VOL. 10, NO. 23, DECEMBER 2015 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences


www.arpnjournals.com

UNDERSTANDING FACTORS INFLUENCING USER EXPERIENCE OF INTERACTIVE SYSTEMS: A LITERATURE REVIEW

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ABSTRACT

In recent years, the notion of User Experience (UX) has gained a greater attention among HCI researchers in academia and industry. Due to its importance, several frameworks and models have been proposed to design and assess UX of interactive systems. These models guide to improve the design and help to determine the quality of interactive systems, products and services. UX is highly subjective, dynamic, and context dependent; it evolves during the interaction with the system. Different factors collectively influence UX and present a challenging task to define, model, measure and validate it. The less attention is paid to understand and underline these factors; this paper is an attempt to understand and underline the core UX factors based on literature review. These factors make UX more complex, diverse and vague in nature. It is recommended to incorporate the management aspect in UX process that may help to overwhelming the issues of complexity, diversity and vagueness.

Keywords: human computer interaction, user experience frameworks, user experience models, factors influencing user experience.

INTRODUCTION AND BACKGROUND

Since the invention of computers, various types of human computer interfaces have been designed and developed using different technologies. Users in different domains have experienced with the inventions for a variety of general and special purpose applications. For example, at earlier stage of computing, users experienced both Command Line Interface (CLI) and Graphical User Interfaces (GUIs) with desktop and laptop computers. Although, these interfaces support users to access digital information but at the same time present a challenge to address different factors such as easy to use, efficiency, effectiveness and error rate [1]. In order to address these challenging issues, the extensive research studies are conducted that introduce the notions of usability and usability engineering in the field of HCI [1, 2]. The usability studies have improved user performance in terms of user comfort, ease of use, and satisfaction. However, it is argued that usability mainly deals with the task related factors (e.g. efficiency and effectiveness) and metrics (e.g. time to complete and error rate) of the system [3]. Usability models generally focus on user performance and cognition related factors [4].

There is always an evolution process in the field of HCI to improve the system design and evaluation. In recent years, the development of multi-touch tabletop systems facilitates users to experience the Natural User Interface (NUI) [5, 6]. These systems introduce a new paradigm shift in user interaction and user interface design [7]. They support co-located collaborative workspace, simultaneous multi-user multi-touch interaction, direct and natural interaction [8]. They are useful for co-located collaboration among multiple users and perform various collaborative activities on the same digital surface [9]. To some extents these systems enable users to use their full interaction capabilities to access the digital contents directly using their hands and fingers.

The focus of UX research is to design and develop systems that must support usability and user's affective needs and goals[10-11]. UX research has gained more interest due to limitations of the conventional usability models [4]. UX studies do not only focus on task related aspects but also on affective qualities, sensation, meaning and value of interactive systems, products and services [12-14]. In order to better understand the concept of UX, many frameworks and models are proposed e.g. [11, 14, 15] that include various integrated UX constructs and measures. These frameworks are presented from different perspectives that include interaction-centered, user-centered and system-centered [16, 17]. It is also focused to understand and document different types of experience created while interacting with systems.

Experience is described as a constant stream of "self-talk" that occurs while interaction is carried out with products e.g. using instant messaging systems. An experience is described as something that can be articulated e.g. watching a movie and sitting on free fall ride. Co-experience is described as the motions and meanings created together while interacting with products e.g. playing mobile messaging games with friends. UX can be created either positive or negative depending on systems qualities perceived by users [18-20]. It introduces a valid point of interest to research that how positive UX of interactive systems can be created, measured and modeled [19]. Thus, UX is being studied extensively in HCI field to design systems to be more useful, pleasant and attractive [14, 18].

Despite the availability of different frameworks and models, there is still no consensus on the definition of UX [3, 10, 21]. It is argued that UX encompasses various integrated aspects and shares diverse views. The wider scope and incoherent views on UX make it more complex [4, 10]. It presents many challenges such as selecting and validating the core constructs, factors and relevant

measures to design and evaluate interactive systems [3, 22]. However, it is reported that some factors influence UX [23-29] and bring more dynamics [18, 22, 24, 25], diversity [26] and complexity in modeling, measuring and predicting UX [10, 21, 23, 25]. Despite the presence of these issues and importance of UX, the less attention is paid to factors influencing UX. It creates a need to present the synopsis on developments made in UX and to underline its core influencing factors. This paper is an attempt to understand how UX is created, influenced and the possible remedies needed to define the scope of UX for interactive systems design and evaluation.

The organization of this paper is as follows: the second section presents the research methodology whereas the third section highlights different key factors influencing UX. The fourth section discusses some key issues based on the theoretical assessment of the related literature. The fifth section concludes the paper.

METHOD

This literature review includes the articles from the reputable databases such as Springer Link, ACM portal digital library, IEEE Xplore digital library, ScienceDirect Scopus, and Google Scholar. The search criterion (keywords) is carefully selected that includes user experience, UX frameworks, UX models and factors influencing UX. This literature review includes 91 articles in total.

