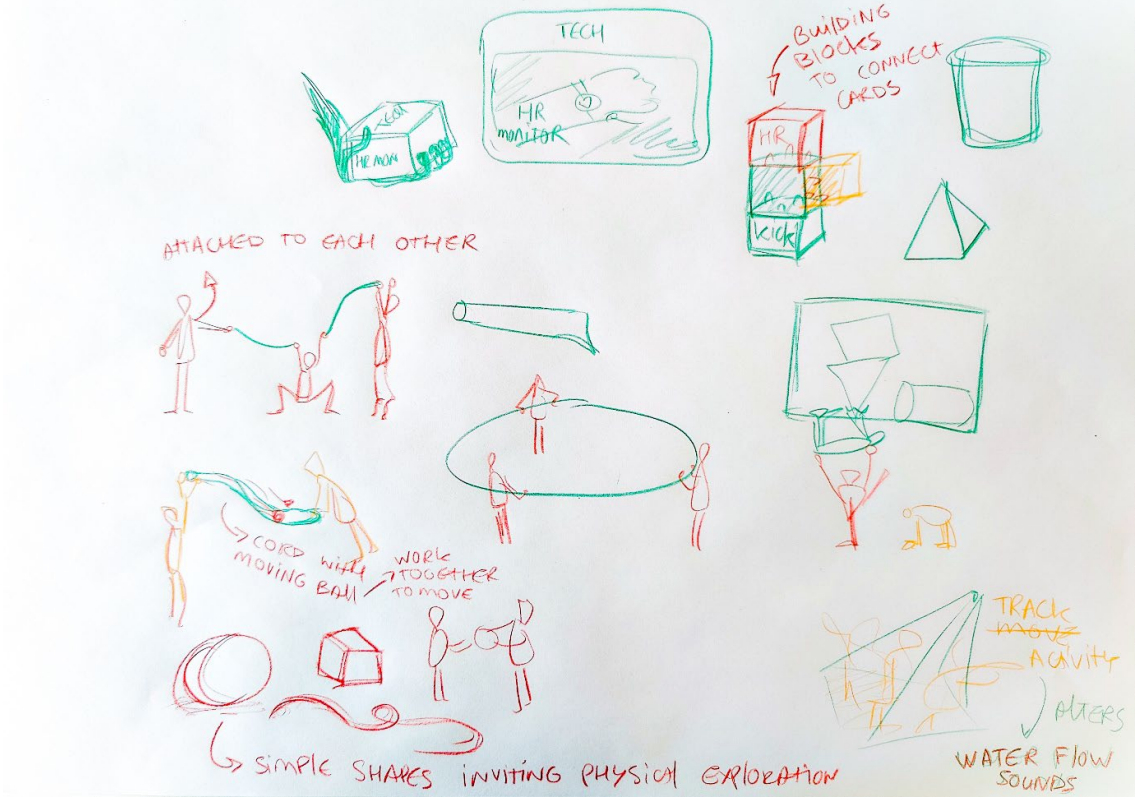

TILTED FLOOR
30°
NUDGE WITH LIGHT
DYNAMIC CHANGING FLOOR


LIFTEBAND
SUITE
ATTACH OBJECTS
ANIMATION
FALLING APPLE
IMMITATE ART WORK
MOVEMENT INFLUENCES ANIMATION
DIFFERENT TYPES OF MOV
CALM, TURBULENT FAST, MESSY
WATERFLOW KEEP ALIVE
THROW FLY
BOMB
EXPLODE WHEN NOT MOVING
BUZZ WHEN STATIONARY FOR TOO LONG
FOLLOW PERSONAL BLOB


flower
light sound
KEEP SOMETHING ALIVE WITH MOVEMENT ENERGY
MOVE ENOUGH TO GET NEW WORD
kicking
SENSORS REGISTER MOVEMENT
DIFFERENT LOCATIONS
TRACKING MOVEMENT
PROGRESS
MOVEMENT TRACES
BALL ASKS FOR DIFFERENT MOVEMENT
visualise movement
LASERS THROUGHOUT ROOM
STAY IN SPOTLIGHT THAT MOVES
TWISTER
SONG PLAYS/TEACHES TO MOVEMENT
NORTHERN LIGHTS
FLOW
KEEP FLOW PRETTY/ACTIVE


ZACHT
MODIFYER
ZWAAR
MODIFY
DIFFERENT PROPERTIES
DOOR. ZICHTIG
MAKING STRANGE
CHANGE BODY PARTS
MOVEMENT VOORSPRIET
THE CONSTRAINER
CONSTRAIN BODY PART
ANIMAL BEHAVIOUR MODULES
AIR-TIME
JUMPS
ACCELERATION

