Prototype-Centric Explorative Interaction Design Approach in the Case of Office Energy Coaches Projects

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Abstract. This paper presents an explorative prototype-centric interactions design approach, as applied to the processes of designing interactive products for encouraging sustainable occupant behavior in office environments - the "Office Energy Coaches". In this approach, iterative making and trying out of prototypes is central to the organization of the design process, and no strict time separation is imposed on design activities, whether of analytical, creative or executive type. Instead of being organized by predefining the type of design activity to be performed during a given phase of the project, the design process phases are characterized only by increasing fidelity of created prototypes. The paper discusses projects from two design studios at industrial design faculties in the Netherlands and in China, where the prototype-centric approach was performed. Despite cultural and organizational differences, in both cases the approach proved to be successful. Fast, iterative prototyping involving interactive technology helped in organizing design teamwork, accelerated obtaining in-depth insights, facilitated conceptualization of meaningful interactions and supported development of experiential interactive product concepts. At the same time, some shortcomings of the approach have been observed, including several forms of fixation that designers faced when prototyping, as well as limitations of prototyping tools impacting the overall process performance. Based on discussed cases, we suggest areas for improving the prototype-centric approach, including recommendations for design methods, techniques and tools aimed at interaction design students and professional designers alike.

Keywords: Experiential prototyping · Iterative designing · Tangible interaction · Interaction Design · IxD education

1 Introduction

Interaction Design (IxD) is facing challenges of increasing societal and technological complexity. On the one hand, designers often have to deal with systems that involve multiple interconnected products and services. An example here are building automation and management systems that integrate heating, ventilation, lighting, information and security features of a building, controlled based on input from a

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multitude of sensors and control panels. While being made up of multiple interactive products, installations and services, such systems also involve simultaneous interactions with many individual users, who may have different roles, needs and can be engaged in a variety of social practices. For example, an office climate control may need to cater to various working styles of a single user, or to various kinds of social interactions such as having a meeting or a brainstorm session when several people use the room simultaneously. The work presented in this paper follows on the above example, as it addresses designing in the context of a "smart" office environment, and specifically deals with the challenge of encouraging sustainable office occupancy in that context. The approach we propose for dealing with entailed design complexity involves frequent iterative making and trying out of experiential prototypes, in order to comprehensively understand and address design problems at hand and to deal with related technological and social challenges.

Iterative design processes that support designing with technology are gaining popularity [9, 14], and we seek ways for using these processes to design for complex challenges. Many established design process models define a sequence of steps, phases or stages grouping design activities of certain type [4]. Most of these models resonate the distinction of analytical, creative and executive activities in the design process introduced by Bruce Archer [1], while often introducing more specific divisions. For example, IDEO uses respectively "inspire", "ideate", and "implement" [3], while Kumar proposes "research", "analysis", "synthesis" and "realization" [11] as phases. Steps back, jumps or organizing the order of these phases in different sequences are often indicated as a possibility [8].

Even though existing design process models can well describe iterative design processes, they also imply that individual design activities of similar kind need to be performed sequentially, and that each such activity has a clear termination moment before the next activity can begin. In the experience of our IxD education and professional design practice we have observed that such clear separation of design activities is rarely taking place, and design activities of different types tend to overlap. For example, while performing design research, designers may come up with creative ideas, that guide the direction of research, mixing analytical and creative activities. To support processes where complex design opportunity spaces are dynamically explored through more dynamic interplay between design activities of different kind, in this paper we propose a different approach. Here, separation of activities of different kinds is not imposed, and prototypes are considered to be both results and enablers of design activities belonging to different types and potentially occurring concurrently.

2 Prototype-Centric Framing of the Design Process

With the approach presented in this paper, our aim is to provide a better support for design processes where analytical, creative and executive design activities can all be initiated at the outset of the process, and mutually support each other throughout its entire duration. To achieve this goal, firstly, we support working with technology from the start of the design process. Hacking and tinkering can trigger many ideas and concepts if performed with design goals in mind [7]. Similarly, creative ideas developed and prototyped early on in the process can give direction and focus design research, can be involved in obtaining tacit knowledge from users and can help in discovering new research questions. Similarly taking executive steps early in the process allows to better understand the challenges of realizing the product and bringing it to the market, and inspire dealing with these challenges in a creative way. Testing of prototypes of varying fidelity as they are continuously generated in such process, can thus enable continuous generation of new, revised or improved insights, ideas and blueprints as outcomes of respectively analytical, creative and executive activities.