FACTORS INFLUENCING USER EXPERIENCE

Interacting with computers involves a wide range of factors that influence UX. These factors may be broadly categorized into user, system, context and temporal aspects. The following sub-sections describe these aspects.

Understanding Users

The continuous development in the field of HCI has improved interaction between users and computers by making systems useful and receptive to user's needs. At the same time, rapid advancements in computer interface technologies present the several challenges to design for UX in user's perspective [21, 27, 28]. The research journey is still ahead where HCI research community is committed to improve UX and overall quality of life while interacting with systems. It is mentioned that "old computing is about what computer can do, but new computing is about what people can do" [29]. It emphasizes the importance and understanding of users, their need and goals. From user's perspective, interactive systems should be designed and developed in a way that must meet their needs and goals accordingly.

Motivating to this, the several research studies are conducted to understand users. It is understood that there are different types of users that can be classified into different categories according to their characteristics [29-32]. Generally, users can be classified into four main categories i.e. novice, experienced, expert and focus group. All types of users are associated with some unique characteristics that include the physical and cognitive abilities and disabilities. These abilities and disabilities are associated with user personality, status, demography, functional and affective needs and goals [33-36]. These characteristics collectively build and signify a natural capacity of user interaction with systems. Moreover, every characteristic is further related to other inherent qualities. For example, any user's abilities are related to individual's knowledge and status [37-39], physical [33], perceptual [34] and cognitive skills [31, 35].

The term "ability" refers to an individual's capacity of actions and perceptions used perform various types of tasks and perceive the system qualities. The physical abilities of users assist them to perform the actions or tasks with same mental ability. It leads to user performance while interacting with systems. For example, the interaction ability of expert users with systems can be higher than novice users due to have sound background knowledge and better skills [32, 36]. Similarly, the disable users can be considered as special case that relate to some physical and mental unfitness (e.g. visual impairment) [35, 37]. It may restrict them to obtain dexterity in interacting with system as compared to normal users. In addition, if an interactive system is designed for focus groups (e.g. medical doctors) to access the specific information to diagnose and monitor the disease of any patient and even plan for surgery. Then, it is required to provide the training to medical doctors before to use it in real time or practical scenarios. This helps to improve their physical and mental interaction dexterity while using these systems. In contrast, these systems will be hard to learn and use by novice and disable users. It suggests that how interaction behavior and perception of users may change over time and impact on UX. Additionally, it creates a need to study users and understand their characteristics at large scale in user-centered design aspect.

Realizing the importance of user abilities, users' knowledge aspect is researched where it is described that knowledge and familiarity are the relevant factors for interaction behavior. The presence of prior knowledge and familiarity about any interactive system improve the overall user performance. More acquainted input/output modality can be used frequently as compare to less familiar [33, 38-40]. In general, the term knowledge relates to a broader sense making about things, objects and interactive systems [41]. Thus, it is hard to claim that every user has complete knowledge about interactive systems. The level of knowledge can be varied from person to person and may have also difference of opinion about interactive systems. To assess the user's knowledge, an evaluation method is proposed and experimented to assess computer literacy as well as evaluating user knowledge [42]. There is another evaluation method presented by [43] that help to assess experience of computers.

Moreover, some effort and attention are also given to study the impact of user's spatial abilities on the performance [44, 45]. There is one study where it is reported that user with spatial abilities perform better while using the GUIs than those users who have low

spatial abilities [45]. It clearly suggests that users with high spatial abilities may prefer the GUIs over speech control while having a facility of multimodal interaction. Based on these findings, it can be said that user behavior influence experiences and will be different while interacting with different systems. Moreover, the notion of UX is associated with user's different motor capabilities (e.g. gestures and facial expression). These can be created while interacting with system in particular context. Thus, to assess these users' motor capabilities, an evaluation method is proposed that is called "Assessment of Motor and Process Skills (AMPS)" [46]. It helps to evaluate the motor capabilities but lacks to provide the generic results about all types of users. There is another evaluation method named as Wechsler Adult Intelligence Scale (WAIS) that assists to assess user's perceptual cognitive abilities [47]. Despite the presence of these methods, it is reported that less research is conducted on user's cognitive abilities and evaluation methods [12, 39].

As, UX is subjective and dynamic in nature, it incorporates user's affective qualities (e.g. moods and feelings). User mood is associated with affective or emotional qualities of UX [14, 48]. User emotions can be created either positive or negative depending on the system's qualities and context in which it is being used [14, 49]. Thus, much attention is given to study user emotions. It is studied in various frameworks and models that consider it as a core component of UX [12, 14]. It is emphasized that interactive systems should be designed in a way that must leverage the pleasure, attraction and identification while interacting with them [18, 20, 50].

