The incorporation of User Centered Design and Industrial design

戴峥 Zheng Dai
Mads Clausen Institute
University of Southern Denmark
Alsion 2, Sønderborg, Denmark
+45 60728081 twindai@gmail.com

Ólafur Ómarsson
Industrial Designer
221 Hafnarfjordur,
Iceland
oli@omarsson.com

Abstract: **Traditional Industrial Design (TID) has been an important aspect in the NPD process since last decades. User centered design (UCD) is a growing research field for product innovation start from the end of 20th century. An NPD process needs support from both design knowledge and research methodologies. Both TID and UCD focus on user's perspective when multi-disciplinary work together. They provide skills and method for designing the style and usability, and balancing user need and reality. The skills from TID help design expression and realization to communicate efficiently with other participants by vivid pictures and real prototypes. The skills from UCD help idea generation and opportunity finding by holding workshop and interview with participants. TID and UCD represent different perspectives of the subjective and the objective respectively. Their methodologies is the essential for designer carry out the design solution, and at the same time the project improves the methodologies of TID and UCD through a reflection process.**

Keywords: UCD; Industrial Design; Product development

I. INTRODUCTION

As industrial designers, we have several years' experience in tangible product design. Through our design practice in New Product Development (NPD) projects, We feel the advantage of industrial design is to think from User's perspective. That leads us to make a deeper study in User Centered Design (UCD). The study of UCD has granted us a new vision and understanding about New Product Development (NPD).

At the same time, the knowledge of UCD and TID gives designer abundant methodology and skills to research, organize, create, reflect, design, and communicate. All the abilities are mixed together so that it is easy to confuse a designer when choosing and applying the abilities in his arsenal, which can match any given situation. For better apply the knowledge form UCD and Traditional Industrial Design (TID). We will describe and analysis these two fields.

From our perspective, the goal of the NPD process is to build a product which is meaningful to user with higher quality and value. Or based on an existing product to improve the overall competency and add new function. UCD and TID are necessary to reach this goal. In this paper we will present our understanding and experience of using the method and skills from UCD and TID for in NPD projects, and feedback and reflection from the customer and development group. To figure out the role and contribution of UCD and TID in NPD project, we list following points. They are the fundamental of the incorporation between TID and UCD.

A. Multiple-disciplinary

In the NPD projects that we have participated, they mixed variety of disciplines, which include industrial design, mechanical design, marketing plan, electronics, software development and advertisement. They could be put in to three categories: Technical, Marketing, and Design. Comparing with the other two aspects, the most of our colleagues agree that the contribution of design is to guide project involve plentiful user's perspective and turn their needs to real and practical solution. At the same time, for carry out a more successful and meaningful product, the TID needs technical engineer to tell the realization possibilities and market specialist to see the market scale. This point also fit the principle of UCD that needs to involve all projects participants. When a project involves UCD, all members need basic training of UCD, and participate in the workshop together to generate idea and make decision.

B. Innovation and dynamic

The innovative is one of the essential properties to a NPD project, and there is a trend direct to integrate customer in the development process and to enhance the aspect of multidisciplinary. [4] That developer has to do abundant research and investigation on a new topic which less people are familiar. This innovative property leads project has higher risk by lots of complex and uncertainty. [7] Mathiassen and Stage discussed on this issue and propose to use experimental method to solve uncertainty and to use analytical way to reduce complexity. [7] In his book, Larman suggested that to use agile and iterative method to plan and carry out an innovative project dynamically. [6] Aiming for solving uncertainty and complexity, UCD and TID provide the methodology of analytical and experimental respectively. And follow the principle of plan based on iterative process

C. Emotion and reason

User research contributes to the development of methods target at the identification and recognition of user needs and its use in the concepts generation. [10][9] This process figures out to a more considerable role of emotion aspects in the context of user behavior. There is thus a need for methods that acknowledge both reason and emotion in decision-making processes, and enable user to represent their emotions, feelings and experiences towards products.[10][8] TID has a fundamental theory that is product design should be the balance between emotion and reason. As the Bauhaus's slogan said "Art and Technology - a New Unity" [11] At this point UCD is a balance between user need and practical product. It is not only follow user's wishes, but find out the most practical and efficient design opportunity.

