EMOTION ELICITING IN AFFECTIVE DESIGN

Yoke-Chin LAI
VIA University College, Denmark

ABSTRACT
A successful product needs the designer's conceptual model congruent with the user's mental model. The fundamental affective design principle also applies to assistive product design. Eliciting effectively the user's mental model has been a big challenge for most novice designers. This paper outlines the concept of an integrated design method that is developed to aid novice designer through the conceptual design stage. Multi-modal stimulation is used in this design method to induce user's emotion, a key element in the user's mental model. Visio-haptic Augmented Reality technology is integrated with 3D digital prototype as emotion stimulus. To form a closed loop reflective model, the emotion response from the user is assessed with an emotion assessment tool. Emotion ontology is established to form the backbone of the emotion assessment tool.

Keywords: Assistive product, mental model, emotional elicitation, digital prototype, visio-haptic Augmented Reality, multimodal stimulation

1   INTRODUCTION

The changing age-related demographics raise implications for altering the product demand trend in the society. This is due to the potential product consumers who may be functionally limited by age or disability increases at a dramatic rate. Along with the growing size of this user group, the quest for assistive products that are specifically designed to enhance physical, sensory and cognitive abilities of users is escalating. User's image with respect to the fear of stigma is another key success criterion that is usually overlooked. The design methods practiced in assistive product designing shall be reviewed from the user-centred perspective as the departure point.

This paper is to propose an integrated design method aiming at strengthening the learning outcome in the pedagogical dimension of a design course offered to students at the tertiary educational level. The proposed method is anticipated to be beneficial for creating assistive products that could satisfy the actual affective needs of users. This paper briefly reviews the User-Centred Design relevant methods and tools practiced by students in the design course. The designing shortcomings exhibited in the completed student projects are discussed in an attempt to outline problem areas with respect to assistive product design with focusing the actual emotional response of user. Literatures within the relevant areas including affective engineering and emotion elicitation and assessment methods are reviewed intending to portray the importance of affective needs for successful assistive products. This review lays the basis for the integrated design method proposition, which is explained in end of the paper.

2   THE DESIGN COURSE SET-UP

PUDM1 is an elective course offered in every spring semester to the 6th and 7th semester Mechanical Engineering students. The main objective of the course is to introduce user-centred design (UCD) practices to the mechanical engineering students who have acquired adequate engineering design skills in their previous semesters. The curriculum framework of the course is organized in two dimensions: 1) the skill and knowledge learned (curriculum content), and 2) the pedagogical approach (how the skill and approach is learned).

Project-based active and cooperative learning are the pedagogical approach used. Active learning is a teaching approach that involves student-student and student-teacher (facilitator) interactions in various forms to convert the learning environment from passive to active. Cooperative learning is a technique that puts students to work in teams under conditions that promote the development of teamwork skills while ensuring individual accountability for the entire assignment. Students are assigned a design

project from the beginning of the semester, which lasts for 12 weeks. The design project is divided into five assignments that combine together to form the whole project. The assignments must be completed in a successive order as the outcomes of one assignment will form the development basis for the next assignment. Each assignment is formulated mapping correspondingly to the user-centred design process: problem area defining, user's needs discovery, discovery data analysis, design exploration and prototyping, and prototype evaluation.

3 PROJECT EXPLORATION AND THE ESSENTIAL OUTCOMES

The design project assigned to the students was usually open-ended but with a specific theme, for instance "design a product that assists the mobility of the elderly". Defining an explorable problem area based on inspirations gathered from their living surroundings would be the first attempt for the students to explore the design project. Searching the web and design magazines, observing their surroundings followed by brainstorming were the most practiced methods to find inspirations. Group storytelling was also one of the approaches used by some groups to find inspirations. Failure experiences of every group member were shared within the group through storytelling. A scenario was then produced to outline a problem area. To continue the subsequent step in the conceptual design stage, i.e. analyzing user's needs, a wide range of methods were used by the students. Among these methods were interviews, questionnaire surveys, observations, role-play, persona and mood-board. Persona and mood-board were produced as the media to communicate understandings about the targeted user groups, their use-experiences and needs. A design brief that outlined the problem area and design specification was the outcome of the early design stage.