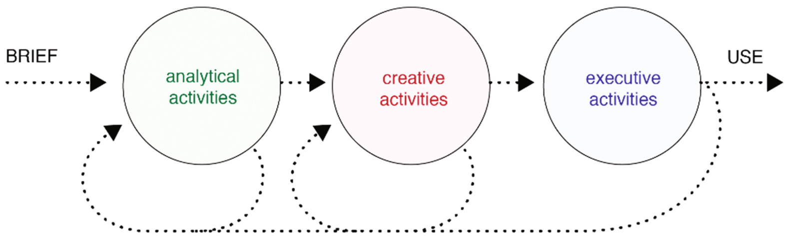


Fig. 1. A typical design process is divided into consecutive phases, which can be repeated while iterating over the entire process or its parts.

When discussing this approach with practicing designers and design students, we have observed that communication of an iterative designing process as a sequence of steps (as in Fig. 1) implies that each of these activities needs to have an explicit termination before the next one can start. In addition, we have noticed that starting a new iteration is causing resistance in design education because students consider this as "going back" and "starting all over". In order to remove this bias from the process representation we have decided to conceptually depict these activities as independent loops. We have also realized that in each of these activity loops, an autonomous iteration takes place, which can correspond to Mintzberg's do-see-think cycle [13] Kumar's two axes of real-abstract and making-understanding [9] or Kolb's learning cycle [10]. In all activities we take the position of supporting designers and design students in being able to perform such iterations quickly, as we see value in all the aspects of the process, as much as continuous gathering of understanding from the real-world phenomena. Lastly, this organization of the design activities emphasizes the unique position of making and trying out prototypes, as being a result and enabler of the three activity loops, as depicted in Fig. 2.

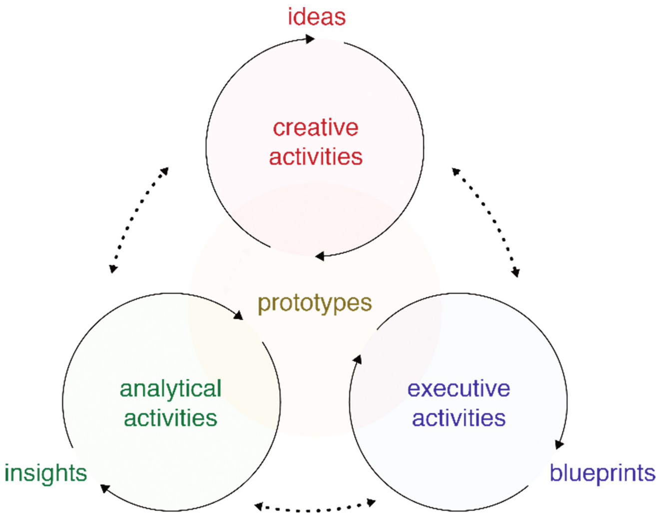


Fig. 2. Iterative, prototype-centric design process can be depicted as three independent activity loops bound together by affecting and being affected by prototypes.

The above work-in-progress model has given us a new framing to reflect on the organization of a design process, which we have been practicing in much of our education and design activities.

3 Approach

The proposed model for prototype-centric iterative designing is based on experience from a wide range of courses and workshops organized by us, as well as many other design processes inspired by the maker culture. We encourage frequent iterations across context researching, conceptualizing and implementing, as well as fast iterations within each one of the above as a way to increase the diversity and novelty of produced outcomes. To support this way of working we have appropriated and developed a number of techniques and methods, each of which aims at accelerating a particular kind of iteration in the design process.

Our "make-first" approach focuses on the early moments in the design process. It involves a short but intense hacking workshop, in which designers are required to build a simple interactive prototype, answering a simple brief loosely related to their main assignment and are steered to do it without overthinking the purpose of the prototype. The purpose of this activity is to learn that technology can inspire ideas, and having a concrete idea can be useful in focusing initial context research.