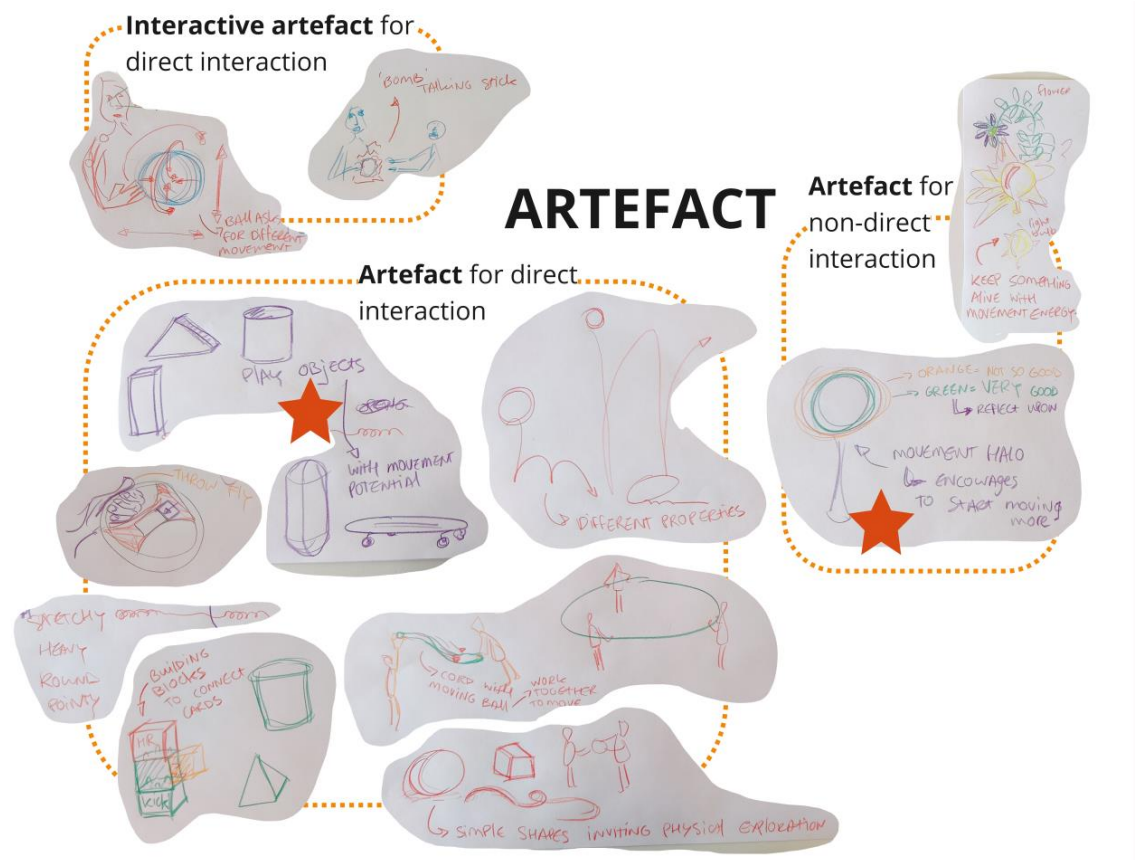

LOAD THE OBJECTS WITH A CARD
OBJECTS THAT HAVE MOVEMENT POTENTIAL
CARDS
FLYING
TRY TO CATCH
WATER SHOOTS
DIFFERENT PROPERTIES
PLAY OBJECTS
SKETCHY
HEAVY
ROUND
POINTY
WITH MOVEMENT POTENTIAL
FLYING
ACCELERATING
JUMPING
ROLLING

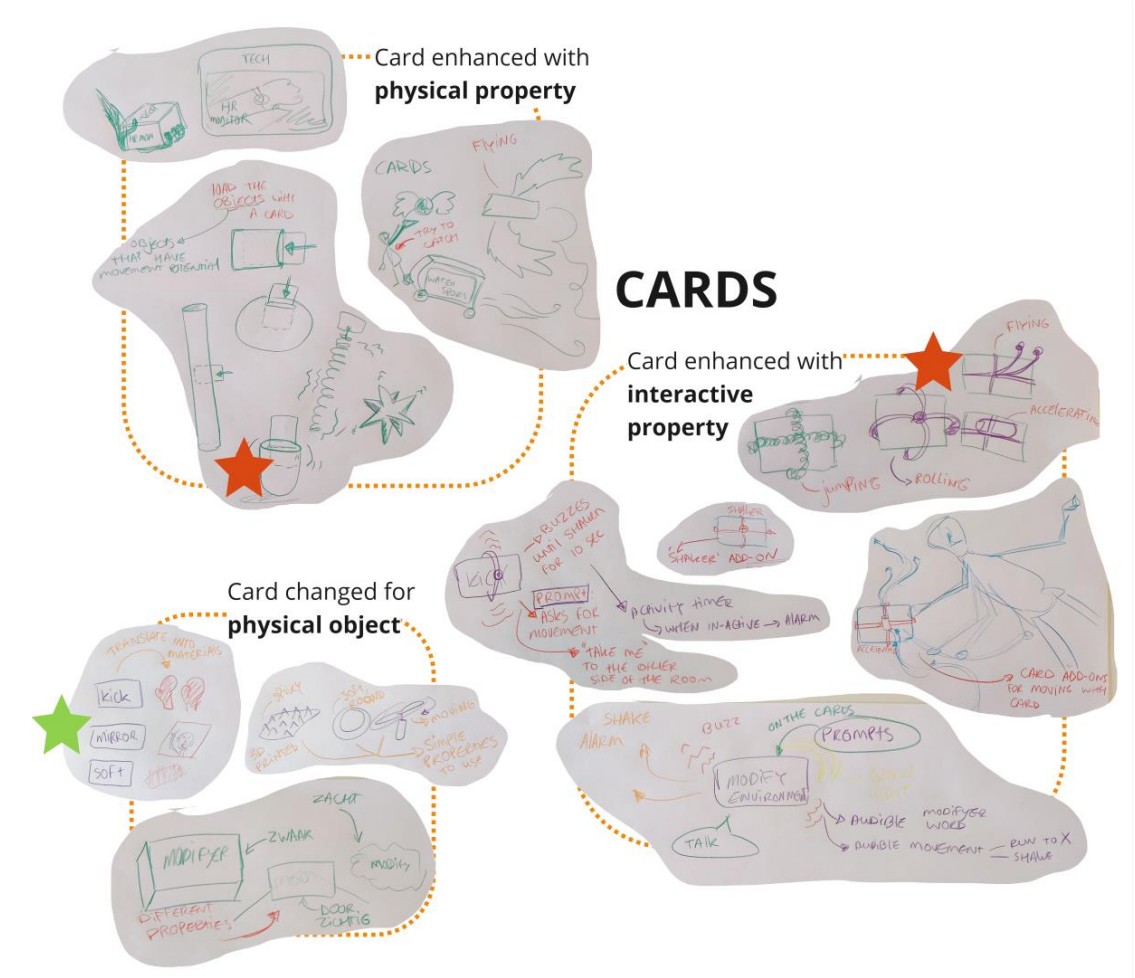

TECH
HR MONITOR
BUILDING BLOCKS TO CONNECT CARDS
HR
KICK
ATTACHED TO EACH OTHER
CORD WITH MOVING BALL
WORK TOGETHER TO MOVE
TRACK
ACTIVITY
ALTERS
WATER FLOW SOUNDS
SIMPLE SHAPES INVITING PHYSICAL EXPLORATION

