An Affective Prototyping Approach for the User-Satisfying Assistive Products

Yoke-Chin Lai*

** VIA University College, Denmark, lyc@viauc.dk*

Abstract: This paper outlines the key concepts of a study whose main aim is to devise an integrated design method for efficiently designing usable assistive products. The study grounds on Affective Design principle formulated for user's needs, emotions and experience handling in an attempt to outline an integrated approach so that the key concept of participatory design could be practiced. Incorporating the maturing Augmented Reality technology is expected to create a design setting that could motivate active end-user involvement from the start throughout the product design process. With the aids of ontological modeling approach, the design setting is envisioned suitable for disabled and elderly end users participation and to support capturing the abstract but valuable user's real needs that are influenced by emotions and experiences. The ontology model will outline the basis of a design knowledge communication platform to facilitate cross-disciplinary communication, in particular between the designers and untrained users, as well as translating the user's real needs into design attributes.

Key words: affective design, assistive product, augmented reality, emotion ontology.

1. Introduction

Prototypes are needed for the iterations required by the user-centred design approach as they are useful for 1) collecting user feedback, 2) provide a better understanding of the product and also its use. A prototype is used, for consumer product design, to prove design concepts, evaluate alternative solutions, test product manufacturability, or to present the final design to the potential users or consumers. Prototyping is therefore essential in the design process, and it could occur at any stage of the design process.

Using prototypes at the earliest stages of the design process will better involve end-user participation. Participatory design is the key to successful user-centred design [23]. To actively engage end-user participation at the earliest design stage attempting to acquire user's emotion, a human-product interactable prototype is essential. In view of such limitations as costly and time consuming found in physical prototype construction, an interactable digital prototype could be beneficial. CAD-based digital model restricts interactivity with untrained user (non-expert). This restriction is apparent from student projects, which will be delineated later in the paper.

This paper proposes an integrated design framework aiming at strengthening the learning outcome in the pedagogical dimension of a design course offered by a tertiary educational institution. The proposed framework is anticipated to be beneficial for designing assistive product that could satisfy the user's real need.

This paper is divided into three sections: 1) a brief outline of the design methods and tools employed by students of a design course offered in the Mechanical Engineering Department of VIA University College; 2) an analysis of the student's learning outcomes with respect to the methods and tools used in completing design projects; 3) a proposition to an integrated design method in an attempt to better the learning outcomes.

2. The Current Practice

2.1 The Course Set-up

PUDM1 is an elective course offered in every spring semester to the 5th and 6th semester Mechanical Engineering students. The primary objective of the course is to introduce user-centred product design practices to the mechanical engineering students who have acquired adequate engineering design skills in their previous semesters. The curriculum framework of the course is organised in two dimensions: 1) The skill / knowledge learned (curriculum content), and 2) the pedagogical approach (how the skill / knowledge 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 [19]. 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 [26]. Students are assigned a design project from the beginning of the semester to its end. The project is divided into several assignments that combine together to form the whole project. The assignments must be completed in a sequence as the outcomes of one assignment form the development basis for the subsequent assignment. Each assignment is formulated correspondingly to the user-centred design process: problem area defining, user's needs discovery, discovery data analysis, design exploration and prototyping, and prototype evaluation.

2.2 Design Project Exploration and the Essential Outcomes

The design projects assigned to the students was usually open-ended but specified only with a theme, for instance "Welfare Technology". The students required defining an explorable problem area based on inspirations gathered from their living surroundings. Searching the web and design magazines, observing their surroundings followed by brainstorming were the most practiced methods to find inspirations. A scenario was then produced to outline a problem area. To continue the subsequent step in the early design stage, i.e. analyzing user's needs, a wide range of methods were employed by the students. Among these methods were interviews, questionnaire surveys, observations, role-play, scenario, persona, and mood-board. Persona and mood-board were produced as the media to communicate understandings about the targeted user groups, their relevant experiences and needs. A design brief that was composed of a clearly outlined problem area and design (technical) specification was submitted to end 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, students were guided to carry out a detailed evaluation on the function and usability of, at minimum, one existing grabber. Several usability evaluation methodologies were instructed for this purpose, e.g. 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, would be employed to generate ideas. As for a project whose aim was to create a novel product, brainstorming would usually be the first attempt chosen to generate design ideas. Showing hand sketches of all the ideas generated were demanded as teacher-student communication means in order to gather feedback from teacher. One final idea would be chosen using idea/concept selection techniques such as Scorecard, Weighted Objectives Table, or multi-voting.