For designers with little technology experience, making interactive prototypes is a big challenge, requiring large investment of time, and often also money and other resources. We use a number of techniques to avoid "prototype love" - the particular type of fixation triggered by loss aversion, and to encourage developing prototypes in an explorative way. The iconic Arduino platform and the community of its users support fast interactive prototyping, but in our experience it is not sufficient on its own, especially for novice interaction designers. This is mainly due to the difficulty in understanding programming and electronics. To remove those obstacles, we provide designers with a wide range of modular electronic components, which allow them to prototype with only basic understanding of electronics. Having a stock of electronic components readily available as modules, which can be used without extra costs and without having to wait for an order, and re-used when the prototype is disassembled reduces loss aversion and helps designers in ad-hoc trial and error prototyping. We also provide designers with a short practical introduction to finding online examples of code-snippets and making prototypes through creative mashing up of existing code. We also support fast prototyping of embodiments by ensuring designers obtain basic 3d modelling skills and throughout the design process have walk-in access to rapid prototyping facilities such as 3d printers and laser cutters, as well as collections of a variety of scrap materials that can be easily repurposed for use in prototypes without extra costs or effort.

Nonetheless, in many situations making fully operational prototypes is still time and energy consuming. During the course of the project we introduce designers to a variety of methods that support evaluation and exploration of the envisioned interactive experiences with unfinished prototypes, or even without prototypes at all. Enactments allow designers to explore and communicate interactions without a prototype, and gradually introduce mock-ups and half-working prototypes. They also allow understanding of interaction styles, first explored in human-human communication and later translated to device-human interaction. We also encourage Wizard-of-Oz simulation of not implemented features during user tests and enactments.

Although the approach can apply to individual projects, work described in this paper has been done by groups, where individuals are encouraged to specialize in a particular design activity, or tasks such as managing the process or communication that involve dealing with all design activities.

The brief of the design assignment has been deliberately open, indicating context and challenge, but leaving room for interpretation in order to stimulate critical thinking and stimulate explorative research. We encourage designers to revise their understanding of the design challenge throughout the entire design process. However, many design research methods are time consuming, which makes it difficult to embed them in a highly iterative design process. Therefore, in the process of defining and evaluating ideas, we promote informal user tests [6].

Progress cards (Fig. 3) are a format for designers to shortly and informally report and reflect on the project progress on a daily basis. Each card has to include a central picture of a prototype, a list of "victories" and "defeats" of in the process from that day, a one-sentence description of the latest version of the design, and in the last version of the format, also a simplified process diagram (Fig. 2) indicating the journey through particular design activities which took place in the reflected day. Progress cards push designers to regularly reflect on their ("doing" as well as "thinking") actions [12] providing valuable learning and self-improvement moment. They also provide coaches with an easy to follow overview of the design process.

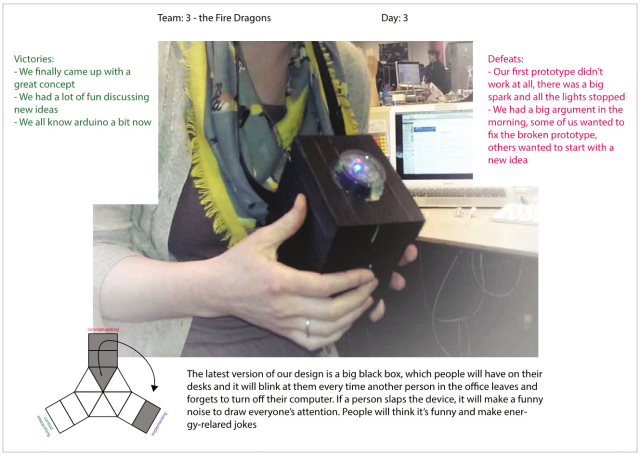


Fig. 3. A progress card required to be filled at the end of each day encouraged designers to reflect on their process and provided process documentation for further research.