D. Reflection

The iterative process needs the reflection from phase to phase. Schön mentioned that the practitioner get reflection-in-action, and get reflection–on-action afterwards. [12] Especially to the designers, the reflection is a basic power for practitioner to undertake next action in a process. According to the context, developers need to change, choose, and even develop the right methodologies, to design an effective process or research, and to optimize the next process by reflecting on previous project. [5] The theory of TID includes design process and design methodology, which can be seen as a cycle and can evolve through the reflection. In this process, UCD collect the feedback from user in every step, it can be seen as a reflection-on-action from user. UCD give user a space and time to tell their dynamic feeling and experience in the process.

II. The necessary of TID

A. TID provides creativity

From our previous projects, we feel that in a user-driven project, TID helps to define the direction of the project from the start of project. [1] For not limit the possibility of the end product, it needs strong creativity and large space to imagine and to make connection between design materials. [2][3] Even in a technical driven project, TID provide creativity to help developer escape from the limitation by focusing on the final goal and by thinking about alternative solution.

The basic purpose of applying TID is to execute a design solution by using a specific approach for realization. But the effect of TID can be larger and influence the whole process and project direction. Especially, when development team meets an abstruse problem or an accidental matter, the way of design thinking could avoid going on the difficult way. From design perspective, industrial designers could foresee the degree of difficulty and the level of meaning of the product definition. They also always provide several design concepts as backup solution to reduce the risk of one way plan.

B. TID connects concept to actuality

From our experience, there are two typical scenarios in the design process which leads to low user satisfaction. One of the scenarios is a clients'-driven process: At the beginning of a design project, the clients define the concept of the product, and they require the designer works out and realize the concluded product form and function. Then they control any changes of the design concept through the whole project, and insist on their feeling and vision to the product. The clients may collect users' and customers' thought, and turn part of their ideas into the design concept. However the problem is many of this kind of clients normally accept less advice from designer and develop team. Because they feel the user research and marketing investigation are enough to define the product concept.

To deal with the issue in this scenario, TID is aiming for balancing between emotion and reason, and bridging user and technology. In the practices, an industrial designer at least needs to work with a mechanical designer. They discuss the possibility of form and style, and feed into some new and useful function. Industrial designers are not end user, but they think from users' perspective. Mechanical designers are not manufactures, but they carry out engineering files which can be produced out directly. These two roles reduce the gap between user and product. But there must be some fall between user's imaginary and technology limitation.

III. Inducting UCD

A. UCD and participatory innovation

Another scenario is the developer-driven process: In this case developer-driven means a closed development environment which developers accept less advice from clients, users, and customers. Some of this kind of projects starts by clients defines the design concept, and in the later stages, the design decision is end up by developer group. The final result may still in the range of the project specification but it reduce or has less users' satisfaction.

Because the NPD process is a cooperation of multiple-disciplinary, it needs some knowledge and method to balance different inputs which are origin from multiple-disciplinary knowledge and real-life experience. Basically there are three groups give the inputs: the clients, the developer, and the user. Each of the group has their own vision to the design. Some is clear and some is vague. We should respect these design visions, considerate them together to balance these input.

To facilitate the balance, the developers need to get the training to study and to practice this balance in design process. Participatory Design and UCD involve all stakeholders into the project, and make them speak out their feeling and suggestion, and allow them participate into the decision making process. It is a process management method

and system to ensure the development cycle is healthy and balanced.

B. *UCD is a dynamic reflection*

Normally, in a NPD process, UCD is aiming for the step that just before TID. To compare with TID, UCD is focusing more on field investigation, user research, user reflection, organizing participants, and the management of development process. Depending on context of each project, the developer needs to make a niche targeting plan, to design the process, and to choose the methodology for user research. Especially in the later iterative step in the process cycle that got a turn of user's feedback, UCD facilitator needs to adjust method or redesign the UCD plan, which forms a dynamic process. This feature make UCD follow the theory that reflection on action, which fit the needs of NPD and will improve its quality.