Detailed design stage started after one final idea was selected. Hand sketches of all the 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 to attain common understanding. 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 obtain 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 sheets, clay, MDF and metal sheets. The prototype would then be peer evaluated from usability perspective in a classroom session called Prototype Evaluation Studio. Rapid prototyping technology was noticed seldom employed by the students although the facility was available and easily accessible.

3. The Design Practice Analysis

In the past two years, the outcomes of the student projects have involved a wide variety of different products within such categories as mobility, communication and household. Most of these products shared a common target: they were designed to assist the elderly or disabled people to complete ordinary tasks, such as walking, self-care (e.g. bathing, foot-cleaning, toileting, hair washing) in their daily lives. These products are categorized as assistive products in this paper. According to Hersh [16] that assistive product is a product that is designed to modify the interactions of disabled and elderly people with their environments in order to remove barriers. In this paper, assistive product is a term to represent all products and services designed to assist the disabled and elderly people to carry out daily activities, otherwise without them, the elderly and disabled people would face difficultly because of the decreasing mental and physical abilities.

The design practices performed by the students demonstrated critical shortcomings as follow:

1. Prototyping skills were inefficient.
   Creating digital 3D model using CAD software packages was the most preferred technique. This technique however demonstrated shortcoming in performing usability evaluation as user interaction with the designed product was 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 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 users involved in usability test of the student project was found another challenging task. For instance, a scaled model with very limited testable functions and user-interfaces was impracticable in this respect as real users 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 in many of the student projects completed in the design course PUDM1. The methods used in the user's need analysis stage were found inadequate to derive the user's real needs. For instance, observation was remarked a subjective method that exhibited shortcoming in the users' needs collecting and articulating process. The observer's personal knowledge and experience would bias needs analysis process. The interview method employed by students of the two design courses also exhibited pitfall with respect to uncovering the user's real needs. Being knowledgable to ask the right questions would be a critical skill required to succeed an interview. Under the circumstances that students were novices in the area, probing for the right information from users was rarely attained.

To summarise, the experience accumulated from the user-centred design process carried through by course participants of design course PUDM1 could outline central issues as follow:

1. Users do not understand what they want or they could not articulate what they want.
2. Users often do not participate in reviews (usability test) or are incapable of doing so.
3. Users are technically unsophisticated.
4. Users often do not speak the same language as the designer.

4. A Conceptual Model and the Concepts Behind

In view of the central issues outlined in section 3, a conceptual model is examined. This model will form the basis of an integrated design approach whose aim is to strengthen designer-user-prototype interaction. The integrated design approach is to guide students more efficiently in performing user-centred design for assistive products. Before the model is formulated, relevant theories and concepts corresponding to the following three key questions need to be examined: 1) is assistive product design different from consumer product design; 2) how to actively engage end-user at the inception design stage (planning stage); 3) how to align the designer-user communication context. The relationship between these relevant theories and concepts is illustrated in Figure 1.