When designers are encouraged to start prototyping early, there is an increased risk of fixation on early design ideas and technological solutions. To encourage design concept revisions, we implement "forced iterations" meaning that there are intermediate presentations, where a fully experiential prototype needs to be demonstrated and explained, and following this presentation, aspects of the design indicated by the jury are required to be changed.

4 Case Studies

In this paper we present two examples from two recent IxD courses organized according to presented approach. We use the presented model to reflect on projects from these courses.

4.1 Project Setup

The first case is a large IxD course called Interactive Technology Design (ITD) [2] taught to 1st year Design for Interaction Master of Science students at the TU Delft faculty of Industrial Design Engineering, in the Netherlands. It is a large 6EC course followed by 108 students in the spring semester of 2015 when described case took place. In this course students work on a design assignment as a group of 4–5 members. The workload of the course is one day per week spread throughout an entire semester, accumulating 20 workdays. In this case students have prior knowledge of interaction design, design research and product engineering, but may not be accustomed to working in an explorative way and to prototyping with interactive technology. In ITD design briefs given to students vary. In this paper we focus on the work of 4 groups, which have been following the "office energy coaches" brief.

The second case is a 10-day IxD workshop we have organized at a Tongji University College for Design and Innovation. The workshop involved 50 participants from across China, mainly university students from design or engineering faculties or university teachers. Chinese students have been given the same brief as the ITD students. However, in this case the students had less IxD experience, they had no time to improve their skills between design session days and we faced a communication barrier.

4.2 Office Energy Coaches Design Brief

The design brief given to students in both cases varied only slightly. The brief has been inspired by the research project in which the first author is involved. The brief dubbed "energy feedback objects" in the ITD context was renamed to "energy coaches" in the Chinese workshop context, while retaining the assignment largely unchanged.

In both cases participants were requested to design a device that provides feedback about energy use and coaches office workers to make their work environment more energy-efficient. At the same time, the coaching also had to help office workers to make their office more comfortable to work in. In the design brief the standpoint was emphasized that in order to make people comfortable and energy-conscious, their control of the office environment cannot be decreased, hence removing building automation from the range of possible solutions. On the other hand, solutions that increase office worker's energy awareness beyond the office context were encouraged. A number of research examples [12] were used to indicate the direction in which students were encouraged to seek for solutions.

4.3 Design Process Evaluation Method

In both cases, the design process of the projects has been monitored through evaluation of progress cards and other deliverables submitted in the course of the design process, including short textual descriptions, storyboards, videos of interactions enactments, technical documentation, process pictures and notes of the project coaches. The evaluation has been performed in a data analysis session with research staff, which involved hanging all printed progress cards of compared projects in horizontal, aligned timelines, and based on other observation materials adding relevant information.

5 ITD Case

5.1 Project Setup

The ITD course follows a program of 5 main phases dubbed "rough", "standalone", "nutcracking", "users", and "integration". The "rough" phase is a hacking exercise where students transform a simple interactive Simon game with open source code into a new prototype that fits into their design brief. The purpose of this exercise is to acquaint students with explorative use of technology and show how quickly new ideas can be generated through prototyping. The following "standalone" phase lasts for 3 course workdays and requires students to develop a concept and build a partially working prototype of it. The "nut-cracking" phase lasts for 5 course workdays and aims at revising and developing in the prototype the most difficult challenges of the concept. During the 2 workday "users" phase students prepare and execute a more elaborate user test. The "integration" phase lasts for 7 course workdays and ends with the exhibition of all projects, which students are encouraged to approach as a final user test. Throughout the course students work in groups of 4–5 members. During the project they are encouraged to take different roles in their team, with focus on conceptualizing, engineering, constructing, communicating and management in the project. They are also encouraged to publish their progress on a private blog, part of the education web platform called Projectcamp.us. Next to it, they are also required to submit a progress card at the end of each workday. The format of progress cards in the ITD project did not yet include marking the progress on the process diagram. While given the design brief, each group in ITD was provided with a different context of use. The contexts included a two-person office, an open office, a studio space, and a large presentation room.