The design exploration stage started from idea generation. Idea generation was practiced following several parallel paths depending on the nature of the defined problem area. As for a project whose aim was to improve an existing product, for instance a grabber or a can-opener, students were guided to carry out a detailed evaluation on the function and usability of, at minimum, one grabber/can-opener available off-the-shelves. Several usability evaluation methods were instructed for this purpose, including Hierarchical Task Analysis (HTA), Task Analysis for Error Identification (TAFEI) and Verbal Protocol Analysis (VPA). Brainstorming or the engineering-design-oriented tool such as Morphological Analysis, were employed to generate ideas. Showing hand sketches of all of the ideas generated were demanded as a teacher-student communication means in order to gather feedback from the teacher. One final idea would be chosen using some idea/concept selection techniques such as Scorecard, Weighted Objectives table, or multi-voting.

The product development process was then carried on to the detailed design stage. Hand sketches of all of the key components of the final idea would be produced. Hand sketches showing the connecting mechanisms of the relevant moving parts (components) would be produced as the key team-centric communication means. As an alternative, digital 3D models would be generated to express the design concept using CAD software packages such as Autodesk Inventor. 3D scanning technology was not a popular alternative to produce digital models although the facility was available. Physical prototype of the whole or partial product that could enable user interface evaluation would be created using low cost and easy access materials such as cardboards, polystyrene sheet, clay, MDF and metal sheets. The last stage in the design project was prototype evaluation, which was peer-evaluated from the usability perspective in a classroom setting. Rapid prototyping technology was noticed seldom employed by the students although the facility was available and easily accessible.

4 THE MISSING ELEMENTS

The design practices performed by the students demonstrated critical shortcomings as follow:
1. Prototyping skills needed room for improvement. Creating digital 3D model using CAD software packages was the most preferred technique. This technique however demonstrated shortcoming in performing usability evaluation as user –prototype interaction was found infeasible. Students reported that physical prototype constructing was time consuming. Rapid prototyping technique was rarely chosen though available. The rapid prototyping method was reported costly by the students. The printed 3D model was usually scaled down and this has restricted its feasibility for optimal usability test.
2. Usability evaluation was inadequate. The aforementioned prototyping situations have caused the difficulty in performing effective usability test. Getting real user involved in usability test of the student project was found another challenge. For instance, a scaled model with very limited

testable functions and user-interfaces was impracticable in this respect as real user's differed from trained/experienced experts as in the focus group study.

3. User need was found not satisfactorily met. User needs were found difficult to be interpreted accurately in many of the student projects. The methods used in the user's need analysis stage were found inadequate to derive the user's actual affective needs, which are tacit. For instance, observation was remarked a subjective method that exhibited shortcoming in the user needs collecting and articulating process. The observable needs analysis could be biased by the observer's personal knowledge and experience. The interview method employed by students exhibited also pitfall with respect to unleashing the user's tacit needs. In interview, the users would tell what they want the designer (student) to hear. Under the circumstances that students were novices in the design area, being knowledgeable to ask the right questions would be a critical skill of which that the novices were lack.

5 AFFECTIVE NEEDS FOR ASSISTIVE PRODUCTS

According to [19], functionality and usability are not the only success criteria of a product but also the user's self- image. A person's self-image can be enhanced if the product is consistent with how the user perceives him/her-self and what s/he wants to be and what s/he wants to show off to others. This aspect is of particular importance in assistive product design. A product designed with taking self-image into consideration could offer a product's expression that corresponds to a user's dreams, longings, and desires to make the user regard the product as meaningful. Possessing experience of meaningfulness is essential to encourage user adoption because product as such is perceived by user useful to improve his/her quality of life.

A meaningful user experience is use-context dependent and inseparable from emotion [20]. A positive experience will cultivate a positive self-image to the user. User experience, self-image and user's emotion are the key elements in the study area of emotional affects. As reported by many emotional research literature, for instance [19, 7, 8], that emotional affects have the tendency to change cognitive processes [21] and therefore influencing how mental models are formulated, perceived and interpreted. It can change how people interact with one another as well as with products/objects.