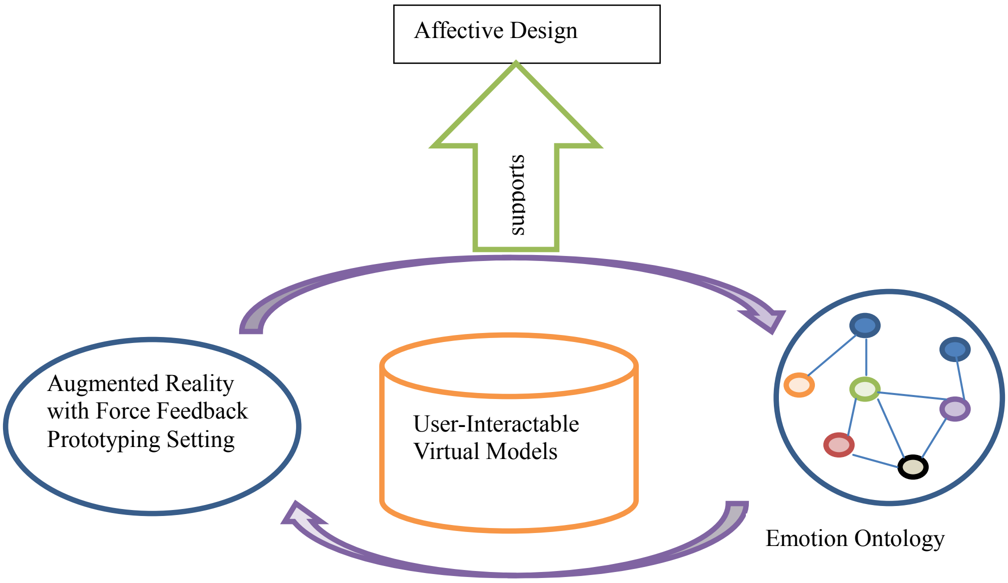

Figure 1: Relationship between the concepts behind.

4.1 Is designing Assistive Product the same as Consumer Product?

Assistive products are developed sharing such ultimate goals as to enhance the elders and disabled people functional abilities or to increase access to information and communication. A wide variety of devices ranging from high technology eldercare robots, communication devices to easy access but low-cost products as walking sticks are available. A brief review to the study [17,32] concerning the users' appreciations towards their assistive products uncovers a general tendency: assistive products have generally economic and psychological costs that hinder user adoption. Assistive products are generally produced in small quantities for specialty markets thereby become pricey to many users. In addition, assistive products are designed in a way to enhance user's functional abilities and thus unintentionally highlight user's disabilities. This situation consequently contributes to social stigma associated with disability [4,17, 32]. The arousal of dislike feeling is reflected through the following user's reactions frequently reported by caregivers: avoid using the product or come up with own solution by redesigning the product's functional appearance.

The arising question is whether all the efforts made in design approaches employed in designing consumer product such as User-centred design, Universal Design, and Inclusive Design adequate for designing user-satisfying assistive products. If not, what causes the inadequacy, what challenges assistive product design? As reported by the relevant research [17,32] that challenges to be embraced in assistive product design are many but centralizing issues as user's self-image, user's experience of meaningfulness (the user feels if a product has a meaning to him/her), and stigmatization.

According to [30], a product can be more than the sum of its functions but it also confirms 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 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.

4.2 User's emotions and needs

Translating user's needs effectively into valuable design attributes has been remarked by many relevant literatures a challenge in all product development projects. The reasons of eliciting users' needs are difficult as suggested by for instance [24,23,33] are several including the followings:

1. Users lack the awareness of needs.
2. Users tend to have difficulty to articulate needs into words as needs are ambiguous.
3. Users lack capability to define what their needs are because the needs are subjective matters changing with the user's emotion.

As suggested by Smith [38] that a big numbers of existent assistive products are abandoned the use due to their lack of compatibility with the user's needs, roles, values and context. Like all other consumer products, assistive products are more likely to be used if they could maintain dignity and improve life quality [17,32]. The implication is a deeper exploration is required for better user's need identifying and capturing in assistive product design.

As reported in, for instance [40,35,5], that the existent user's needs finding approaches including those practiced by the PUDM1 course participants (e.g. observations, interviews, questionnaire surveys and role-plays) have demonstrated their respective limitations to inhibit effective thoughts communication between designer and the concerned user group. This drawback becomes significant in the area of assistive products design [16], in particular for the elderly community. This is because a good design for the elderly user group is expected to meet a few requirements that contradict each other:

1) Easy-to-use, intuitive but be transparent from the complex-looking modern technology.
2) Introduce as little change as possible because old people in general fear of change. Both mental and physical abilities of the elderly are however decreasing gradually without self-awareness.
3) Ubiquitous but attributed with proper perception values (not too modern and not too conservative). The perception values of the elderly people, however, tend to be intensified by their past experiences.

User experience is subjective in nature and context dependent while user’s emotion is inseparable from experience [15]. User needs are significantly affected by user emotion [30,28,27]. Within emotional research literature, “emotional affect” is a term used to denote emotions affect cognition. Emotional affect is emotional reactions that have a high tendency of producing changes in awareness, facial expression, body language, physiological function, and behavior. According to the authors in [6] that (emotional) affect is different from cognition as it tends to influence motivation and arouse feelings while cognition is concerned with facts. This argument is also supported by research in neuroscience, which has pointed out the importance of emotions in even simple decision making, like choosing clothes to wear in the morning [10], information categorizing, risks evaluating and problem solving [18].