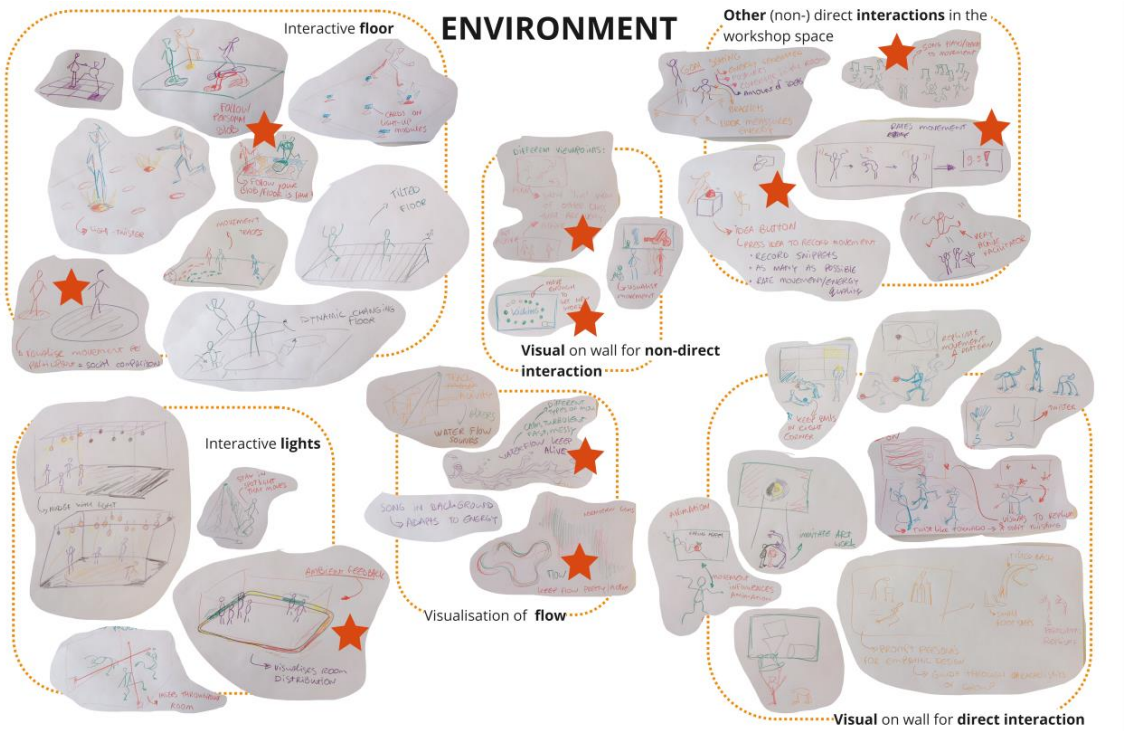

REPLICATE MOVEMENT PATTERN
'BOMB' TALKING STICK
KEEP BALLS IN RIGHT CORNER
FOLLOW YOUR BLOB / FLOOR IS LAVA
SHAKER
'SHAKER' ADD-ON
CARD ADD-ONS FOR MOVING WITH CARD
LIGHT - TWISTER
CARDS ON LIGHT-UP MODULES
VISUALS TO REPLICATE

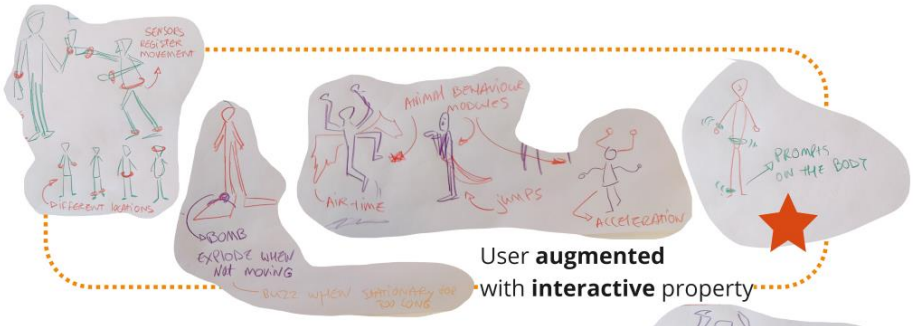
D Affinity Diagram

The affinity is fully displayed, including detailed images of the four different categories.


Interactive artefact for direct interaction
'Bomb' falling stick
ARTEFACT
Artefact for non-direct interaction
Artefact for direct interaction
PLAY OBJECTS
with movement POTENTIAL
DIFFERENT PROPERTIES
ORANGE= NOT SO GOOD
GREEN= VERY GOOD
MOVEMENT HALO
ENCOURAGES TO START moving more
BUILDING BLOCKS TO CONNECT CARDS
CORD WITH MOVING BALL
WORK TOGETHER TO MOVE
SIMPLE SHAPES INVITING PHYSICAL EXPLORATION


Card enhanced with
physical property
CARDS
Card enhanced with
interactive
property
Card changed for
physical object





USER

User **augmented** with **physical** property

E Survey's from the design workshop

Survey

Thanks for your participation in the workshop! I have a few questions related to your movement during the workshop and the effect this had on the creative outcome of your group.