IV. SUBJECTIVE AND OBJECTIVE IN NPD

A. *TID and the subjective*

NPD is a process that needs to combine both subjective thinking and objective thinking. To fulfill the goal of NPD project, the research of market trend and target users' context will tell you the design opportunity and guide the project direction. The investigation of current practical technology which is available on the market will put the project practical and cut impossible ideas or give more space to new ideas.

Based on the research and the investigation, TID has ability to translate users' expectation to a design concept, and has ability to know and study the application and integration of a technology to a project goal. After the analysis of objective information, TID undertake a subjective design behavior to create and build design concept to surprise user, and improve user experience.

B. *UCD and the objective*

However the subjective design behavior is not the exclusive and only step for designing concept. UCD is also taking charge of the integration of the users' and participants' ideas into a product by objective methodologies and principles. NPD process is not a process to create an artwork. The developer should not just follow the feeling and flow of artistic and subjective expression. There is risk if only follow the subjective thinking, because a basic part of the knowledge and education in TID has come from the art field. To an industrial designer, the type of ideation and the way of solving problems follow the principle that combing the emotional and rational ways. Depends on scenarios, topic, and issues the industrial designer could choose either a user-based or tech-based principle to make the product have a particular feature. A designer can also explore value from artistic perspective or from functional perspective to increase the competency of the final product.

C. *Uncertainty and complexity*

Furthermore, as we mentioned in the beginning, NPD is a highly innovative process which includes mass uncertainty and complexity. As Mathiassen analyzed, this two issues are mixed together and they needs experimental method and analytical method respectively to solve. [7] But when people solve them, the countermeasure for each one would increase the issue for another. Plenty of research and analysis would be helpful for complexity issues, and a variety of experiments and prototypes would take valuable knowledge for the unpredictable issues. [7]

UCD takes analytical method into this process of problem solving with objective perspective. It performs subjective research and investigation to collect information for later analysis which includes both qualitative and quantitative method. This work resolves complex issues in to small segments, and puts them into clear category, and then carries out a framework to put segments into it. This framework works as a plan but not too detailed, because it can be adjust in later iteration dynamically.

TID takes experimental method into the process of problem solving with subjective attitude. It undertakes objective creation by reflection in action to produce design concept for later experimental by prototype test. This work deals with uncertainty issues by trying some ideas and concepts, of which the method includes suppose, inference, and establish connection. Then designer gives evaluation, and test to these concepts to reduce the uncertainty and filter out the possible directions. This is a subjective process through an individual design action.

To demonstrate how we apply these knowledge and analysis in real project we will show a real project in the next part.

V. CASE STUDY: ROWING TRAINING SYSTEM

A. *Case introduction*

This project was about a Rowing Training System with the goal of developing a device that could assist professional rowers train and compete. In this project team we had a User Center Designer, Industrial Designer, and an Electronic Engineer. Danske Studenters Roklub (DSR) and Sønderborg Rowing Club (SRC) were also involved in this development. We planned a user study process with several iterations, which was following the guide of iterative methods from Larman.[6] After each iteration, we had feedback from user and reflection on action. We turned these feedback and reflections to the next the next iteration.

The whole process included three parts: an interview and investigation phase for user study, several lead user feedback phases, and an open exhibition phase for ordinary user. We put a lot of focus on organizing and planning the user study workshops, and from the result, we tried to provide the user a new experience by integrating user's ideas and available technology together to make a workable prototype. Through the project, we were always careful about two correspondences. At first, we tried to keep correspondence between the inputs from different stakeholders. Secondly we tried to get correspondence between user research and physical prototyping.

B. Conduct a user research

For the start of user research, we chose to get some interviews and held a workshop with lead users. The interviews helped us understand an opinion or idea more deeply and workshop could inspire ideas between participants. Before these interviews, we needed to understand and analyze the role of each interviewee and the relation between them.