Keeping in view the challenge to assess user's emotions, some efforts are also undertaken to propose evaluation methods. Related literature informs about early example of a questionnaire-based UX evaluation method which includes a face scale that is ranging from 'very sad" to "very happy". It helps the respondents to indicate the face that matches to their mood created while interacting with system in a specific context [51]. Interestingly, there is another questionnaire-based evaluation method named as Brief Mood Introspection Scale (BMIS) [52]. It incorporates sub-scale to assess emotions i.e. pleasant-unpleasant mood, arousal-calm mood, positive-tired mood and negative-relaxed mood [53]. User's good or bad mood feelings may influence UX of interactive systems. The incorporation of different factors in UX evaluation method clearly reflecting that user's perception about and interacting with the system may create the different emotions. Some studies report that user's judgments about interactive systems and products may be affected or inconsistent in a particular situation [49, 54-56].

It suggests that the appropriate identification and evaluation of user needs e.g. physical and psychological needs guide interaction designers to design better systems. Realizing the importance of user needs, some studies are conducted to address the issues of psychological needs for stimulation, relatedness, competence and popularity. The outcome of these suggest the accomplishment of user needs contribute in motivation to use systems, products and services again [57, 58]. The fulfillment of user needs leverage the success, acceptability and also maintain the consistent use of interactive systems in the mass markets. Similar to other user characteristics, user personality is studied to identify the impact on interaction behavior and judgments about interactive systems. It is highlighted that user personality involves the two main variables i.e. traits and attitude [59]. The psychological personality traits include the openness, conscientiousness, extroversion, agreeableness and neuroticism. These traits are also called as Big Five in psychological studies [60, 61]. A user study is carried out to assess the psychological personality while using the interactive system. The findings indicates that extrovert users identify more usability problems than introvert users [59]. It suggests that personality has impact on interaction behavior and judgments. Realizing its importance, some evaluation methods are proposed where psychometric measures are considered to assess user personality [61, 62]. These methods assist to evaluate personality but include limited measures and are available in a short version [63]. Additionally, the attitude variable also represents user's perception, believe or an approach that leads to the positive and negative behaviors. It is documented that user attitude has impact on interaction behavior and judgments [56]. For example, if a user has positive attitude towards the technology that determines its acceptance and success and vice versa too. To assess the user attitude towards interactive systems, a questionnaire-based evaluation method is proposed that includes two sub-scales. One sub-scale is used for to evaluate the positive attitude and another sub-scale for negative attitude [27, 64].

Generally, it is assumed that the growing age also causes the difference in user performance and interaction behavior. Thus, the demographic variables have gained much attention into HCI studies. There have been various demographic variables that include age, gender, culture, region, profession and level of education [65]. However, user's age and gender variables are widely researched to assess UX of interactive systems. It is documented that there is a difference in user performance and interaction behavior while considering different age and gender [25, 66, 67]. The findings of some existing studies demonstrate that the gender effect is not moderated by other factors like previous experience. In contrast, some studies show the effect is largely moderated [25] and less moderated [68]. However, the motor impairment [35], decrease in cognitive abilities [31, 35] and the degree of previous experiences [27] create the difference in user performance and interaction behavior. It is mentioned that the lower memory span may provide inconsistent ratings about used systems. In some studies, it is argued that younger users perform better than older users [67]. It is also reported that despite the decrease in performance of older users, they rate the system more positive than younger users [67]. It suggests that interactive systems should be designed and developed by considering the different types of users, their characteristics, needs and goals. The users in HCI, their

types, characteristics, needs and goals are shown in Figure-1.

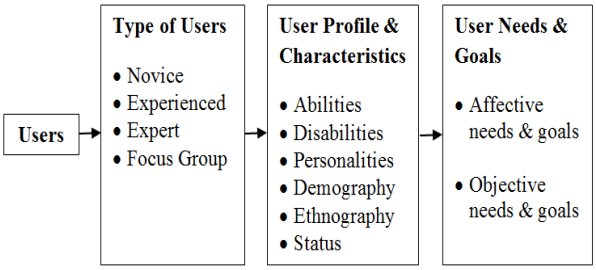

Figure-1. Users in HCI.

Understanding Systems

Over the years, the enormous developments in software and hardware technologies have encouraged to produce the various types of personal computers (e.g. desktop and laptops) [69, 70]. These systems are associates with hardware and software interfaces and therefore relates to two main quality characteristics i.e. physical and software. The physical characteristics are associated with physical description of hardware aspects of systems that include the size, shape, orientation, height, reach and aesthetics. These aspects always remain focused in ergonomic studies to meet the physiological and psychological needs [71, 73]. For example, the conventional input devices (e.g. keyboard and mouse) and output devices (e.g. LCD monitors) are designed, developed, experimented for personal computers and still are being used frequently. These I/O devices have remarkably facilitated users to access the digital information from computers in different ways. Despite that, some ergonomic, interaction and performance related issues are highlighted while using these devices [25, 74]. It is also informed that these hardware interfaces provide indirect interaction and limit the natural capacity of user interaction [75]. It confirms that the use of conventional hardware interfaces influence user's interaction behavior and performance either positively or negatively that highly depends on the context.