Movement and body. The next questions are about your experience with moving in this workshop.

I felt **comfortable** to use my body and movements

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

I felt **limited** in the ´craziness' or **freedom** of my movements.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

Most movements were **meaningful** and had **added value** to the design process.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

There was **a lot of play and playfulness** during the process.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

There were quite some **movements or actions** that had **nothing** to do with the **design process**.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

I got **new insights and design knowledge** because I focused on the movements and your body.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

I believe this **made a difference** on the **creative process** and the outcome

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

Modifier Cards. The next questions are specifically about the **Modifier Cards**

The modifier cards were **valuable** for us during the creative process

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

The words on the cards **sparked new movements** and discoveries.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

There were a lot of **new movements** I could do **only because** of the cards.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

The modifier cards that we got, **fitted to the context** of our design discussion.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

The cards **hindered our movement** and body exploration.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

I **could not move together** with the cards: there was a separation between my movements and my interaction with the cards.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

Can you write a few sentences about your **experience** with the **modifier cards**?

Do you have other **tips** or **remarks**?

Thank you so much for filling in this survey, and participating in the workshop.
I hope you enjoyed it!

Would you be available for a short interview (+-30 minutes) where I can ask you a few more questions about your experience with the Momo-block? If so, write your email address here below:

Survey

Thanks for your participation in the workshop! Here are a few questions related to your movement during the workshop.

Movement and body. The next questions are about your experience with moving in this workshop

I felt **comfortable** to use my body and movements

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

I felt **limited** in the ´craziness' or **freedom** of my movements.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

Most movements were **meaningful** and had **added value** to the design process.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

There was **a lot of play and playfulness** during the process.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

There were quite some **movements or actions** that had **nothing** to do with the **design process**.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

I got **new insights and design knowledge** because I focused on the movements and your body.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

I believe this **made a difference** on the **creative process** and the outcome

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

Momo-block. The next questions are specifically about the **Momo-block**

The Momo-block was **valuable** for us during the creative process

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

The **interactions** of the Momo-block **sparked new movements** and discoveries.

○ Strongly disagree ○ Disagree ○ Neither agree/disagree ○ Agree ○ Strongly agree

The **shape** of the Momo-block **positively influenced** us to move and explore.

Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
◯	◯	◯	◯	◯

There were a lot of **new movements** I could do **only because** of the Momo-block.

Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
◯	◯	◯	◯	◯

The audio-words that we got, **fitted to the context** of our design discussion.

Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
◯	◯	◯	◯	◯

The Momo-block **hindered our movement** and body exploration.

Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
◯	◯	◯	◯	◯

I **could not move together** with the Momo-block: there was a separation between my movements and my interaction with the Momo-block.

Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
◯	◯	◯	◯	◯

I would have **preferred** to do this workshop **without the Momo-block**

Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
◯	◯	◯	◯	◯

Can you explain your last answer in a few sentences?

In what way did it effected your focus on movement and your body?

Do you have other tips or remarks?

Would you be available for **a short interview** (+-30 minutes) soon? Where I can ask you a few more questions about your experience with the Momo-block? If yes, write your email address here below:

Thank you so much for filling in this survey, and participating in the workshop.
I hope you enjoyed it!

F Design Workshop Slides

This is the information that was provided to the participants of the design workshop, taking place on 17-04-23.

MOVEMENT-BASED DESIGN WORKSHOP

1

THE PLANNING

9:15 - 9:30	Intro to movement-based design
9:30 - 9:45	Warm-up
9:45 - 10:30	Design block 1
10:30 - 10:45	Break
10:45 - 11:30	Design block 2
11:30 - 12:00	Demo round & closing

2

THE PLANNING

9:15 - 9:30	**Intro to movement-based design**
9:30 - 9:45	Warm-up
9:45 - 10:30	Design block 1
10:30 - 10:45	Break
10:45 - 11:30	Design block 2
11:30 - 12:00	Demo round & closing

3

INTRO TO MOVEMENT-BASED DESIGN

4

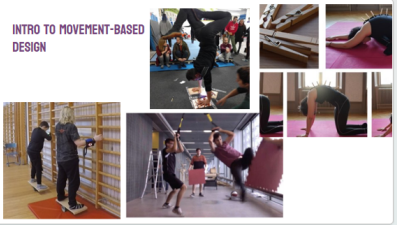
INTRO TO MOVEMENT-BASED DESIGN

5

INTRO TO MOVEMENT-BASED DESIGN

6

INTRO TO MOVEMENT-BASED DESIGN



7

THE PLANNING

9:15 - 9:30	Intro to movement-based design
9:30 - 9:45	**Warm-up**
9:45 - 10:30	Design block 1
10:30 - 10:45	Break
10:45 - 11:30	Design block 2
11:30 - 12:00	Demo round & closing

8

WARM-UP

9

THE PLANNING

9:15 - 9:30	Intro to movement-based design
9:30 - 9:45	Warm-up
9:45 - 10:30	**Design block 1**
10:30 - 10:45	Break
10:45 - 11:30	Design block 2
11:30 - 12:00	Demo round & closing

10

DESIGN BLOCK I

Managing **time & things** that are important to you

procrastination planning Habit tracking

11

DESIGN BLOCK I

Explore a problem with:
Managing time & things that are important to you

procrastination planning Habit tracking

12

DESIGN BLOCK I

13

DESIGN BLOCK I


MOMO-BLOCK

MODIFIER CARDS

14

DESIGN BLOCK I

- **Find a problem** with: Managing your time and the things that are important to you. Think of procrastination, planning, tracking habits, etc.
- **Exploring** the problem in a movement/sequence
- Use the **Daily Movements** technique
- Use sports **materials**, modifier cards/MoMo-block
- Outcome: a problem summarised in your body & movements
- Until 10:30