Emotional affect is an important design consideration for interactive products, particularly those used in stressful and dangerous situations [30]. This is because emotional affect can change thought processes, and therefore influencing how events are perceived and interpreted. It can change how people interact with one another as well as how people interact with products/objects.

In brief, the user’s real needs are affected by user’s emotions and experiences. An approach that could capture and translate the user’s real needs instead of the perceived needs would be a new dimension to explore.

4.3 Affective response to design

There are many poorly designer products, according to Norman [30] because designers and engineers believe they do not need to see real people use their products. These engineers and designers know too little about people’s lives and too much about technology. Similarly, Cooper [8] explained this situation by giving the argument that designers either are unaware of the differences among users’ abilities, or they do not know how to satisfy the users through their design process. The user-centred design approach focuses on a designing process through which the user context is the driving force. This design approach has been widely applied to the design of nowadays consumer products. However, assistive products give the impression of lagging behind because they are usually designed for their functionalities. Balaram [4] comments that even assistive product that is given design awards compromises with form, colour and style. No matter how well the assistive products function, their appearance elicits pity. Therefore, it is essential to provide designers with knowledge about subjective values such as user’s experience and emotions apart from only the functional and usability values.

Norman [30] suggests that the mental model of designer could differ from the one of user. A conventional design process (more accurately idea generation) 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, feelings, aspirations, goals, rituals, and values into a product that elicits positive emotional responses? A user interacts with a product by his or her will. In other words, a user could intentionally use the (assistive) product for something other than that for which it was intended while experience and meaning could only be created as a product is being used, observed, and discussed about by the user.

4.3 Affective Design

Norman [30] regarded designing is an activity that intertwines three aspects: visceral, behavioural and reflective. Visceral design concerns the aesthetic values of product. Behavioural design concerns pleasure and effectiveness of use (functional and usable). Reflective design considers the user's culture and values, the experience of meaningfulness of the product to user, social convention, prior knowledge, and learned habits. Incorporating these three key design aspects into a basic design process model, for instance the one outlined by Cross [9] has formed a basis of affective design that has become prominent in the recent decades.

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 [27]. In the area of Kansei Engineering, diverse techniques including those applying psychological measurements have been explored [28,27,7] in an attempt to in acquire 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 [11,31,14,25,7] the widely applied method for the user's emotion grasping purposes. Those photos are usually taken from a wide collection of some existing products related to the targeted design domain. 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 help externalize user's emotion and subsequently the implicit real need.

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-product interactivity as the relevant product users are usually non-experts in CAD modeling. The implication is exploring a new dimension for virtual model that could provoke emotional response will be needed.

4.3 How could Augmented Reality play a role?

A prototype is used, for product design, to prove design concepts, evaluate alternative solutions, test product manufacturability, or to present the final design to the potential users. Prototyping is therefore essential in the design process, and it could occur at any stage of the design process. The optimal practice of prototyping is however found distinct from the students' practice as explained in section 3. The physical prototypes created in the later stages of the design process practiced by students were to test the ergonomic aspects of the new design solutions. The physical prototypes were found costly and causing a delay in detecting mismatches in the solution under development with the users' real needs.

Research related to augmented reality (AR) aiming at either directly or indirectly supporting interaction design has been explored and achieving varying degrees of success [1,2,3,29,36,37]. 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, if necessary, haptic feedback, would provide a relatively realistic interaction with the user. Virtual models enhanced with immersive and interactive sensation could better provoke emotional response compared with either the 2D photos/pictures or CAD models. The implication is AR-based virtual model could be an alternative applicable in assessing the intensity of user's emotion and thereby assist users articulate their real needs.

4.4 Ontology Models

An ontology is defined as a formal explicit specification of a shared conceptualization [13]. Ontological modeling 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 [21], and to structure the complex and implicit design rationale [22]. 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, thoughts, feelings, aspirations, goals, rituals, values, and translating them into a product (prototype) that elicits positive emotional response, a design setting that could assist solicitation of the affective attributes from user will be essential. Many efforts in the area with respect to modeling emotions with ontology have been carried out in the last decades. For instance, Mathieu [25] 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 [39]. 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 [7]. Ontological modeling, by implication, is plausible to structure the implicit and contextual emotions of user to better the communication of emotional response between designer and user.