However, users always learn from their previous experiences and bring the changes in their needs. In parallel to that the rapid growth in touch sensor, processor and display technologies have contributed to design and construct the smart computers such as smart phones, multi-touch Tablet PCs, iPads, multi-touch tabletops, multi-touch interactive walls) [76, 77]. They provide a multi-touch screen as input interface where users can select and manipulate digital contents directly. They are widely accepted into the mass markets due to the modality of the direct and natural multi-touch interaction. The directness in touch interaction gives a natural feel to their users [78]. Multi-touch and tangible input modalities in smart surfaces also influence user's interaction behavior and performance. It is reported that these systems support the natural style of interaction leverage the bandwidth of user interaction and performance while accessing the digital information [79]. From the physical characteristics aspects, the introduction to multi-touch screen as I/O device present various challenges issues i.e. size, shape, orientation and resolution of the screen and input support [80].

However, from the software aspects, interactive systems incorporate the different quality characteristics such as functionality, correctness, usability, reliability, maintainability, reusability, portability and efficiency [81]. These software characteristics play an important role to design and develop different type of software user interfaces. As, a major shift is extended in human computer interface technologies i.e. from Command Line Interface to Graphical User Interface and recently Natural User Interfaces. The association of these user interfaces with interactive systems brings a major paradigm shift in user interaction. It confirms that users always demand for novel and intuitive interfaces to replace the conventional interfaces [82]. It can be said that developments in the system technologies contribute in creating and influencing UX. It is therefore, a research study is carried out where the functionality, aesthetic, hedonic, responsiveness, input/output modalities and interaction affordances are considered to design and assess UX of the interactive systems [15, 17]. Users perceive these qualities while interacting with the system [18, 74]. The system's functional properties relate to the number of functions available to use, frequency of use, their structure and complexity.

Furthermore, system's modalities deals with the number of input/output streams that a user can perform while interacting with the system [83]. If a system supports uni-modal interaction then one input can be given to the system for performing a task. If a system supports multi-modality, then multiple input can be sent to complete the single or multiple tasks [39, 40]. Similarly, the system is incorporated with aesthetic qualities that may increase its beauty. Users can be pleased and attracted while using the system. It confirms that system properties can influence UX extensively. All system qualities are equally important to study while designing and evaluating UX. These properties collectively contribute in creating the different types of experiences. In order to assess different systems, various usability [4] and UX evaluation methods [3] are proposed in the different perspectives. These methods contribute to assess UX of interactive systems but include the different dimensions and limited scope. It is still required to confirm the suitable factors, their validity and measures to provide a consolidated solution to measure UX.

Based on the above ground related to the system aspects, it can be said that the rapid growth in hardware and software technologies are the key determinant of evolving and shaping up the variety of UX. It is observed that as technology grows then user needs changes over time. Users always demand for the quality of interaction methods that includes the direct and natural style of multi-modal interaction. It facilitates users to use their natural capacity of interaction to access and manipulate the digital

information. It can be argued that advancements in human computer interfaces technologies of interactive systems highly influence UX. Interactive systems, their interface technologies and user interaction support are shown in Figure-2.

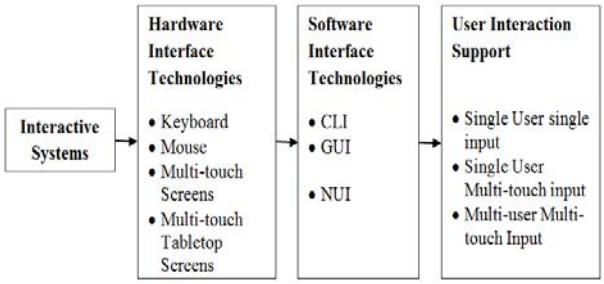

Figure-2. Interactive systems, their interface technologies and user interaction support.

Understanding Context

Similar to the above factors, the context factor plays an important role in creating and shaping up UX while interacting with systems. Thus, it is widely researched in the field of HCI to quantify UX. The term "context" in HCI refers to the physical environment or location where the system is used by users. The conditions where interaction takes place between users and computers to accomplish different tasks [68, 74]. The context is seen from the different perspectives such socio-cultural, market, time/historic, physical, use contexts [84]. The socio-cultural context refers to user personality like user's self-image, attitude, values, life style and previous experience. The market context refers to the product novelty like products comparison of other product relation. It may lead to the product generalization. The time/historic context relates to the product meanings like attachment, storytelling, memories, product penetration and roots while users experiencing it or experienced it before. The physical context refers to physical, aesthetic and atmosphere environment where user can perceive situations. The service context refers to the system availability, network connection, privacy, security, and associated costs [4, 60]. Finally, use context relates to interaction perspective where user performs different actions to accomplish the tasks and goals [84].