15

THE PLANNING

9:15 - 9:30	Intro to movement-based design
9:30 - 9:45	Warm-up
9:45 - 10:30	Design block 1
10:30 - 10:45	**Break**
10:45 - 11:30	Design block 2
11:30 - 12:00	Demo round & closing

16

BREAK

Until 10:45

17

THE PLANNING

9:15 - 9:30	Intro to movement-based design
9:30 - 9:45	Warm-up
9:45 - 10:30	Design block 1
10:30 - 10:45	Break
10:45 - 11:30	**Design block 2**
11:30 - 12:00	Demo round & closing

18

DESIGN BLOCK 2

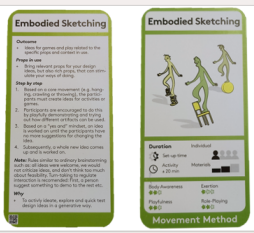
Explore solutions to your discovered problem

Think of embodied things/movements/solutions...

...that solve your bodily problem

19

DESIGN BLOCK 2



20

DESIGN BLOCK 2

- **Explore solutions** to your problem
- Make them **embodied** things/movements/solutions that solve your bodily problems
- Don't think about realistic/requirements/rules/etc. Think **crazy and unrealistic!**
- Use **materials** to make physical solution
- Until 11:30

21

THE PLANNING

9:15 - 9:30	Intro to movement-based design
9:30 - 9:45	Warm-up
9:45 - 10:30	Design block 1
10:30 - 10:45	Break
10:45 - 11:30	Design block 2
11:30 - 12:00	**Demo round & closing**

22

SHORT ELEVATOR DEMONSTRATION

- **1 minute** per group
- Explain your **problem + solution** in few sentences
- Demonstrate your solution! Enact, show, use the space and your bodies
- **Show, don't tell**

23

CLOSING UP

24

G Descriptive Statistics Post-Workshop Survey

Ind. Survey Item	Condition	Mean	Median	Mode	St.Dev.	Range	Skewness
Comfortability movement	Cards	3,286	4,000	4,000	0,881	4,000	-0,764
	MoMo	4,000	4,000	4,000	0,775	4,000	-1,531
Limited freedom of movement	Cards	2,286	2,000	2,000	0,700	2,000	-0,595
	MoMo	3,000	3,000	2,000	0,894	2,000	0,000
Meaningfulness movements	Cards	3,714	4,000	4,000	0,452	4,000	-1,230
	MoMo	3,900	4,000	4,000	0,943	4,000	-0,610
Playfulness movement	Cards	4,571	5,000	5,000	0,495	5,000	-0,374
	MoMo	4,800	5,000	5,000	0,400	5,000	-1,779
Relation movement to process	Cards	3,571	4,000	4,000	1,050	4,000	-0,725
	MoMo	3,400	3,500	4,000	0,917	4,000	-0,111
Movement design insights	Cards	4,143	4,000	4,000	0,639	4,000	-0,174
	MoMo	3,800	4,000	4,000	1,077	4,000	-1,800
Impact movement on process	Cards	3,857	4,000	4,000	0,350	4,000	-2,646
	MoMo	3,800	4,000	4,000	0,600	4,000	0,132
Value on process	Cards	3,143	3,000	3,000	0,990	3,000	0,772
	MoMo	2,400	2,000	4,000	1,200	4,000	0,280
Ability to inspire	Cards	3,000	3,000	2,000	0,926	2,000	0,000
	MoMo	2,500	2,500	4,000	1,204	4,000	0,000
Provoking movemnet	Cards	2,429	2,000	2,000	0,728	2,000	1,760
	MoMo	2,500	2,500	2,000	1,025	2,000	0,000
Fiting context	Cards	3,143	3,000	3,000	0,990	3,000	-1,520
	MoMo	2,800	3,000	3,000	1,166	3,000	0,018
Constraining movement	Cards	2,571	2,000	2,000	0,728	2,000	1,115
	MoMo	2,800	3,000	3,000	0,748	3,000	-1,290
Separation movement-interaction	cards	2,857	3,000	3,000	0,639	3,000	0,174
	MoMo	3,100	3,000	3,000	0,300	3,000	3,162

Table 2. Descriptive Statistics of the individual survey items.

H Information Brochure and Consent Form for the Interviews

The information brochure and consent form that were reviewed and accepted by the ethics committee of the University of Twente, used during the pilot tests and interviews.

Consent Form for 'Facilitation in Movement-based Design'

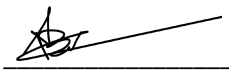
YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	Yes	No
Taking part in the study		
I have read and understood the study information dated 10/01/2023, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves an interview where information is recorded through audio & video and written notes. The recordings will be transcribed as text and all recordings will be destroyed once the research project is finished (no later than 01/07/2023).	○	○
Use of the information in the study		
I understand that information I provide will be used for the researcher's thesis report.	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	○	○
I agree that my information can be quoted in research outputs (the thesis report)	○	○
Future use and reuse of the information by others		
I give permission for the anonymised transcripts that I provide to be archived in password protected storage of the researcher so it can be used for future research and learning.	○	○

Signatures

_____	_____	_____
Name of participant	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Anne van den Biggelaar		15-02-23
Researcher name	Signature	Date

Information Letter for 'Facilitation in Movement-based Design'

To help you make an informed decision about participating in this study, this letter will explain the contents of the study, the risks and benefits and your rights as participant. Please ask the researcher if something in this letter is unclear to you.