As designer needs to understand the insight of user's emotional response to a product, a setting that enables user-designer-product interaction will be needed. Fulton Suri [12] emphasized design experience as a key influence in conceptualising good designs. A prototype 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. A conceptual model of the prototype system is illustrated in Figure 2. The prototype system will integrate Augmented Reality (AR) modeling 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 (virtual model) from user. The virtual model is envisioned to support better sharing of emotion data between user and designer to facilitate the designer in identifying the user's real needs.

The prototype system will contain a user's experience inquirer to capture the user experience accumulated from various dimensions ranging from cultural background, trend and social influence to educational and knowledge level. AR models that are relevant in the specified design domain will be collected and/or created by designer in an attempt to simulate a use context that would provoke the user's emotional response. The user's emotional response will be categorized using affective engineering approach. The categorized emotion data will then be ontologically structured to facilitate designer in the design attributes formulating process. An AR-based virtual prototype will then be created by the designer by taking into account the three main aspects: function, usability and aesthetic. This AR-based virtual prototype will be user-interactable to allow real-time customization to meet the user's real needs. This prototyping setting is envisioned could assist more effectively the participatory design.

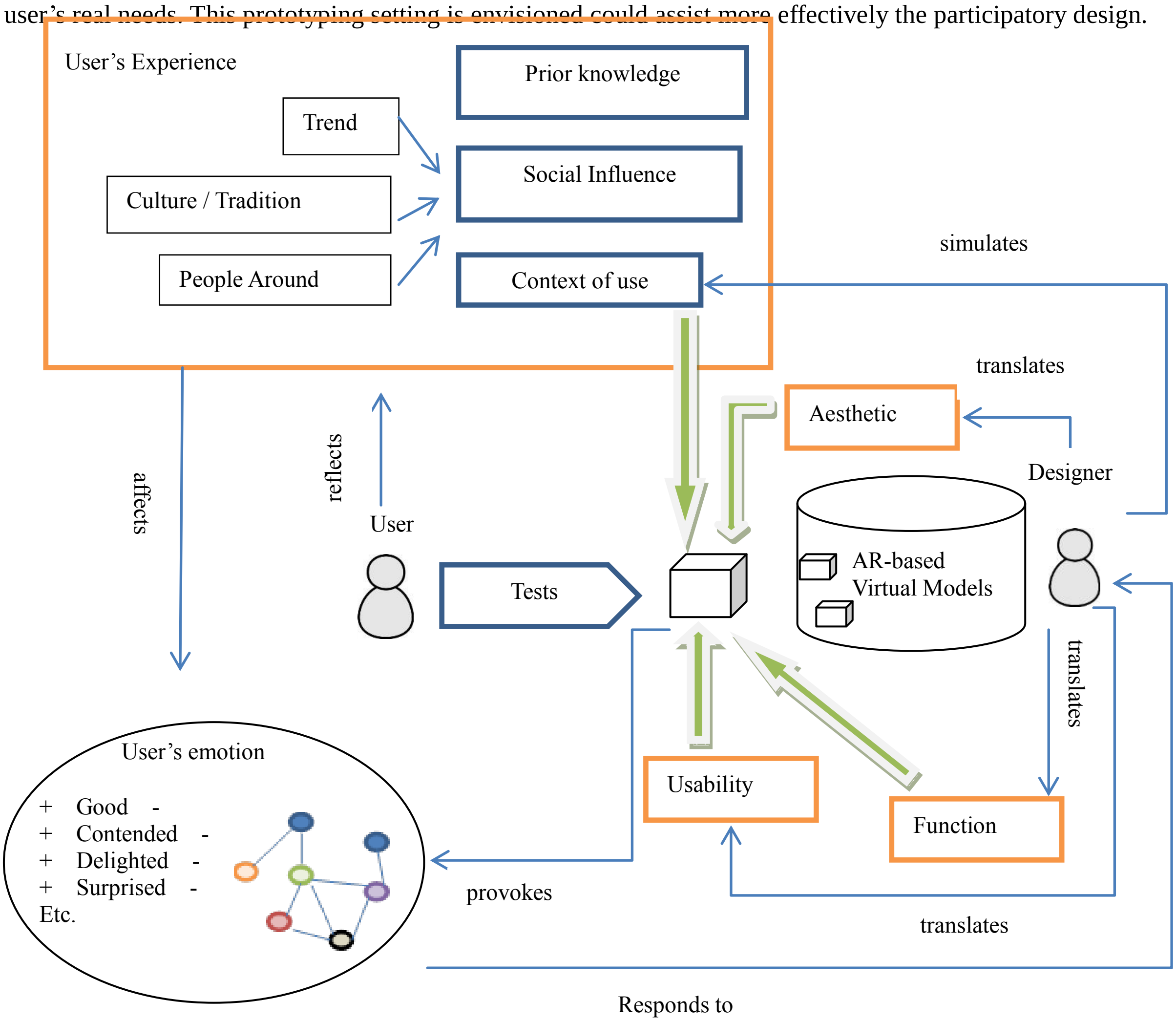

Figure 2: Conceptual Model of Integrated Design Approach

5. Conclusions and Future Work

In this paper, a conceptual model of an integrated design approach is formulated. The integrated design approach is envisioned to strengthen the reflective aspect of user-centred design approach practiced by students of design course PUDM1. The integrated design approach will play a crucial role to designing efficiently user-satisfying assistive products as the user's emotional affect will be incorporated in the iterating design process. The basis of this approach is a prototyping system that could provoke emotional response from user throughout the iterating design process, particularly at the planning stage in which the participatory of end user is of importance.