It suggests that researching the different types of contexts in the different domains show their importance and contribute in design and evaluation of interactive systems. For example, the rapid growth in interface technologies and miniaturization in computing devices like smart mobile phones and iPads enable users to use them in the mobile context e.g. on the road while walking, in the bus or in the cars while driving [16]. In the task context, sometime, a user requires more attention to accomplish the specific task [85]. Furthermore, UX is studied in the social context where a group of people work together [27, 86] to achieve a common goal. It clearly suggests that interacting with systems in different contexts contribute in creating various types of experiences such as experiences, an experience and co-experience [16]. It also suggests that when a context changes then UX may change accordingly, even the system and its related functionalities do not change. These different perspectives of contexts ultimately impact on UX [63]. The different types of contexts are shown in Figure-3.

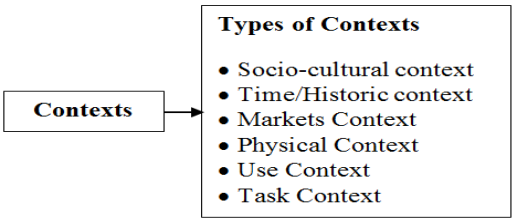

Figure-3. The different types of contexts.

Understanding Temporal Aspect

The notion of time is considered as a critical factor in UX and usually presented as a temporal aspect. The term "time" represents the duration or change and therefore time and experience are closely linked with each other. It is not possible to have experience without time. The term "time" can be categorized into two types, first the physical time that can be measured through clock, second the psychological time which reflect that how people sense time. It can be measured through person's sense of estimation. The psychological time has got greater attention in UX research. It is further categorized into two type i.e. retrospective and introspective time. The prospective time represents person's sensing time when an event is unfolded. However, the retrospective time reflects when a person recalls an event and its sub-events to estimate time therefore a memory related task [87]. Keeping in view such description on time, it can be said that the temporal natural of experience is therefore seen as integral aspect of experience. It involves the continuous process while creating and shaping up UX of interactive systems. It also suggests that UX can be anticipated, momentary and long term. It evolves over time therefore can be said that UX is highly subjective and dynamic in nature [88]. The dynamic experience represents that variety of experiences are to feel the changes [22]. From this perspective of feel to change, it can be said that user experiences can be continuous or discrete.

Many studies have demonstrated that different UX qualities changes over time [89]. For example, UX of personnel computer systems is different than the novel and intuitive systems such as Apple iPhone, multi-touch walls and multi-touch tabletop displays. These novel systems are associated with multi-touch screen as I/O device and support a direct and natural interaction method. Despite that, UX will be expected different after some time due to its evolving nature. It may bring change in user needs in terms of novelty, social meaning, hedonics, value and other qualities to be associated with interactive systems. Moreover, the existing qualities of systems can be perceived as fade up or outdated with respect to time. It suggests that understanding the temporal aspects in UX is

still evolving. It is creates a need to explore it to get deeper and expanded knowledge about the temporal aspect of UX. It may help in understanding that how UX evolves over time.

In recent years, a workshop is conducted where researchers have attempted to share their views on the notion of UX. From temporal aspect, it is mentioned that UX of interactive systems can be captured before usage (e.g. expected), during usage (e.g. momentary), after usage (e.g. episodic) and over time usage (e.g. cumulative) [88]. The temporal aspects along with the types of user experiences are shown Figure-4.

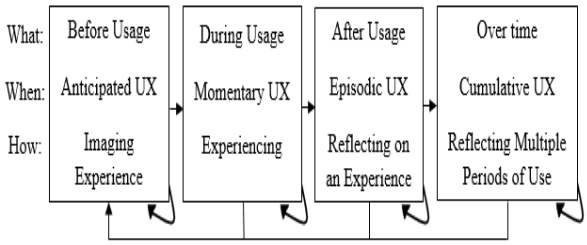

Figure-4. Temporal aspects along with the types of user experiences [88].

It is emphasized to study the core temporal aspect of UX that can be incorporated to design and assess actual usage of interactive systems. It suggests that clarifying the time span is extremely important while assessing the UX of interactive systems in a particular context. For example, the momentary experiences can provide information on a person's emotional feedback. The longer period can provide information about the eventual impact of momentary experiences on the cumulative UX. The importance of a strong negative reaction during use may diminish after successful outcomes and the reaction may be remembered differently. The previous experiences influence the future such as reflecting or recounting after one usage episode will frame expectations of future ones. The phases of experiencing overlap and interleave in a variety of orders, there is no fixed sequence from anticipating to recounting.