Besides the lead user group, we also tried to involve some common and ordinary users. As more user would extend the ideas and inputs. However that could make the analysis more complicate because of mass and conflict materials. We treat the extended material as another group which is used to compare with original material to evaluate the quality of each concept. The common interest is biggest design opportunity and that should be direction of the project.

C. Mass inputs

DSR and SRC gave us a wide range idea and concept about their needs. They show the vision and possibility of the final design. We were very confused about these mass inputs, because they were conflict to each other. Some users expected we can provide a tiny and wireless device that can be worn on the arm and the leg. Someone users expected we can improve the rowing machine Concept2 [14] which they just bought recently. At the beginning, it was so difficult to give up any ideas that we collected from the users. Thus, we were back to a research in papers and made a selection to these inputs. Some papers suggested that the users' and experts' vision should be integrated with the designer's vision. [13] Following these papers, we thought that as the core developer, we should follow our design vision and interest to be sure we kept our enthusiastic on the goal. However in a UCD process, the designers should be complying with and regarding to the users' input. We didn't want to make the decisions by ourselves, as we were afraid our vision is too objectively and too narrow. Therefore, we held a meeting with some stakeholders and review the user inputs together. We treated the common interest as our biggest design opportunity. Finally, we choose the idea that showing a real-time motion trace to the rower.

D. Research and prototyping

The practice in this Rowing Training System project made us find that we need to keep the correspondence between user research and physical prototyping. This correspondence improves the quality of the result and the meaning to the user. We tried to investigate in the current technologies. We believed that user research and physical prototyping should enhance each other in a balancing way. After a deeper user research we could get the idea to put into the physical. And a high quality physical prototype with more idea could make us acquire more useful feedback efficiently during the user research.

E. The process of adding functions

Because we have confidence on the concepts prototyping skills which are from industrial design education, we made a full size wooden rowing machine, and programmed a user interface by Adobe Flash [15] to shows the motion trace on computer screen which is captured from the motion of the rower's hand. (fig 1)

Figure 1. User interface of the Rowing system on computer

The physical tangible and interactive prototype made our user speak out their truly feeling about the motion capturing feedback in a real-time. The user from DSR told us the action of the hand is the one of most important factors in a single competition. But they also need to participate in team row competitions which consist of two or four rowers. The most important to team rowing is rhythm. This point guides us to design a function that could remember the action from the coach, and then, each rower from the team can practice by matching the coach's motion to study the same movement as other teammates. Our prototype at this step gave us a success in the open exhibition workshop (fig 2) which was for the testing from ordinary rowers. Mainly of the tester was from SRC. The purpose of the exhibition was to collect the ordinary users' feedback which may different from lead user. E.g. someone suggested us should display some key points of the motion, that will indicate the time difference between each two points. This need was aiming for rhythm training.

Figure 2. The test of towing machine prototype at an exhibition workshop

VI. FILTERING IDEAS

We had a reflection on action as following analysis: From this project, we could also find that UCD process is not only complying with user's input, but also a process of filtering out the most possible design opportunity from mass materials. It is also an open collaborated process which makes decision in each step for the next iteration, with dynamic event driven.[16]

A. *Inputs groups*

In this Rowing Training System project, we could find that there were three participants groups: DSR was the lead user group, and SRC was common rowers. We were the design and technology consultancy. At last, we had a project facilitator and investor. At the beginning we was afraid that too many materials would come from these three groups and that would make us confuse.

B. *The richness of material*

We filtered out the inputs by following Buur and Binder's book "User Centred Product Design". [16] The inputs group had different role in the project. They also should get and share knowledge with other groups. We could see that a workshop was an effective way to transfer information between different groups. This point was descripted by Buur and Binder. [16] To compare with our experience, where they mentioned that the right degree of richness in the design materials can bridge the gaps between different workshop participants. [16] Based on this, we also found that a comprehensive interview could provide more accurately user research material to the interviewee (users). Besides users' material, the perspective from developers was also essential.