Norman [19] suggests that the mental model of designer could differ from the one of user. A conventional design process (more accurately engineering design process) usually starts from a technical specification. In such technical description, the subjective values, such as experience and emotion, are usually not formulated explicitly. However, these values play a crucial role in providing the designer with a deeper insight and understanding of the user's experience of products. In accordance with Koskinen & Battarbee [20] that designer needs to translate user's experience and emotion into physical products. The question arises here is what approach could a designer use to translate effectively a user's experience, emotions, aspirations, goals, rituals, and values into a product that elicits positive emotional responses?

6 EMOTION ELICITING AND ASSESSMENT

In light of the significant role of affective needs, a method to capturing and translating them into relevant design attributes is of need.

Affective engineering is an approach used in the recent decades to elicit affective attributes (e.g. emotion, feeling and experience) from customer or potential user so that the affective attributes can be translated into design specification [7]. In the area of Affective Engineering, diverse techniques including self-reporting and physiological monitoring (e.g. measures of cardiovascular, electrodermal) have been explored [7,8,3] in an attempt to in assess user's emotion.

User's emotion is generated through cognition and five senses: sight, auditory, taste, smell, and touch. Pictures or photos are found in many literatures [5,8,12,3] the widely applied method for the user's emotion eliciting purposes. Those photos are usually taken from a wide collection of some existing products related to the targeted design domain. This method was employed by some project groups of the design course PUDM1 as one of the user's needs acquiring tools. The user's emotional response to the pictures was assessed at the time when the pictures were shown to the user using self-reporting tools including Self-Assessment-Manikin, Plutchik Emotion Wheel and Geneva Emotion Wheel. The emotion words in the self-reporting tools were chosen from various sources including design magazines, user interviews and emotion measuring relevant literatures such as [22, 23,24] so that they could sufficiently describe the emotional responses possibly evoked by the shown pictures. The most

used positive emotion words were joy, fascination, satisfaction, pride, hope and desire while the most common negative emotion words were boredom, dissatisfaction, shame, fear, disgust. Likert scale was one of the tools applied to interpret the subjective emotional response evaluated through the emotion words into the corresponding numerical values, which vary from for instance 0 (i.e. no affection) to 5 (i.e. high affection). The emotion assessment results were then used to find a generic trend of likeness of the relevant products.

2D picture in general exhibits a limitation: user-product interaction is restricted. The question is if the use of 2D photos could be further strengthened by some other option to access deeper of the user's expression for probing the tacit needs

Based on the experience accumulated from the design projects completed in course PUDM1, to actively engage end-user participation at the earliest design stage aiming for user's emotion acquiring, a human-product interactable prototype is essential to help designer directly observe what a user thinks or feels while the user interacting with the prototype. In view of such limitations as costly and time consuming exhibited in physical prototype construction, an interactable digital prototype could be beneficial. CAD-based digital model restricts human-prototype interactivity as most end users are usually non-experts in CAD modelling, in particular the assistive product users. The implication is exploring a new dimension for virtual model that could better elicit emotional response will be needed.

7   A PROPOSITION

Research related to augmented reality (AR) aiming at either directly or indirectly supporting interaction design has been explored and achieving varying degrees of success [1,2,15,16,17]. AR technology could augment the real-world environment with virtual models in an attempt to assist the designers to visualize and communicate their design ideas. AR-based virtual model integrated with stereographic visualization, and haptic feedback, would provide a relatively realistic interaction with the user. Virtual models enhanced with immersive and interactive sensation projecting some relevant use-contexts could better provoke emotional response when compared with the 2D photos/pictures and CAD models. The implication is visio-haptic AR-based virtual model could serve as a multi-modal stimuli and that could be an alternative applicable in assessing the intensity of user's emotion and thereby assist the users articulate their affective needs.

An ontology is defined as a formal explicit specification of a shared conceptualization [7]. Ontological modelling has contributed into design research in two main areas. It has been used to establish framework to describe the complex and contextual design knowledge. Many ontology models were developed, for instance to describe design process [10], and to structure the complex and implicit design rationale [11]. Ontologies have also been developed as computer-understandable dictionaries of the lexicon in design activities.