It is observed that presence of dynamics in UX enriches its scope. It leads to totality of UX that can be expected, actual, reflective and experiential experiences about interactive systems, products or services in different contexts. However, it increases more diversity and complexity too [90]. It presents challenges to quantify UX of interactive systems in different contexts. Motivating to these challenges, it is observed that several UX evaluation methods are proposed but less attention is paid to consider the temporal aspects of UX in their propositions. Thus, it is important to address issues of expected, momentary and long term UX in empirical and analytical evaluation methods to be produced. The temporal aspects related evaluation methods can be useful to assess UX at the different stages of interactive systems. These methods can be helpful to overcome issue of evolving nature of UX. Based on the review of temporal aspect, it is clear that UX can largely be influenced either positively or negatively at different stages while using the interactive system. It opens a new debate in the area that what UX aspects are measureable and what not such as love, affection and anger in the certain period of time and circumstances. Despite the evolving nature of UX, it can be assumed that everything can be measured and predicted. But, it is required to identify the relevant and appropriate subjective and objectives measures. There is further need to explore the area of temporal aspect in order to see that how UX evolves overtime. It can help interaction designers to improve quality of interaction through design and evaluation of interactive systems.

DISCUSSIONS

UX is grounded from various disciplines and associated with underlined core factors i.e. user, system, context and temporal aspect as mentioned above. These factors play a pivotal role in creating and influencing UX of interactive systems. It is observed that these factors are researched and practiced from different perspectives based on researchers' interest and background. These factors are interrelated and interdependent that collectively influences UX. For example, users have different inherent characteristics such as gender, age and region with their physical, cognitive and socio-cultural abilities, attitude and beliefs. It influences their UX while interacting with different systems. Users may have different UX while interacting with the same system and vice versa. It suggests that construction of UX highly depends on user profile, their characteristics, abilities and interaction methods facilitated by interactive systems. The presence of such diversity increases the scope of UX and gives an insight to design and develop generic interactive systems that should be useful and meet the affective needs of all types of users. But practically, it is a quite challenging task. To deal with such issues, the concept of user-centered design and development gained more interest in these years.

In order to fulfill user needs and goals, over the years, various types of interactive systems are designed and implemented using the different technologies. These systems deal with unique quality attributes such as technology, functionality, task, input/output modalities, design and aesthetics. However, these unique quality attributes of interactive system make them quite different from each other and contribute to create different types of UX. It confirms that technology and system design play major role in influencing UX. Interactive systems are widely used in the different contexts that also highly influence UX. Moreover, the temporal aspects deal with term time in UX research studies. It is mentioned that UX of the interactive system can be different, if it is used for momentary and long-term aspects in the home, office or public places.

For example, if a system is designed for disable people, would it be useful for or meet the requirement of normal users. Moreover, if a system is designed for

children, would it be useful for adults and old age users. From contextual perspective, if a system is designed for an office environment, then it would be hard to use in a public environment or field. In some contexts, the privacy and security have become more intimate to users.

Based on the existing literature review, it is also understood that UX can be seen as a process in field of HCI. From that point of view, an insight on theories of UX is presented where it is concluded that UX process is classified into three categories i.e. interaction, construction and evaluation [87]. In the interaction perspective, it is emphasized that actions and perception between user and system is key source of UX creation [91]. Here, it can be said that inherent interaction capabilities of users drive them to perform some physical and virtual actions to control and perform different tasks using the interactive system. Users also have perceptual capabilities (e.g. visual, touch and sensory) that drive them to perceive the system qualities. It is mentioned that UX is created based on perception of system quality, consequences and the process. It leads to a point of interest to know that what and how they perceive and understand interactive systems directly based on the short and long term use. Basically, it leads to UX construction process.

The construction is a basic process that has primary effect on making experiences, understanding and defining the meaningful relationships between user and system. The narratives and storytelling are the good examples of making experiences, meanings, values and defining the relationships about interactive systems based on the current and previous experiences. It refers to an idea to conceptualize and understand the situation where systems are used to perform tasks. The evaluation aspect in the process deals with assessment responses. It is focused to how users perceive, interact, think and make meaning about the interactive systems.

Keeping in view the challenging issues and potential use of three UX categories as mentioned in the above section, it is observed that management category should also be considered in UX process. The inclusion of this category into UX process may provide a strong rational to understand, define, model, measure and validate of UX. The process of UX is further extended and presented into four categories i.e. interaction, construction, management and evaluation as shown in Figure-5.

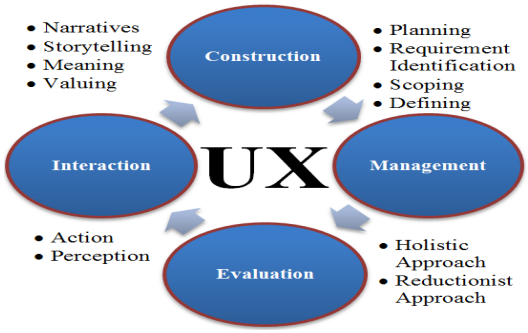

Figure-5. ICME: Dynamic process of user experience (UX) based on [87].