5.2 Example Design Process – Volt

Volt is one of the four ITD projects that followed the "energy feedback objects" brief and was designed for the open office context, and provides an example of a process followed by all other groups. The initial idea of the group during the fast rough phase was to motivate office workers to turn off all lights in the room by unlocking a reward when the last person leaving turns off the last switch. During the standalone phase the new idea was proposed for a "Furry Mothersocket", a creature-like power cord that gets upset and expresses anger at office workers when devices connected to it use too much energy, which later developed to a less literal design metaphor. In the "nutcracking" phase the idea of a power socket has been kept, but the interaction concept has been changed to trigger the practice of sharing of power between different users, in a playful way provoking the discussion on the energy consumption and thereby increasing people's awareness of their energy consumption. The concept has been further explored in the nut-cracking phase as a device balancing on its middle with four power outlets. The prototype was initially made using four bottles taped together (Fig. 4).

In the integration phase a thermoformed plastic embodiment was made filled with free flowing powder material for haptic feedback. Electronic components for measuring power consumption were left outside of the prototype and kept under the table, which was encouraged, as it did not affect the experience of the product and would have caused safety issues if embedded in the prototype (Fig. 5).

At the start of the focused user test, two plugs on the device were working. The users would only be able to use electricity for a short time before power in their socket would be cut off. To get electricity flowing again, they would need to tilt their device their way, "taking" the energy away from the other user. Although the prototype was "ridden with bugs", the test gave many new insights in respect to interaction modalities with the prototype, as users were "more likely to tap, swipe or knock on the prototype than tilt it". Users also started to play with each other's energy as a form of a social game.

Fig. 4. Progress cards of the Volt project show substantial exploration in the first 6 project days, and incremental improvements over the rest of the project.

Fig. 5. Final version of Volt during the exhibition provided a complete experience of using the product in an office setting by a high-fidelity prototype with all features operational.

The insights have led to the next redesign of a 3-socket device without the tipping point and with a chain of 6 LEDs per side, lighting up with different colors and patterns based on user actions with the prototype. The final exhibition was set to resemble a coffee bar, signifying the student's reinterpretation of the open office context as an ad-hoc co-working environment. The interaction with the prototype during the exhibition was intuitive and the project has gained high acclaim.

5.3 Comparison of Projects

Other projects developed in the ITD energy feedback objects brief were very diverse. One project developed chairs for presentation room that provide individual heating or cooling triggered by gentle rubbing of the chair sides and encourage clustering of audience. Another project developed control devices for studio office spaces that could be described as “a remote control for lights in the room with a soul and moods of its own”, by which care and compassion for the room’s energy use was elicited. The fourth project resulted in a feedback device placed on a wall that through an intricate diaphragm mechanism could express different emotions, for example becoming angry if one of the office workers would leave the office leaving the light on. At the same time the device also offered precise feedback on energy consumption and allowed users to indicate planned energy use for the day by rotating the body of the device (Fig. 6).

Fig. 6. Three energy feedback object projects of ITD show the diversity of the kinds of final solutions that the different teams converged on.

Both similarities, as well as differences in the design processes were identified. The “standalone” phase was the most explorative part. In all cases the essence of the concept presented at the end of the “standalone” phase was kept until the end of the project. However, throughout the entire process all groups continued coming up with new ideas about the details of the product, and about the interaction with the products.

All groups also had a tendency to focus their attention on the making process. It often required a design coach to make the group aware of simple improvement to the design concept, while the group was mostly busy solving technical details not critical to the project's experience. For example, one group's concept involved creation of a feedback device to be placed on the wall of a small office. The group has decided early on in the process to use a diaphragm to express the emotion of the device. However, despite its aesthetic qualities the expression of the diaphragm was not well received during tests. Despite this, the group remained invested in the idea and did not give it up, nor organize further user tests to explore alternatives.

On the other hand, another group designed chairs for the lecture room that could be individually controlled and attract people to cluster around each other. The concept was formulated early on in the design process and gained support from coaches and reviewers, however the group has failed for a long time to make a working prototype, continuously exploring alternatives, and only managing to take decisions and accelerating the prototyping process in the last two weeks before the end of the course.