As designer needs to gather and understand the insight of user's activities including thoughts, feelings and personal values followed by translating them into a product (prototype) that elicits positive emotional response, a design setting that could assist unleash these affective attributes from user will be essential. Many efforts in the area with respect to modelling emotions with ontology have been carried out in the last decades. For instance, Mathieu [12] described a semantic lexicon in the field of feelings and emotions using ontology. WordNet ontology has also developed an extension called WordNetAffect to annotate emotions [18]. With the support of ontology technologies, a photos database was structured in such a way that users can retrieve the emotion annotated information in a semantic manner [3]. Ontological modelling, by implication, is plausible to structure the implicit and contextual emotions of user to better the communication of emotional response between designer and user.

In light of the importance of the emotional response to a prototype (or product), a setting that could enable user-designer-prototype interaction will be needed. Fulton Suri [6] emphasized design experience as a key influence in conceptualising good designs. A prototyping system that could encourage students (or designers) to establish positive design experience will be essential. This prototype system is envisioned to assist the students (or designers) gather emotions of user, and translating them into a product (prototype) that elicits positive emotional response. The prototyping system is proposed based on a closed loop reflective model as illustrated in Figure 1. The prototype system will integrate visio-haptic Augmented Reality (AR) modelling technique with emotion ontology to create a user-interactable prototyping environment. The prototyping environment will enable designer to simulate the use context that is essential to provoke emotional response to product

(which is represented as a virtual model) from user while interacting with the AR-based virtual model. The virtual model is envisioned to support better sharing of emotion data between user and designer to facilitate designer in identifying the user's affective needs.

8   CONCLUSION AND FUTURE WORK

This paper summarized the user-centred design approach practiced in a design course, which was offered to students at the tertiary educational level. Some major weaknesses with respect to the UCD approach applied in assistive product design were pinpointed. An integrated design method was proposed based on a reflective design model in which user's emotional response to a multi-modal basis virtual prototype formed the kernel.

The proposition given in this paper lays future development in three key areas: 1) vision-haptic Augmented Reality prototyping environment suitable for laymen users; 2) emotion ontology construction; and 3) affective design for assistive product by getting end users involved in an active role. In-depth study is required to integrate the three areas to make the envisioned prototyping system plausible. The practicality of the system will need to be tested via some real design cases to be carried out as student projects of the design course.
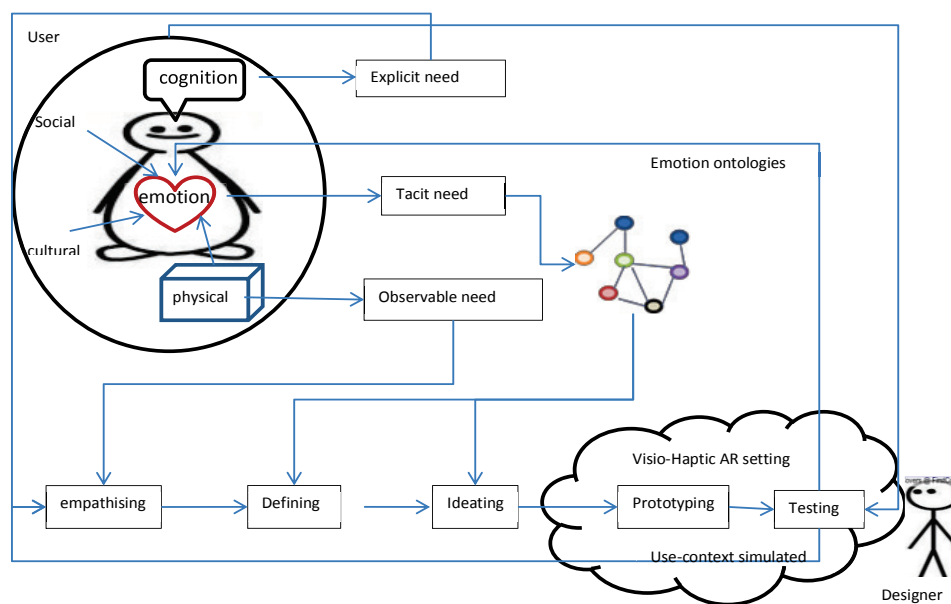

Figure 1. The Conceptual Model of the integrated design method

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