You are invited to participate in a research study about the role of a facilitator in design workshops. In these workshops, people come together to think of solutions to a design related problem. A facilitator is the person that provides guidance to the people during the design process. This study is interested in the role of the facilitator and their potential impact on the design outcome. This study is part of a student research for a master's thesis, and you will not receive payment for your participation in the study.

This study will consist of an interview from 30 to 45 minutes in which you will be asked questions related to your experience as a facilitator or group coach. The interview is a one-on-one conversation together with the researcher, and will take place online.

Your participation in this study is voluntary and there are no benefits or risks of participation. The project has been reviewed by the Ethics Committee Information and Computer Science. You may decide to leave the study at any time by communicating this to the researcher. During the interview, you may decline to answer any question(s) you prefer not to answer. You can also request that your data will be removed from the study up until 01/07/2023 as it is not possible to withdraw the data once the thesis has been completed.

The interview will be recorded through audio and video, as well as written notes. The recordings will be transcribed into text after the interview, and personal identifying information will be removed and not shared outside the research team. The recordings are securely stored on password protected storage and only anonymously used in the research report. All recordings will be deleted after completion of the project, or no later than 01/07/2023. The participant has the right to request access to and rectification or erasure of personal data.

Study contact details for further information: Anne van den Biggelaar, a.vandenbiggelaar@student.utwente.nl

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

I Information Brochure and Consent Form for the Workshop

The information brochure and consent form that were reviewed and accepted by the ethics committee of the University of Twente, used during the main user test workshop.

Information Letter for 'Design workshop in Movement-based Design'

To help you make an informed decision about participating in this study, this letter will explain the contents of the study, the risks and benefits and your rights as participant. Please ask the researcher if something in this letter is unclear to you.

You are invited to participate in a research study about the role of artefacts (objects) in movement-based design workshops. In these workshops, people come together to think of solutions to a design related problem. They use movement and physical activities to `brainstorm' with their bodies. An artefact is a physical object that gives you inspiration and suggestions during the design process. This study is interested in the role of the artefacts and their potential impact on the amount of movement that is used in the design process. This study is part of a student research for a master's thesis, and you will not receive payment for your participation in the study.

This study will consist of an design workshop of 3 hours in which you will take part in multiple design activities. You will do these activities with your classmates from the Embodied Interaction course. After that, you will fill in a short questionnaire survey with some questions about your usage of movement. The workshop will take place at a location of Uppsala University. Your participation or performance in the workshop will not influence your grades of the course `Embodied Interaction'.

Your participation in this study is voluntary and there are no benefits or risks of participation. The project has been reviewed by the Ethics Committee Information and Computer Science. You may decide to leave the study at any time by communicating this to the researcher. During the workshop, you may decline to take part in any activities prefer not to do. You can also request that your data will be removed from the study up until 01/07/2023 as it is not possible to withdraw the data once the thesis has been completed.

The workshop will be recorded through audio and video, as well as written notes. The recordings will be analysed into text after the workshop, and personal identifying information will be removed and not shared outside the research team. The recordings are securely stored on password protected storage and only anonymously used in the research report. The participant has the right to request access to and rectification or erasure of personal data.

Study contact details for further information: Anne van den Biggelaar, a.vandenbiggelaar@student.utwente.nl, or Annika Waern, annika.waern@im.uu.se (supervisor at Uppsala University), or Dees Postma, d.b.w.postma@utwente.nl (supervisor at University of Twente)

Contact Information for Questions about Your Rights as a Research Participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee Information & Computer Science: ethicscommittee-CIS@utwente.nl

Consent Form for 'Design workshops in Movement-based Design'

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

Please tick the appropriate boxes	Yes	No
Taking part in the study		
I have read and understood the study information dated 10/03/2023, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves a design workshop where information is recorded through audio & video and written notes. I understand that the study will also involve a survey questionnaire, which I will fill in truthfully. The recordings will be transcribed as text and all recordings will be safely stored and kept.	○	○
Use of the information in the study		
I understand that information I provide will be used for the researcher's thesis report and potential research publications.	○	○
I understand that personal information collected about me that can identify me, such as [e.g. my name or where I live], will not be shared beyond the study team.	○	○
I agree that my information can be quoted in research outputs (the thesis report)	○	○
Future use and reuse of the information by others		
I give permission for the audio/video recordings that I provide to be archived in password protected storage of the researcher so it can be used for future research and learning.	○	○

Signatures

_____	_____	_____
Name of participant	Signature	Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Anne van den Biggelaar	_____	_____
Researcher name	Signature	Date

J Arduino Code of the MoMo Prototypes

This section contains the code for the high fidelity prototypes.