6 Tongji IxD Summer School Case

6.1 Project Setup

The Tongji IxD Summer School has been organized as a two-week, hands-on introduction course to interaction design. It involved students from a variety of Chinese universities, recent university graduates and several university teachers. Participants had their backgrounds in a wide variety of design and engineering disciplines, and little or no experience with IxD. There were three main phases organized in the course. The first phase was set to deliver a rough concept through enactment, the second was aimed to deliver a sketchy prototype and a video, the third – a fully autonomous, working prototype, a video showing the interactive experience, an A1 poster describing the challenge and product and a pitch presentation. Throughout the Summer School many lectures and exercises were provided to introduce students to various IxD methods and techniques, as well as to teach them prototyping with technology.

Students worked in 10 groups of 5 participants. Each group was assigned with a brief to design for an office located within close proximity to the workshop location, and was provided with an emotion keyword describing an interaction style to be the starting point of their ideation. The design brief required students to design an interactive device that would make office workers more aware on the impact of their practices on energy consumptions and at the same time help them improving comfort at the office and reduce energy use. The students were encouraged to reinterpret this brief throughout the course of the workshop.

At the outset of the project we were anticipating communication problems between local students and non-Chinese speaking coaches. We have emphasized that using the prototype or an enactment can help with communication. Considering the short time frame, less skills of participants and no time between design sessions for individuals to improve specific skills, we were initially expecting much less elaborate results than in the ITD case.

6.2 Process Example – Tired Lamp

The design process of the “Tired Lamp” was similar to all other projects in the Summer School workshop. The process started with the introduction of the brief. The group was assigned to the “sad” emotion of the initially to be explored interaction style and to the context of one of the offices at the university. The students visited the assigned office and after observing and interviewing office workers they have decided to focus their design on office lighting. On the second day they have decided on the general concept, which can be summarized as a lamp becoming “sad” when it’s being used too much, but which can be comforted by users to brighten it up. In this way, they aimed to achieve more awareness of the energy consumption among workers in the office. The first idea to achieve this goal was a face projected by the light on the desk, reflecting the light’s emotional state. The group explored this idea by making storyboards and performing improvised enactments in the first phase (Fig. 7).

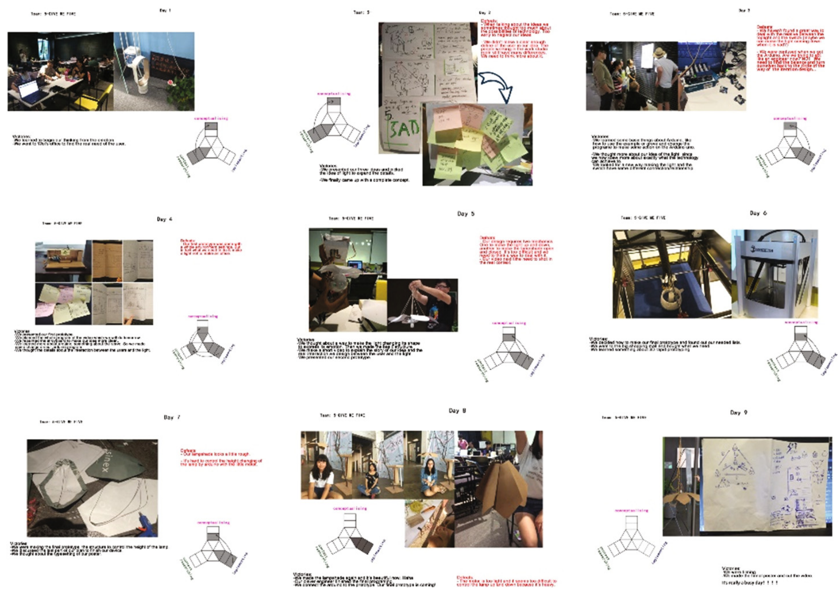


Fig. 7. Progress cards of the “Tired lamp project” showed that the first phase was dominated by “understanding” activities, the third phase by “implementing” while “ideating” took place all along.

