Mind the Gap: Probing Exertion Experience with Experiential Design Landscapes

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In this paper, we report our study on applying Experiential Design Landscapes as the basis of design process to support the design of exertion games. We approach this question by setting up an 8-day interaction design module with 7 groups of students. The methods of our module were developed based on the process model of Experiential Design Landscapes. According to the provided framework, the students were engaged in designing embodied interaction for office workers in their daily routine to support active lifestyles. We collected data including their design process and design results to discuss on how Experiential Design Landscapes lead students to explore the exertion experience. The students also wrote self-reflections after the course to reflect on their experience of the methods used during the module. We finally discuss the strengths, limitations, and opportunities of our approach in this context to enlighten future research and practice initiatives.

Keywords: exertion games, experiential design landscapes, experiential probes, exertion experience.

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Introduction

Exertion games, the digital games that require physical performance, have been seen successfully sometimes in providing individuals with sufficient physical activities to aid health-related issues, such as weight loss (Dunning, 2008), rehabilitations (Cameirão, Badia, Oller, & Verschure, 2010), fall preventions (Fenney & Lee, 2010), exercise promotions (Floyd) Mueller, Vetere, Gibbs, Agamanolis, & Sheridan, 2010; F. Mueller, Gibbs, & Vetere, 2010), and anti-sedentary behaviour (Gao & Mandryk, 2011; Mandryk, Gerling, & Stanley, 2014), etc.

Previous theoretical studies have supported the design of exertion games from many perspectives. Sinclair et al. (2007) proposed a dual flow model to balance two important factors in terms of attractiveness and effectiveness when designing exertion games. Gerling et al. (2010) paired the criteria of exertion games with age-related psycho-physiological requirements to identify the design guidelines specific targeting for elderly people. Gao and Mandryk (2011) adopted the theory of casual game to develop casual exertions that increase the accessibility to provide low-intensity exercise in a short period. Similarly, Mandryk et al. (2014) established a series of design guidelines taking the motivational perspectives into account to encourage people to do light exercise repeatedly in the daily life to combat sedentary behaviour. Based on the appreciation of the fundamental role that body in interaction, Muller et al. (2011) have identified the Exertion Framework, which provides four lenses of body-related schema that designers can use when designing exertion games. Due to their abstract nature, however, it is still very hard to generate explicit strategies to support designers’ creative process when designing exertions for the specific context (F. F. Mueller, Gibbs, Vetere, & Edge, 2014).

In fact, there has been long run to close the gap between theoretical frameworks and practical design process in the HCI and design communities. While existing examples tried to bridge such connections by developing card sets for ideation use (F. F. Mueller et al., 2014), by involving end-users in the design process (Walldius, 2015), and by adopting Flow Experience (Mirvis, 1991) into the design for serious exertions (Arnab, Perttula, & Suominen, 2014), we approach this context based on Experiential Design Landscapes (EDLs), which was first introduced by Gent et al. (2011) and aimed at offering designers a means to introduce, tailor, and adapt their novel design, Experiential Probes (EPs) (Peeters, Megens, Hummels, & Brombacher, 2013), to people and in return to support their design process.
This paper explores how to adapt EDLs in designing exertion games to support designers to open up the design space with and for people in specific contexts. For this purpose, we organized an 8-day progressive design module based on the model of EDLs with 7 groups of students. The students were engaged in the task of designing embodied interaction in the working environment to stimulate active lifestyles of office workers. By analysing the data in terms of their design process and design results with Exertion Framework (F. F. Mueller et al., 2011), we examined how our methods supported the development of exertion experience. Lastly we asked for self-reflections from all the students on their experience of using the methods during the module. With this approach, we aim to identify the opportunities of EDLs in relevant researches and practices.