The management category in UX process may provide benefits of accommodating the richness of UX. It also may help in avoiding its complexity, dynamics and vagueness through planning, identifying the requirements, defining and scoping UX. It may provide a roadmap to focus on different kinds of users and identify their needs and goals for system design. It may help to deal with evolving nature of UX overtime and the contexts for which systems are designed and developed. It may also guide in terms of designing, developing and validating evaluation methods for interactive systems. There is a need to explore management category in the area of UX design and evaluation either considering the holistic or reductionist approach. It is still required to come up with the unified definition of UX for interactive systems. There is still need for more reliable, valid, lightweight, straightforward and cost effective evaluation methods to assess UX for interactive systems.

CONCLUSIONS

This paper aims to present the literature review on understanding factors influencing UX of interactive systems. It is understood that there are four core factors i.e. user, system, context and temporal aspects. These factors are comprehensively presented and discussed where it is understood that each factor is associated with various characteristics and qualities that collectively influence UX. They enrich the scope of UX but at same time bring vagueness and diversity in UX. It is grounded from many disciplines and encompasses many constructs and their relative dimensions and measures. It is a challenging task for HCI researchers to provide a unified definition of UX. The absence of an agreed UX definition presents limits to model, measure and quantify UX of interactive systems in different domains. However, to remedy these issues, this study suggests that UX can be seen as a process where it is important to include the management aspects. It can help interaction designers and UX professional to design and evaluate the interactive systems from different perspectives i.e. user, system and interaction.

REFERENCES

[1] J. Nielsen, Usability Engineering, vol. 44, no. 3. Morgan Kaufmann, 1993.

[2] F. Chen, "Chapter 5 USABILITY DESIGN AND EVALUATION," Evaluation, pp. 123–165, 2006.

[3] J. A. Bargas-avila and K. Hornbæk, "Old Wine in New Bottles or Novel Challenges ? A Critical Analysis of Empirical Studies of User Experience," in Most, 2011, pp. 2689–2698.

[4] E. L.-C. Law, V. Roto, M. Hassenzahl, A. P. O. S. Vermeeren, and J. Kort, Understanding, scoping and defining user experience. ACM Press, 2009.

[5] D. Wigdor and D. Wixon, Brave NUI World: Designing Natural User Interfaces for Touch and Gesture. Morgan Kaufmann Publishers Inc, 2011.

[6] M. Haller, P. Brandl, C. Richter, J. Leitner, T. Seifried, A. Gokcezade, and D. Leithinger, "Interactive Displays and Next-Generation Interfaces," Hagenb. Res., p. pp 433–472, 2009.

[7] C. Shen, "From Clicks to Touches : Enabling Face-to-Face Shared Social Interface on Multi-touch Tabletops," Communities, vol. 4564, pp. 169–175, 2007.

[8] C. Shen, K. Ryall, C. Forlines, A. Esenther, F. D. Verniers, K. Everitt, M. Wu, D. Wigdor, M. R. Morris, M. Hancock, and E. Tse, "Informing the design of direct-touch tabletops.," IEEE Comput. Graph. Appl., vol. 26, no. 5, pp. 36–46, 2006.

[9] S. Buisine, G. Besacier, A. Aoussat, and F. Vernier, "How do interactive tabletop systems influence collaboration?," Comput. Human Behav., vol. 28, no. 1, pp. 49–59, 2012.

[10] N. Bevan, "Classifying and selecting UX and usability measures," Int. Work. Meaningful Meas. Valid Useful User Exp. Meas., vol. 11, pp. 13–18, 2008.

[11] S. Adikari, C. McDonald, and J. Campbell, "A design science framework for designing and assessing user experience," Human-computer Interact. Des. …, pp. 25–34, 2011.

[12] S. Adikari, C. Mcdonald, and J. Campbell, "LNCS 6761 - A Design Science Framework for Designing and Assessing User Experience," Design, pp. 25–34, 2011.

[13] J. Takatalo, J. Häkkinen, J. Kaistinen, and G. Nyman, "Presence, Involvement, and Flow in Digital Games," in dots Experience in Games, no. 3, R. Bernhaupt, Ed. Springer, 2010, pp. 23–46.

[14] P. Desmet and P. Hekkert, "Framework of product experience," Int. J. Des., vol. 1, no. 1, pp. 57–66, 2007.

[15] R. Beauregard and P. Corriveau, "User experience quality: A conceptual framework for goal setting and measurement," Lect. Notes Comput. Sci. Incl. Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinforma., vol. 4561 LNCS, pp. 323–332, 2007.

[16] J. Forlizzi and K. Battarbee, "Understanding experience in interactive systems," Proc. 2004 Conf. Des. Interact. Syst. Process. Pract. methods Tech. DIS 04, vol. 37, no. 2, p. 261, 2004.