This study lays future development in three orientations i.e. 1) force feedback enhanced augmented reality prototyping environment set-up; 2) emotion ontology construction; and 3) affective design implementation in assistive product design. 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 real design cases in relation to designing assistive products, which is the main goal demanded in student projects of the design course.

6. References

[1] ARMES. Available at http://www.armes-tech.com [Accessed 27 Sept 2012]

[2] ARTESAS. Available at http://www.artesas.de [Accessed 27 Sept 2012]

[3] ARToolKit. Available at http://www.hitl.washington.edu/projects/shared_space/ [Accessed 27 Sept 2012]

[4] Balaram, S. (2001) Universal Design and the majority world, In Universal Design Handbook, McGraw-Hill.

[5] Barnes, C., Childs, T. and Lillford, S. (2011) Kansei/Affective Engineering for the European Fast-Moving Consumer Goods Industry. In Kansei/Affective engineering, CRC Press.

[6] Cacioppo, J.T. and Petty, R.E. (1989) The elaboration likelihood model: The role of affect and affect-laden information processing in persuastion. In Cognitive and affective responses to advertising, pp 69-89.

[7] Chi, YL, Peng, SY and Yang, CC (2007) Creating Kansei engineering-based Ontology for annotating and archiving photos database. In J. Jacko (ed.) Human-Computer Interaction Part 1, LNCS vol 4550, pp 701-710.

[8] Cooper, A. (2004) The inmates are running the asylum: why high-tech products drive us crazy and how to restore the sanity. Sams, Indianpolis, US.

[9] Corss, N. (1984) Developments in design methodology, John Wiley and sons.

[10] Damaiso (1995) Descartes'Error: emotion, reason and the human brain, Picador.

[11] Deana M. and Denton H. (2004) Exploring the degree to which individual students share a common perception of specific moodboards: observations relating to teaching, learning and team-based design, Design Studies 26, pp 35-53.

[12] Fulton Suri, J. (2003) Empathic design: informed and inspired by other people's experience. In Empathic Design – user experiences in product design, pp. 51.57.

[13] Gruber, T. (1993) Towards principles for the design of ontologies used for knowledge sharing, International Journal of Human-Computer Studies, special issue on Formal Ontology in Conceptual Analysis and Knowledge Representation.

[14]Halliday D. and Setchi R. A comparative study of using traditional user-centred and Kansei Engineering approaches to extract user's requirements.

[15] Hassenzahl, M. and Diefenbach, S. (2010) Needs, affects and iteractive products – facets of user experience, Interacting with computers 22, pp 353-362.