**Experiential Design Landscapes**

The term of EDLs was defined by Gent et al. (2011) as a design tool to inform market research of disruptive intelligent systems. EDLs method is a design research method aimed at designing for and with people in their natural environments to find ways to structurally change people’s behaviour (Peeters & Megens, 2014). As is shown in Figure 1, EDLs method is based on 4 progressive steps, revolving:

- **Envisioning:** Designers (with others) envision and explore an unfamiliar context and come up with new visions of design.
- **Designing interventions:** Designers start to find desingerly ways to create their propositions that could support to stimulate new behaviour change in the specific context. The propositions will therefore act as probes, more precisely EPs, for the design research team to study the outcomes of their design interventions.
- **Acquiring data:** Designers collect data in EDLs by deploying EPs to record behaviour and context. The acquired data enables designers to dig in people’s conscious or unconscious decision, behaviours and motivations.
- **Analysing & validating:** Designers use the techniques of data analysis, such as data mining and process mining, to discover data patterns and extract meaning from them.
In the design process, the design researchers search and explore opportunities together with the people using the EPs in a short loop of analysis and design synthesis. EPs act as smart sensor agents and can be seen as probes as they use in their intelligence to gather data of their use and on the behaviour of people in the EDLs (Peeters et al., 2013). This way of probing allows the design researchers to gain first person perspective and understanding of the people in the EDLs (Megens, Peeters, Hummels, & Brombacher, 2013). By incorporation with observing, interviewing, and questioning, designers can acquire rich information to find more to reason the behaviour pattern and in return modify their design propositions in next iteration.

While previously EDLs have been involved in design researches as tools to inform market innovation (Gent, Megens, Peeters, Hummels, & Lu, 2011b), as a way to support social transformation in the health-related topics (Megens et al., 2013), as a method to probe emergent behaviour
(Peeters et al., 2013), we access EDLs as a design process to support the development of exertion games for particular contexts. For this purpose, three important features of EDLs can be observed: First, it provides a real life environment for understanding people’s behaviour, in turn designers can reflect on the information to create, modify or extend their design concept. Second, it requires building interactive prototype during the early phase of design process, thus designers can quickly transform their knowledge to the implementations. Third, rather than a finished solution, EPs are designed as a research tool to stimulate designers to create future initiatives, thus designers can utilize the insights they gained from EDLs to develop new systems. In the remaining, we investigate how these features of EDLs work when designing exertion games.

**Methods**

To examine further on how EDLs work in developing exertion games, we decided to setup an interaction design module with our students. The purpose of this study was to evaluate the utility and to identify the value of EDLs in designers’ practice. We present our methods in details in the remaining parts of this section.

**The module**

We conducted an 8-day module with 7 groups of students and each group has 5 students respectively. As part of the joint summer school between Eindhoven University of Technology (TU/e) and Zhejiang University (ZJU), this course was carried out in the International Design Institute of ZJU in China. On the first day, we began by introducing the term of EDLs, EPs, and exertion games with some video examples. We then showed the framework we proposed and explained how it could work out in the design process. Lastly, we assigned them the design challenge in this course. The goal of this module was for each group to go through at least two iterations based on EDLs and to come up with a workable prototype to demonstrate their design of the exertion game. In the course, we assigned them a collective design task for every group to ask them to design embodied interaction for office workers in their daily routine to support active lifestyles. We held progress meeting on the second day, third day, fourth day, sixth day, and eighth day and asked them to give us pitch on the first concepts, the first EPs and results, new design propositions, new findings, and final design respectively.
Participants
7 students from the Department of Industrial Design at TU/e and 28 students from ZJU were joined in this module. The participants from TU/e were industrial design bachelor students in their second year (3 year in total), while participants from ZJU were bachelor students in their third year (4 year in total). To be noted, all the students from ZJU were industrial design minor students and received design education for two years and a half. They were originally from different bachelor schools ranged from electrical engineering, computer science, mechanical engineering, architecture advertisement, art design, business management, and English study. To moderate the bias of imbalance between groups, we teamed up 1 student from TU/e with 4 students from ZJU as one group. Each group also had students from different disciplines to ensure the balanced competencies.

The tool
To facilitate their explorations, we prepared open-source electronics such as Arduino and Raspberry Pi, exertion game platforms such as Kinect and Nintendo Wii, necessary sensors such as Force Sensing Resistor and Pixy camera, other data-collection devices such as GoPro and mobile phone, and responding physical materials (cardboard, paper, foam, aluminium foil, etc.). We also gave individual tutorial for every group every day regarding prototyping and Q&A of using our framework in their design process.