Code for the Adafruit Circuit Playground, handling the movement interactions acceleration and balancing.

```

float X, Y, Z;
#include <Adafruit_CircuitPlayground.h>
#include <Wire.h>
#include <SPI.h>

int sensorPin = A10;
int sensorValue = 0;
int brightVal = (20);

int redX, redY = 0;
int greenX, greenY = 255;
int blueX, blueY = 0;

float ax, ay, az, atot;
float averAcc = 0;
float averAccCalculate[1000];
float changeX = 0;

float initAcc = 0;

boolean Buzz1, Buzz2, Buzz3;

uint8_t myFavoriteColors[][3] = {
  { 200, 0, 200 },    // purple
  { 200, 0, 0 },      // red
  { 200, 200, 200 },  // white
};
// don't edit the line below
#define FAVCOLORS sizeof(myFavoriteColors) / 3


#define MOVE_THRESHOLD 10
const int buzzer = 9;  //buzzer to arduino pin 9
/


void setup() {
  Serial.begin(9600);
  CircuitPlayground.begin();
  CircuitPlayground.clearPixels();
  CircuitPlayground.setBrightness(brightVal);

  pinMode(0, OUTPUT);
  pinMode(1, OUTPUT);
  pinMode(2, OUTPUT);
  pinMode(3, OUTPUT);

  pinMode(6, OUTPUT);
  pinMode(9, OUTPUT);
  pinMode(10, OUTPUT);
  pinMode(12, OUTPUT);

}


void balansLights() {
```

```
  X = CircuitPlayground.motionX();
  Y = CircuitPlayground.motionY();
  Z = CircuitPlayground.motionZ();

  if (X < -6) {

    redX = 0;
    greenX = 255;
    blueX = 255;
    CircuitPlayground.strip.setPixelColor(0, redX, greenX, blueX);
    digitalWrite(12, HIGH);  // LED on
  } else if (X >= -6 && X < -2) {

    redX = 255;
    greenX = 0;
    blueX = 255;
    CircuitPlayground.strip.setPixelColor(1, redX, greenX, blueX);
    digitalWrite(6, HIGH);        // LED on
  } else if (X >= -2 && X < 2) {  //+x, -y = GREEN

    redX = 255;
    greenX = 0;
    blueX = 0;
    CircuitPlayground.strip.setPixelColor(2, redX, greenX, blueX);


  }

  else if (X >= 2 && X < 6) {  //+x, -y = GREEN

    redX = 0;
    greenX = 0;
    blueX = 255;
    CircuitPlayground.strip.setPixelColor(3, redX, greenX, blueX);
    digitalWrite(9, HIGH);  // LED on
  }

  else if (X >= 6) {  //+x, -y = GREEN

    redX = 0;
    greenX = 255;
    blueX = 0;
    CircuitPlayground.strip.setPixelColor(4, redX, greenX, blueX);
    digitalWrite(10, HIGH);  // LED on
  }

  if (Y < -6) {  //+x, -y = GREEN

    redY = 0;
    greenY = 255;
    blueY = 255;
    CircuitPlayground.strip.setPixelColor(5, redY, greenY, blueY);
    digitalWrite(1, HIGH);  // LED on
  }

  else if (Y >= -6 && Y < -2) {  //+x, -y = GREEN

    redY = 255;
```

```
    greenY = 0;
    blueY = 255;
    CircuitPlayground.strip.setPixelColor(6, redY, greenY, blueY);
    digitalWrite(0, HIGH);        // LED on
  } else if (Y >= -2 && Y < 2) {  //+x, -y = GREEN

    redY = 255;
    greenY = 0;
    blueY = 0;
    CircuitPlayground.strip.setPixelColor(7, redY, greenY, blueY);
    //digitalWrite(12, HIGH);  // LED on

  }

  else if (Y >= 2 && Y < 6) {  //+x, -y = GREEN

    redY = 0;
    greenY = 0;
    blueY = 255;
    CircuitPlayground.strip.setPixelColor(8, redY, greenY, blueY);
    digitalWrite(2, HIGH);  // LED on
  }

  else if (Y >= 6) {  //+x, -y = GREEN

    redY = 0;
    greenY = 255;
    blueY = 0;
    CircuitPlayground.strip.setPixelColor(9, redY, greenY, blueY);
    digitalWrite(3, HIGH);  // LED on
  }

  CircuitPlayground.strip.show();
  delay(299);
  CircuitPlayground.strip.clear();
  digitalWrite(12, LOW);
  digitalWrite(6, LOW);
  digitalWrite(9, LOW);
  digitalWrite(10, LOW);
  digitalWrite(1, LOW);
  digitalWrite(0, LOW);
  digitalWrite(2, LOW);
  digitalWrite(3, LOW);
}

void accelPiano() {
  ax = CircuitPlayground.motionX();
  ay = CircuitPlayground.motionY();
  az = CircuitPlayground.motionZ();
  atot = sqrt(ax * ax + ay * ay + az * az);

  long sum = 0L;

  initAcc = atot - 9, 81;
  for (int i = 0; i < 2000; i++) {
    averAccCalculate[i] = abs(initAcc);
    sum += averAccCalculate[i];
  }
```

```
  averAcc = ((float)sum / 2000);
  changeX = 0.5 * averAcc * 4 + abs(initAcc) * 2;
  Serial.println(averAcc);
  if (averAcc > 1 && averAcc <= 5) {
    CircuitPlayground.playTone(131, 100);
  }
  if (averAcc > 5 && averAcc <= 10) {
    CircuitPlayground.playTone(220, 100);
  }
  if (averAcc > 10 && averAcc <= 15) {
    CircuitPlayground.playTone(294, 100);
  }
  if (averAcc > 15 && averAcc <= 20) {
    CircuitPlayground.playTone(392, 100);
  }
  if (averAcc > 20 && averAcc <= 23) {
    CircuitPlayground.playTone(587, 100);
  }
  if (averAcc > 23) {
    CircuitPlayground.playTone(784, 100);
    for (int k = 0; k < 10; k++) {
      CircuitPlayground.setPixelColor(k, random(0, 255), random(0, 255), random(0, 255));
    }
    delay(200);
    for (int j = 0; j < 10; j++) {
      CircuitPlayground.setPixelColor(j, 0, 0, 0);
    }
  }
}


void loop() {
  balansLights();
  accelPiano();
}
```