[16] Hersh, M.A. (2010) The design and evaluation of assistive technology products and devices Part 1: Design [Online PDF]. Available at http://cirrie.buffalo.edu/encyclopedia/en/article/309/ [Accessed 20 March 2013]

[17] Hirsch, T., Forlizzi, J., Hyder, E., Goetz, J., Stroback, J. and Kurtz, C. The ELDer Project: Social, Emotional, and Environmental Factors in Design of Eldercare Technologies [Online PDF]. Available at http://www.cc.ntut.edu.tw/~wwwdtl/93DTL_02/class/93_05_Wang/930304.pdf [Accessed 20 March 2013]

[18] Isen (1999) Positive affect. In Handbook of cognition and emotion, pp 521-540.

[19] Johnson, D.W., Johnson, R.T. and Smith, K.A. (1991) *Active Learning: cooperation in the college classroom*, Edina, MN: Interaction.

[20] Koskinen and Battarbee (2003), Introduction to user experience and empathic design. In: Empathic Design-user experiences in product design, pp 37-50.

[21] Lai, YC (2006) IT in Collaborative Design (IT-CODE), PhD Thesis, Aalborg University.

[22] Lai, YC and Carlsen, M (2004) An ontology-driven approach for monitoroing collaborative design knowledge. In proceedings of 5th ECPPM.

[23] Luck, R. (2003) Dialogue in participatory design, Design Studies 24, pp 523-535.

[24] Maslow, A. (1943) A theory of human motivation, Psychological Review 50, pp 370-396.

[25] Mathieu, Y (2005) Annotation of Emotions and Feelings in texts. In Proceedings of ACII 2005, LNCS vol. 3784, pp 350-357.

[26] Millis, J.E. and Cottell, P.G.., Jr. (1998) *Cooperative learning for higher education faculty,* Series on Higher Education, Phoenix, AZ: American Council on Education, The Oryx Press.

[27] Nagamachi, M (2010) Methods of Kansei/Affective engineering and specific cases of kansei products. In Kansei/Affective Engineering, pp 13-30.

[28] Nagamachi, M. (2002) Kansei engineering as a powerful consumer-oriented technology for product development, Applied Ergonomics 33, pp 289-294.

[29] Nee,AYC., Ong SK, Chryssolouris G and Mourtzis D. (2012), Augmented Reality applications in design and manufacturing, CIRP Annals – Manufacturing Technology 61, pp 657-679.

[30] Norman, D. (2004) Emotional design; why we love (or hate) everyday thing,. New York: Basic Books.

[31] Ogawa T., Nagai Y. and Ikeda M (2009) An ontological approach to designers' idea explanation style: Towards supporting the sharing of Kansei-ideas in textile design, Advanced engineering informatics 23, pp 157-164.

[32] Olander, E. (2011) Design as Reflection, Doctoral Thesis, Lund University.

[33] Partala, T., Kallinen, A. (2012) Understanding the most satisfying and unsatisfying user experiences: emotions, psychological needs, and context, Interacting with Computers 24, pp 25-34.

[34] Philips, B. and Zhao, H. (1993) Predictors of assistive technology abandonment, Assisitive Technology 5, pp 36-45

[35] Sheldon, KM, Elliot AJ, Kim, Y. and Kasser, T. (2001) What is satisfying about satisfying events? Testing 10 candidates' psychological needs, Journal of Personality and social psychology, 8, pp 325-339.

[36] Shen Y., Ong SK and Nee AYC (2011) Vision-based Hand interaction in Augmented Reality Environment, International Journal of Human-Computer Interaction 27 (6), pp 523-544.

[37] SixthSense, MIT Media Lab. Available at http://www.pramavmistry.com/projects/sixthsense/ [Accessed 27 Sept 2012]

[38] Smith, R. (1995) A client-centred model for equipment prescription (client's values and roles, effective use of adaptive equipment), Occupational Therapy in Health Care 9(4), pp 39-52

[39] Strapparava, C. and Valitutti, A (2004), WordNet-Affect: and affective extension of Wordnet. In: Proceedings of 4th International Conference of LREC 2004, pp 1083-1086.

[40] Ulrich, KT and Eppinger, SD (2008) Product design and development, McGraw-Hill.