Data collection
As shown in Table 1, we captured video and collected their slides for every coach meeting to record their progress. Furthermore, they delivered the file of their final presentations, their final demonstrator, and their demos of every step to us. We were also interested in how they experienced the methods we introduced during the module. Therefore, we asked every student to write a 1-page report to reflect on own experience on joining this class.

Table 1 The source and types of data that we collected from the course.

<table>
<thead>
<tr>
<th>Data source</th>
<th>Design Process</th>
<th>Design Results</th>
<th>Reflections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data type</td>
<td>Video, slides, notes.</td>
<td>Demo, slides, photos.</td>
<td>Self-reflection reports</td>
</tr>
</tbody>
</table>
Data Analysis

We analysed and discussed the data guided by Exertion Framework (EF) (F. F. Mueller et al., 2011), the fundamental theory in this field to encourage a holistic view on exertion experience. There have four body-related lenses accommodated in EF to demonstrate exertion experience, including:

- **Responding body** highlights how body’s internal state change over times because of exertions. For example, a certain time of the cardio training could cause a rise in heart rate and occurrence of sweat.
- **Moving body** highlights how to trigger people’s kinaesthetic sense in order to allow the body’s movement intuitively. The example could be the experienced people in table tennis would hit every ball with specific movement from their intuition.
- **Sensing body** highlights how to provide a context for the interaction between body and the world. Taking the soccer game as an example, people who engage in the game should always keep in mind to interact with the ball.
- **Relating body** highlights how to relate people one to another to facilitate the social interaction in the exercise. Still in the case of soccer, whenever players are doing a match or training, the circumstance for social interaction then have been created.

EF provides a reliable structure for exertion designers to ideate on the concept, to elaborate the technology design, and to extend their works for further design (F. F. Mueller et al., 2011). Therefore, we analysed the process and results of students’ design into the aforementioned three parts, using the framework of EF to examine how EDLs method we used in our course supported the design regarding exertion experience. We also organized students’ reflections into the structure of ideation, elaboration, and extension to evaluate on what role our approach could act to support the design for exertion experience in specific contexts.

Results and initial analysis

We first present four cases of our students’ works in this module in order to show how EDLs worked in practice. We then summarize a few key points from students’ reports to suggest the strengths and limitations of our work. Next, we elaborate on our findings in details.
Design cases

Here we show the design process and results of 4 design cases from 4 representative groups in this study to describe how EDLs actuated students’ work in this course. We started the analysis by reading the slides and watching the recorded video. For each group, we coded our findings into three categories according to the structure of Ideation, Elaboration, and Extension/Revision. All these 4 groups reported that they have carried out 3 iterations and extended/revised their design twice in this course. Therefore, we add one category of Finalization to describe their last extension/revision. In the description of each case, we highlighted the text that showed students’ considerations on exertion experience. The case summary was given in the end followed each case description.

Case 1: Body Sketching

- **Ideation:** They found many Chinese traditional exercises are symbolized as the sustainable activities to change our bodies in a moderate way, such as Tai Chi. They believed that the philosophy of Tai Chi cater for the context of office settings. Their main idea was to use low-intensity activities to gradually change human’s body status.

- **Elaboration:** From this purpose, they started the exploration of how to correlate the way of doing Tai Chi with working experiences so that to create an active working environment. They utilized Kinect to develop the prototype to sense body movement, which enables people to manipulate 3D modelling software by different body gestures.

- **Extension/Revision:** From the first probing, they found that the gesture protocols were too complicated for user to intuitively move their body, given 3D modelling is not a simple tasks. Therefore, they added their focus on how to provide simple task for people to move their body intuitively. They implemented full-body interaction into sketching, in which people only need to do some simple body movements to create geometric graph (e.g. circle, rectangular, line, and triangular etc.) on the screen for brainstorming use.

- **Finalization:** In the second testing, they noticed people preferred to contact with the system together in the public space. Thus they finalized their design to include the considerations of social interaction by allowing people to create some special geometric
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Table 2  The summary of the case Body Sketching.