Code for the ESP32, handling the rotary encoder, segment display and the audio files.

```
    #include "AiEsp32RotaryEncoder.h"
#include "SoundData.h"
#include "XT_DAC_Audio.h"


#define ROTARY_ENCODER_A_PIN 26
#define ROTARY_ENCODER_B_PIN 27
//#define ROTARY_ENCODER_BUTTON_PIN 25
//#define ROTARY_ENCODER_STEPS 4
//AiEsp32RotaryEncoder rotaryEncoder = AiEsp32RotaryEncoder(ROTARY_ENCODER_A_PIN, ROTARY_ENCODER_B_PIN,
    ROTARY_ENCODER_BUTTON_PIN, -1, ROTARY_ENCODER_STEPS);
AiEsp32RotaryEncoder rotaryEncoder = AiEsp32RotaryEncoder(ROTARY_ENCODER_A_PIN, ROTARY_ENCODER_B_PIN);

float newPos;
int displayNum;
int oldPos =0;;
#include "SevSeg.h"
SevSeg sevseg;

#define NORMAL_SPEED 1                  // These are the playback speeds, change to
#define FAST_SPEED 1.5                  // see the effect on the sound sample. 1 is default speed
```

```
#define SLOW_SPEED 0.75                  // >1 faster, <1 slower, 2 would be twice as fast, 0.5 half as fast

XT_DAC_Audio_Class DacAudio(25, 0);     // Create the main player class object.
// Use GPIO 25, one of the 2 DAC pins and timer 0

XT_Wav_Class one(oneWav);
XT_Wav_Class two(twoWav);
XT_Wav_Class three(threeWav);
XT_Wav_Class four(fourWav);
XT_Wav_Class five(fiveWav);
XT_Wav_Class six(sixWav);
XT_Wav_Class seven(sevenWav);
XT_Wav_Class eight(eightWav);
XT_Wav_Class nine(nineWav);


// SpeedArray contains the order in which the code will playback the sample at the designated speeds
float SpeedArray[] = {NORMAL_SPEED, FAST_SPEED, SLOW_SPEED};
uint8_t NoOfSpeeds = 3;                 // Number of difference speeds in the Speed array above
uint8_t SpeedIdx = 0;                   // In effect when the checks in the main loop are made this will increment to 0

int counter = 0;

void IRAM_ATTR readEncoderISR()
{
  rotaryEncoder.readEncoder_ISR();
}

void setup()
{
  //Set to 1 for single-digit display
  byte numDigits = 1;
  //defines common pins while using multi-digit display. Left for single digit display
  byte digitPins[] = {};
  //Defines Arduino pin connections in order: A, B, C, D, E, F, G, DP
  byte segmentPins[] = {21, 19, 18, 5, 4, 2, 23, 22};
  byte displayType = COMMON_CATHODE; //Use COMMON_ANODE for Common Anode display
  bool resistorsOnSegments = true; //    false     if resistors are connected to common pin
  //Initialize sevseg object. Use COMMON_ANODE instead of COMMON_CATHODE for CA display
  sevseg.begin(displayType, numDigits, digitPins, segmentPins, resistorsOnSegments);
  sevseg.setBrightness(90);

  pinMode(ROTARY_ENCODER_A_PIN, INPUT_PULLUP);
  pinMode(ROTARY_ENCODER_B_PIN, INPUT_PULLUP);
  //Serial.begin(9600);
  rotaryEncoder.begin();
  rotaryEncoder.setup(readEncoderISR);
  rotaryEncoder.setBoundaries(0, 19, true); //minValue, maxValue, circleValues true|false (when max go to min and vice versa)
  rotaryEncoder.disableAcceleration();

  sevseg.setNumber(int(displayNum));
  sevseg.refreshDisplay();
}

void loop()
```

```
{
  DacAudio.FillBuffer();

  if (counter == 1000){
    counter =1;
  }
  if (rotaryEncoder.encoderChanged())
  {
    newPos = int(rotaryEncoder.readEncoder() * 0.5);

    //Serial.println("test");
    //Serial.println(int(newPos));
    displayNum = int(newPos);
    sevseg.setNumber(int(displayNum));
    sevseg.refreshDisplay();
    counter = 1;
  }

  if (displayNum == 1 && one.Playing == false && newPos != oldPos)
  {
    if (counter == 1) {
      DacAudio.Play(&one);
      counter++;
    }
    counter++;
    oldPos = int(newPos);
  }



  if (displayNum == 2 && two.Playing == false && newPos != oldPos)
  {
    if (counter == 1) {
      DacAudio.Play(&two);
      counter++;
    }
    counter++;
    oldPos = int(newPos);
  }

  if (displayNum == 3 && three.Playing == false && newPos != oldPos)
  {
    if (counter == 1) {
      DacAudio.Play(&three);
      counter++;
    }
    counter++;
    oldPos = int(newPos);
  }

  if (displayNum == 4 && four.Playing == false && newPos != oldPos)
  {
    if (counter == 1 ) {
      DacAudio.Play(&four);
      counter++;
    }
    counter++;
    oldPos = int(newPos);
```

```
  }
  if (displayNum == 5 && five.Playing == false && newPos != oldPos)
  {
    if (counter == 1) {
      DacAudio.Play(&five);
      counter++;
    }
    counter++;
    oldPos = int(newPos);
  }
  if (displayNum == 6 && six.Playing == false && newPos != oldPos)
  {
    if (counter == 1 ) {
      DacAudio.Play(&six);
      counter++;
    }
    counter++;
    oldPos = int(newPos);
  }
  if (displayNum == 7 && seven.Playing == false && newPos != oldPos)
  {
    if (counter == 1 ) {
      DacAudio.Play(&seven);
      counter++;
    }
    counter++;
    oldPos = int(newPos);
  }
  if (displayNum == 8 && eight.Playing == false && newPos != oldPos)
  {
    if (counter == 1) {
      DacAudio.Play(&eight);
      counter++;
    }
    counter++;
    oldPos = int(newPos);
  }
  if (displayNum == 9 && nine.Playing == false && newPos != oldPos)
  {
    if (counter == 1) {
      DacAudio.Play(&nine);
      counter++;
    }
    counter++;
    oldPos = int(newPos);
  }

  //Serial.println(counter);
//oldPos = int(newPos);
}
```