C. *consensus and interests*

In the book: "Designing Engineers", author talks about the notion of shared vision. "The process of designing is a process of achieving consensus among participants with different interests in the design". [17] Thus, in an interview session, as a UCD researcher, we should give interviewee some interesting and rich materials which are coordinate to their background to inspire them speak out their own story in a nature flow. And thus in a workshop, as the facilitator, our role was to control the time and process, and compromise the idea from every group and participant.

D. *Core user and core developer*

Another methodology to solve the mass of material was to define a core user group and a core development group, in Gulliksen's paper: *Key principle for user-centered system design* [18], the core user group was described as some highly active users, that are involved at every stage of a project, e.g. analysis, design, development and evaluation.

In the Rowing Training System project, we concentrated on the DSR and integrated some idea from SRC. The outcome was clear, and it was a stable process growing step-by-step. We believe and relay on the decisions which we made with other participant groups. It is a fairly objective and effective. The feedback from both DSR and SRC are positive. Some individual rowers are also shows great interest. Someone commented that: I would like to use this system to share the picture of my rowing motion to a friend, a coach, an experienced rower, or the members in my club.

Beside this core user group, our develop team is the core development group. That means we have right to manage, control, and make decision, rather than the investor. And we could also use some external development resource, but we keep the most development work. In some case, the project was conducted by several consultancies or several departments in a company. Normally they separate the design part, technology part, and marketing part. In this project, we took charge of both design and technology issues. The investor took charge of marketing issue.

In our development group, we choose an industrial designer as the project coordinator, because TID has quality to understand others, avoid unnecessary problems, and decrease the risk. He had the right to decide the specification for the next development step. If designer, engineer, and marketers work parallel without a coordinator, the result was difficult to integrated together and difficult to get coherence later on. Actually, in our case, the technology that engineer would like to carry out was very interesting, promising, and had tendency. But it needed pretty long time and it was hard to make any draft workable prototype for iterative testing. The Designer control the project and define that our process needed a prototype that can demonstrate the

idea, and had workable function to test even it is not stable or fat from the final product. That was because that the users would provide their feedback based on these workable prototypes.

E. Designer Contribution

TID granted us a skill to ensure the possibility of the project direction. And make the project close to the users' expectation. In the project, our designers built the tangible prototype, and designed the visible user interface in computer. These works directly communicate with users' sense. They are not abstract or nothingness. The tangible and the visible are easier attract users' attention and also inspire them to think and get the impression in the memory. User could connect abstract concept with these appreciable objects. The most important is that they can figure out their idea by point on these objects and demonstrate a process by using these objects. These objects are part of rich material for participants to express their idea and for supporting them to communicate with others.

VII. 7. CONCLUSION

As an industrial designer and a user centered designer, we can clear about our capability and competency in a NPD project. Basically industrial design grants us design expression skills which include sketching, concept prototyping, concept generation, 2D drawing, and 3D modeling. User-centered design grants us the abilities of interviewing, qualitative and quantitative researching, and organizing meetings and workshops.

Whatever kind of work designers got, these skills and abilities provide designers strong competences. In many situations, an active designer needs to have ability to handle a dialogue to present reasonable methods or express ideas by sketching fast and directly. These skills work as designers' second nature after they got them.

Whenever we reflect on methodologies and principles of TID and UCD, we could see the differences are subjective and objective. TID makes design concept from the designer himself directly. UCD collects the user's innovation and creation directly, and turn it into design concept. TID will provide the surprise and amazement to the users when they using the product. And that is contributed by designer's subjective creativeness. UCD will provide the facts of users' expectation and improve users' satisfaction. And that is contributed by user's objective feedback.

TID and UCD take charge of different balances. TID balances the art and technology, style and function, user expects and reality in a subjective perspective. UCD balances the inputs from all stakeholder and participants, and balances between the reliable plan and dynamic changes, and balances designer's vision and user's vision. These balances could make up the obvious failure in a product.

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