<table>
<thead>
<tr>
<th>Ideation</th>
<th>Elaboration</th>
<th>Extension</th>
<th>Finalization</th>
</tr>
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<tbody>
<tr>
<td><strong>Responding Body</strong></td>
<td><strong>Sensing Body:</strong> By integrating Kinect into the system, People can manipulate 3D modelling software by their body gestures.</td>
<td><strong>Moving Body:</strong> provide simple tasks (draw simple geometric graph) for people to move their bodies intuitively.</td>
<td><strong>Relating Body:</strong> allow people to create some special geometric graph together in the system during their meeting time.</td>
</tr>
</tbody>
</table>

**Case 2: Energy Releasing Bottle**

- **Ideation:** Similar to group 1, they also positioned their concept from the particular features in the context. They noticed a healthy behaviour that Chinese people like to carry a water bottle to ensure sufficient water intake in their daily life. They believed that the **bottle could be an ideal carrier to sense data from body in the context** to offer a more comprehensive health experience for office people.

- **Elaboration:** From this purpose, they embedded electronics in the water bottle to encourage physical movement with the bottle. Their considerations fell in **how to interact with body movements consistently:** At first, the LED on the bottle could remind people to do exercise by fading the light away. While exercising, the colour of light would keep on changing according to the intensity and duration of user’s movement.

- **Extension/Revision:** From their first probing, they found this strategy could increase people’s awareness on how much effort they invested and in turn motivate them to do more. From earlier study
(please find the user test demo via: https://vimeo.com/163986613), they also noticed the solitary play could be embarrassing for users in a collective environment, and could also be disturbing for others. Therefore, they revised their design with the concerns from the social perspective, where they proposed to adapt the system to social media to facilitate social exercise and to stimulate repeated play.

- **Finalization:** They finalized their work from the perspective of ergonomics. To lead people to move their body in a more natural way, they redesigned the form of the bottle to make it more durable for playing.

Table 3  The summary of case Energy Releasing Bottle.

<table>
<thead>
<tr>
<th>Ideation</th>
<th>Elaboration</th>
<th>Extension</th>
<th>Finalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing Body:</td>
<td>Responding Body:</td>
<td>Relating Body:</td>
<td>Ergonomics:</td>
</tr>
<tr>
<td>the popular</td>
<td>embed electronics and LED in the</td>
<td>use social media to create</td>
<td>redesign the shape of the bottle, to make it</td>
</tr>
<tr>
<td>water bottle in</td>
<td>bottle to stimulate people to</td>
<td>social mechanisms behind the</td>
<td>easier to use for exercising aim.</td>
</tr>
<tr>
<td>China provides</td>
<td>play with the bottle consistently.</td>
<td>bottle, such as cooperation</td>
<td></td>
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<tr>
<td>the potential</td>
<td></td>
<td>and competition.</td>
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<td>context for</td>
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<td>people to</td>
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<td>interact with.</td>
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Case 3: Bouncing Floor

- **Ideation:** They started their ideation with the question of how to facilitate body-environment interaction. By observing, they found that there were opportunities to utilize the office environment to remain office workers physically active.

- **Elaboration:** They proposed several ideas on how to implement sensors in the office to measure body data and in return to stimulate more movement in their daily routines. They then came up with the concept of smart floor system that mimic lotus leaves in the pond. Their initial plan was to set it on the necessary route in the office environment, such as the entrance of building.
Extension/Revision: From the first iteration, they found that the concept was too disruptive for people to step on the floor. Therefore, they increased the threshold for triggering the system. In their new proposition, the interaction could only be activated when people jump on the floor.

Finalization: From the analysis of data, they realized people were very easy to get bored in their current system. In other words, it could not motivate repeated play with their design. Hence they reformulate a set of game rules with implementations of a display on the wall to encourage exercise behaviour by providing bonus at the end of the game. Please find the demo for final design via: https://vimeo.com/163987271

Table 4  The summary of the case Bouncing Floor.

<table>
<thead>
<tr>
<th>Ideation</th>
<th>Elaboration</th>
<th>Extension</th>
<th>Finalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing Body: use the office as the sensing context to provide body environment interaction.</td>
<td>Sensing Body: add sensors into the floor to interact with people when they step on it.</td>
<td>Sensing Body: increase the threshold for triggering the system to when people jump on the floor.</td>
<td>Incentives (persuasion): provide the bonus to encourage the repeated and prolonged play.</td>
</tr>
</tbody>
</table>

Case 4: Active Station

Ideation: Unlike the other groups focusing on the office surroundings, they looked up daily life routines. They developed their concept based on the context of metro station. They found that people spend a certain amount of time in the metro station everyday and most of them were physically and socially inactive during this period. Therefore, they proposed to design of bodily interaction in the station to motivate active behaviour in a natural way.