During the second phase, the concept was initially simplified with just the brightness of the office light as actuation, while typical light switches were used for input. In the course of the process students kept adjusting their design based on feedback from other students and coaches reacting to their improvised prototypes. They have decided to integrate all the interaction in the lamp object and design the lamp in a way that would resemble a flower opening and closing up. This led to another idea of involving user input in the form of “comforting strokes”. At the start of day 6 the designed experience was presented in a video using mostly Wizard-of-Oz technique. In the following days students have explored various mechanisms and materials that could be used to build the lamp. They have repurposed an umbrella mechanism in a way that also allowed moving the entire lamp up and down. Through informal user tests, students realized that such motion enhanced the interactive experience, by only allowing the light to be comforted and drawing attention of the users in its “tired”, “sad” state.

The prototype has led students to explore a variety of comforting gestures to be used on the lamp “petals”. For the final prototype, capacitive touch sensors embedded in petals were chosen, as they would trigger even with a very gentle touch. A stepper motor was used to control the light position and degree of opening. On the last day the focus of the group was split on preparing communication of the concept and finalizing the prototype, which included many refinements to the behavior and continuous informal user tests by designers themselves and other students. During the final presentation on day 10 the project gained positive feedback from exhibition visitors, although the interaction with the petals required initial instructions (Fig. 8).

Fig. 8. The final prototype of the “Tired lamp” had many qualities of a finished interactive product.

6.3 Comparison of Projects

There has been large variety among the Summer School projects. Some projects stood out by showing sensitivity to the context and innovative ideas. Among those was the “Power mosquito” which created a “virtual mosquito” moving through the office table using LEDs and buzzers. The mosquito would appear when the energy was being wasted, and required users to slap the current location of the mosquito to turn it off and turn the unused lights off at the same time. Another project designed an AC remote control with features resembling an artificial creature, which through emitted light and sound would appear stressed and show it by mimicking increasing heartbeat. Eventually, when the temperature would be set very low, it would stop and briefly produce a heartbeat flat-line sound. Other projects included office nap and relaxation assistants, visitor welcoming devices, or solutions to involve security staff in providing energy-related feedback to office users.

In the course of the Summer School we have noticed most students were having a difficulty in gaining insights into context that would go deeper than initial assumptions coming from the first observation round. For example, one group started the project by interviewing a security worker. They understood from the interview that many security workers are bored during their work, are lonely at work and don't feel any connection to the people working in the building they guard. Following this interview, the group kept coming up with ideas for entertaining security workers, while these ideas did not follow the design brief. It required several coaching sessions to make the group understand that a good design would entertain the security guard, while supporting him to take actions that would help office workers in saving energy, and providing him with more self-esteem. Still the group failed to understand and involve the many design aspects in which the relationship between the security guard and office workers could be supported in a meaningful way by an interactive product.

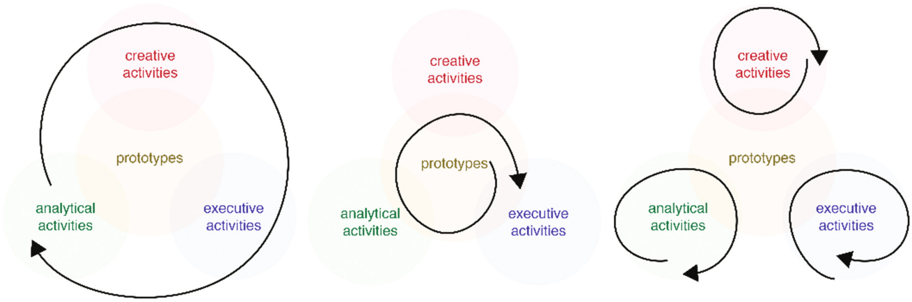
On the other hand, despite limitations of available technology, skills and time, groups have managed to reach a high diversity, originality and intricacy of the products. To the satisfaction of designers, several products, such as the napping pillow or the tired lamp triggered questions from the exhibition visitors about when the products could be brought to market.

7 Reflection

The contexts of the ITD Energy Feedback Objects projects and the Tongji IxD Summer School were very different. However, comparing the projects from those two contexts reveals many similarities. This allows us to draw several conclusions on the iterative prototyping approach we have used to organize both activities.

In all project cases the general design concept was defined within the first quarter of the project. Later revisions of the concept were sometimes encouraged, but never happened. In most cases we have observed a gradual increase of conceptualization focus on details throughout the entire process. We generally saw value in such process, although it has sometimes led to fixation on concepts despite user tests indicating that the concept doesn't work as intended and a different concept could have been more useful. We expect parallel prototyping [5] to be an alternative approach to promote more explorative attitude, and we aim to incorporate it into our approach in the future.

On the other hand, several groups encountered problems with not being able to decide on a specific concept direction and to begin prototyping. They felt the concept is "not good enough" and it would be impossible to change it once prototyping starts. Generally, we encountered this situation in groups that were less technically apt, and we may conclude that easier to use prototyping tools could have helped these groups to start iterating between prototyping and more abstract reflecting. Figure 9 illustrates the two described situations using the iterative design process diagram. Whereas in the first case students find it difficult to reflect more generally and in a more abstract way while they start prototyping (Fig. 9b), in the second case too much abstract thinking creates a barrier to start prototyping activities (Fig. 9a). Unstructured interviews with selected participants have revealed that some aspects of above fixations can be attributed to loss aversion related to the prototypes. This either was a result of resistance to commit time and energy to developing a technological prototype that may not be the final one, not wanting to discard a prototype that has taken substantial amount of time and energy to create, or only one group member developing the prototyping skills, causing separation of tasks and reducing communication in the group when under time-stress. Use of modular electronics and premade code templates has partially mitigated the above problems by reducing the time and skills needed to prototype with technology. However, further reduction of the technological skill-related prototyping obstacles would have clearly improved the analyzed design processes.



a. b. c.

Fig. 9. The prototype-centric framing has revealed forms of fixation such as iterating across activities while avoiding to prototype (a), only prototyping without generating insights, new ideas and blueprints (b) and isolated iterations by not-communicating team members (c).

Other situations where lack of communication across individuals performing different design activities were especially apparent occurred mainly in the later stages of the projects (as illustrated by Fig. 9c). One of the common patterns was that an engineer would underestimate the time needed to implement designed feature, and would largely modify the interaction while implementing it. On the other hand, other members of the group, waiting impatiently for the engineer to finish, would continue revising user experience ideas, and prepare documentation based on earlier versions. To counteract such situations, lessons from agile methods can be drawn. Enforcing daily working builds in the future may help students to develop only features needed by others and may help in reducing the unnecessary complexity of the design.

Another encountered problem has been the limited scope of performed analytical activities. The focus in both courses was on learning technology and experiential prototyping. Yet, we expected designers to use the prototypes to gain deep insights from the design context by using the prototypes. We have observed that with every research iteration new research questions were formulated and student didn't have enough time to answer them in-depth. To resolve this problem and take advantage of the research opportunities in an iterative designing process, we aim to identify and adopt appropriate methods to encourage formulation of research questions that span across multiple research iterations and how more research rigor can be introduced to the process without causing additional delays.

8 Conclusions

The two presented projects show how the prototype-centric iterative IxD approach can be applied in different project setups and how it succeeds in obtaining fast, experiential and rich results. We acknowledge the fact that analytical activities in such processes need to be supported in a better way and we are looking for appropriate methods. By reflecting on the process with help of progress cards and the preliminary version of the prototype-centric framing, we have noticed several patterns where groups would be stuck in a particular kind of iteration that does not cover the entire spectrum of the process, most significantly in executive activities there was a tendency to themselves from other activities. Similarly, students would also experience “being stuck” in the making or thinking across different activities. We acknowledge that better techniques need to be developed to encourage stepping out and in to the prototyping activity. Nonetheless, in all cases the quality of end results has surpassed our expectations and has been very well evaluated by external reviewers. Most significantly, the projects developed in both cases required little explanation to be understood by the public. In most cases the experience of interacting with the prototypes has been sufficient to understand the intention of the product.

Overall we have observed that our approach suits the IxD education context very well. Despite a few shortcomings, both cases have delivered a large variety of relevant concepts accompanied by experiential prototypes. Yet, perhaps the most significant outcome of the projects was the enthusiasm of participating students, who have provided with very positive feedback at the end of the course, and many of them expressed eagerness to continue working on the projects after the course was finished.

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