Elaboration: By the view of stimulating people to move bodies, their initial concept was to blind the entire advertising panel, which
is common object in the station. Only when touching on the panel, individual could see the content of corresponding part. To enrich the interaction, they developed the following mechanisms: Once individual touched on multiple parts in a short time, the system could respond his/her efforts and he/she would see the entire picture/video on the panel.

- **Extension/Revision**: From the first probing, they gained the insights that although the concept was great, the upper body movement might be too much hurdle in the context. It would be more appealing if **people only need to step on the floor nearby to unblock the related part of the picture/video behind the blind**. They adopted this view to further develop their EPs.

- **Finalization**: In the second iteration, they observed new behaviour from people. Some people cooperated with each other to unblock the entire picture/video. By limiting the display time when people stepping on the floor, **people could be encouraged to relate to each other to collaborate together in order to see the whole picture behind the blinds.** Please find the demo of final design via: [https://vimeo.com/163986421](https://vimeo.com/163986421)

### Table 5  The summary of the case Active Station.

<table>
<thead>
<tr>
<th>Ideation</th>
<th>Elaboration</th>
<th>Extension</th>
<th>Finalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moving Body:</td>
<td><strong>Moving Body:</strong> explore how to motivate an active behaviour in the special context such as station.</td>
<td><strong>Moving Body:</strong> reform the existing objects (advertising panel) in the context to stimulate such behaviour.</td>
<td><strong>Relating Body:</strong> find out lower body interaction can optimize the feasibility of the system in this context.</td>
</tr>
</tbody>
</table>

### Student Reflections

In this sub-section, we describe the insights we gained from the self-reflection reports. We assorted the data into **Ideation**, **Elaboration**, and **Extension/Revision**, to demonstrate how our approach was useful during
the design process in this module that could reflect to the design process for exertion games. We also present extra findings in additional category.

**Ideation**
Our framework offered the context to guide designers to initiate their project. As one student mentioned:

*First, we listed some principles our concept should include and we doubted. Then we decided to go outside and we were so luck to see some people are doing Tai Chi on the square, which was inspiring.*

This implies that the way of design is different from lab research. Sufficient contact with target context should be beneficial to connect the ideas to practice. This is consistent with the feature of real-life environment that EDLs provided.

**Elaboration**
Our framework empowered designers in action by prototyping in the early phase. By thinking, discussing, and performing possible bodily interactions, students could weigh up their concepts to craft or modify their proposition, or even to unfold new design opportunities. As some students said:

*Through the intensive prototyping we tried to transform our vision into objects. We also reflected from our practice to make our concept more realistic.*

*I have learned from this course that the prototype can also be designed for exploration, rather than an outcome. And that is the powerful role that the prototype can play.*

**Extension/Revision**
Our framework provided designers more opportunities to explore further on the user experience of the exertion games. From the reflection reports, we noticed that most of the groups finalized their design propositions with extra considerations, such as Relating Body. One student also indicated this fact in his report:

*During the last test, we found it can be better if our product contains some social interactions.*
As described previously, EDLs energize designers to explore their idea iteratively. This nature offers credit for designers to develop their design sustainably along with the process.

From our module, students also realized the importance of early contact with users when implementing their concepts in practice. Some students highlighted this thought in their reports:

*We all test that whether it is suitable and interesting for our target group of and whether it meets our original thought.*

*It made me realize that the concept of user-oriented is essential. We need to know how users feel even the prototype is not good.*

*I have learnt how to implement the knowledge we learnt into our project and collected plenty of useful data.*

This statement also reveals that the data evidence from multiple sources in EDLs could support designers to improve their works further, particularly in the bodily interactive systems in which people’s behaviour data could be collected.

*With the rich data (e.g. behaviour data and interview data) from user tests we did we managed to keep on improving our concept and prototype.*

**Additional results**

We also found that EDLs encouraged students to continue on their work when they were frustrated of their process. As the student said:

*We tried many times of user testing. So we might become impatient, lost our interest and enthusiasm to the project, because all day we just worked on this. But we should stick to it, always finding something fresh and new in the project if we want to do it well.*

Moreover, since EDLs methods by nature requiring multiple tasks in one design process, students are responsive in their project, as they said:

*I enjoy the atmosphere that everybody are high involved with the project and the teamwork is really wonderful.*
Discussions

In this section, we discuss our findings in detail. By relating the results back to the exertion experience, we found that EDLs could support the design process of exertion games in three ways.

First, the study revealed that EDLs offered a context to guide and inspire designers to correlate the real life scenario to the ideation for exertion games. Unlike the typical exertion games lab research (F. Mueller et al., 2012) that mainly focused on body skills and design of technologies for sports experiences, our approach compliment exertion theory to remind designers considering on the practical constraints and opportunities (Consolvo, Everitt, Smith, & Landay, 2006) in the early phase. From the aforementioned cases, we have observed that by gaining awareness on local contexts, students did not just create an exertion interaction but an exertion experience enabled with intention for repeated visit in office workers’ daily routines.

Second, we observed that EPs could act as a technology carrier to elaborate on exertion games in action. With hands-on skills, designers explore, modify, and add their design intentions by developing EPs. Consequently, they gain deeper understanding towards the context, the users, and the design. As was depicted in all the cases from our study, all the students involved design principles, the technology skills, and the context considerations to realize their probes, which explicit their ideas into the accessible demonstrations.

Third, we found that the iterative design process of EDLs provide designers more opportunities to interact with their ideas more dynamically, and in return to extend their design iteratively. This can be facilitated by three observations from this study: First, designers can contact with user in the design process, where they could get crucial feedbacks to reflect on the intention they involved. Second, designers can observe the data from multiple sources along with the design process, which provide objective evidence to support or against their considerations. Third, designers can discuss, explore, analyse with each other to spark their ideas.
Limitations & Opportunities

This study has the following limitations that could be improved further. First, our approach might be too open-ended for all the students to go through. From our observation, we found not every group pursue their design process very well. Some students also expressed their concerns on our way of applying EDLs to design exertion games, as exertion remained abstract to them. The work related to exertion cards (F. F. Mueller et al., 2014) may be an interesting addition to improve from here.

In addition, we have to admit that there is lack of specific design tools to support to apply EDLs in developing exertion games in our study. This observation is even more apparent for students who have absent knowledge on prototyping with technology. It is hard for them to smoothly move around between knowledge, technology implementation, and data and to take necessary design actions. To overcome this, design tools such as body sketching (Stolterman, 2014) or body storming (Buchena, Francisco, & Suri, 2000) may come very handy to gain more profound understanding towards exertion games.

Lastly, evaluating our research question in educational cases is not the same as a designer’s day-to-day practice. However, previous work which also used design courses (Stolterman, 2014) suggested this might be a good way to approximate design practice. Furthermore, a task with team-based design exercises is similar to the teamwork environment to which designers are often exposed. Anyhow, further studies need to be done there to conduct longer study in real design cases and eventually come up with more explicit design guidelines for exertion games.

Conclusions

In this paper, we presented a new way of designing exertion games by combining the basic design process of EDLs. The data collected from the discussed design interaction modules indicates that EDLs can support the design process to develop exertion games targeting for specific contexts. The results suggested that utilizing the EDLs design process when developing exertion games for the specific contexts can offer the context to guide and inspire designers’ ideation; can facilitate technology explorations to elaborate on the exertion concept in action; and can provide the iterative process to help designers to evaluate and to extend their design with users, other designers, and the collected data. We believe that necessary future researches and practices are needed to validate our current works further.
For future work, firstly we plan to modify the framework according to the insights we gained from this step. Particularly, we are going to clarify the necessary theories for designing exertion experience with supporting materials (e.g. cards, slides, etc.). Secondly, we hope to develop a rough EP in advance to narrow down the scope of the design topic. Therefore, students/designers can start the field research with EP and can reflect on the data from EP in the very beginning, rather than struggling on the concept for the first probe. In this way, we are aiming to help them to find the track for their activities more efficiently. With the update of the program, we then plan to conduct several rounds of workshops with industrial design students and designers to finally come up with customized EDLs for designing exertion experience.

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