[17] J. Forlizzi and S. Ford, "The Building Blocks of Experience : An Early Framework for Interaction Designers," Human-Computer Interact., vol. pp, no. 6, pp. 419–423, 2000.

[18] M. Hassenzahl, "User experience (UX): Towards an experiential perspective on product quality," in Proceedings of the 20th International Conference of the Association Francophone d'Interaction Homme-Machine on - IHM '08, 2008, p. 11.

[19] G. Provost and J. M. Robert, "The dimensions of positive and negative user experiences with interactive products," Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics), vol. 8012 LNCS, no. PART 1, pp. 399–408, 2013.

[20] M. Hassenzahl and N. Tractinsky, "User experience - a research agenda," Behaviour & Information Technology, vol. 25, no. 2. pp. 91–97, 2006.

[21] E. L.-C. Law and P. van Schaik, "Modelling user experience – An agenda for research and practice," Interact. Comput., vol. 22, no. 5, pp. 313–322, 2010.

[22] E. L.-C. Law, V. Roto, M. Hassenzahl, A. P. O. S. Vermeeren, and J. Kort, "Understanding, scoping and defining user experience," Proc. 27th Int. Conf. Hum. factors Comput. Syst. - CHI 09, p. 719, 2009.

[23] C. Thompson, R. Anderson, and I. Au, "Managing user experience: managing change," CHI'10 Ext. …, pp. 3143–3146, 2010.

[24] E. L. C. Law and X. Sun, "Evaluating user experience of adaptive digital educational games with Activity Theory," Int. J. Hum. Comput. Stud., vol. 70, no. 7, pp. 478–497, 2012.

[25] J. Park, S. H. Han, H. K. Kim, S. Oh, and H. Moon, "Modeling user experience: A case study on a mobile device," Int. J. Ind. Ergon., vol. 43, no. 2, pp. 187–196, 2013.

[26] D. Ouden, "Introduction," pp. 1–16, 2012.

[27] C. M. Macdonald, "Changing Perspectives on Evaluation in HCI : Past , Present , and Future," pp. 1969–1978, 2013.

[28] I. Benbasat, "HCI Research: Future Challenges and Directions," Trans. Human-Computer Interact., vol. 2, no. 2, pp. 16–21, 2010.

[29] B. Shneiderman, Leonardo's Laptop: Human Needs and the New Computing Technologies, no. October 2002. MIT Press, 2003.

[30] C. Courage and K. Baxter, Understanding Your Users, vol. 2006. 2005.

[31] N. Dordevic, D. Rancic, and A. Dimitrijevic, Evaluation of user cognitive abilities for HCI. 2007.

[32] S. Ahmed, K. Wallace, and L. Blessing, "Understanding the differences between how novice and experienced designers approach design tasks," Res. Eng. Des., vol. 14, no. 1, pp. 1–11, 2003.

[33] S. Keates, P. Langdon, P. J. Clarkson, and P. Robinson, "User models and user physical capability," User Model. User-adapt. Interact., vol. 12, no. 2–3, pp. 139–169, 2002.

[34] B. Reeves and C. Nass, "Perceptual user interfaces: perceptual bandwidth," Communications of the ACM, vol. 43, no. 3. pp. 65–70, 2000.

[35] C. Lewis, "HCI and cognitive disabilities," interactions, vol. 13, no. 3. p. 14, 2006.

[36] J.-W. Chen and J. Zhang, "Comparing Text-based and Graphic User Interfaces for novice and expert users.," AMIA Annu. Symp. Proc., pp. 125–129, 2007.

[37] C. Lewis, "HCI for people with cognitive disabilities," ACM SIGACCESS Accessibility and Computing, no. 83. pp. 12–17, 2005.

[38] T. Lewis, P. M. Langdon, and P. J. Clarkson, "Chapter 10 Prior Experience of Domestic Microwave Cooker Interfaces : A User Study," Des. Incl. Futur., pp. 95–106, 2008.

[39] A. B. Naumann, I. Wechsung, and S. Möller, "Factors influencing modality choice in multimodal applications," in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2008, vol. 5078 LNCS, pp. 37–43.

[40] K. P. Engelbrecht, C. Wootton, I. Wechsung, and S. Möller, "Evaluation of a voice-based internet browser with untrained and trained users," in Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 2009, vol. 5616 LNCS, no. PART 3, pp. 482–491.

[41] S. E. Bibri, The Human Face of Ambient Intelligence, vol. 9. 2015.

[42] G. Van Vliet, P.J.A., Kletke, M.G., & Chakraborty, "The measure of computer Literacy: a comparision of self-appraisal and objevtive tests," vol. 34(4), pp. 457–471.

[43] B. Smith, P. Caputi, and P. Rawstorne, "The development of a measure of subjective computer experience," Comput. Human Behav., vol. 23, no. 1, pp. 127–145, 2007.

[44] A. Dillon and C. Watson, "User analysis in HCI — the historical lessons from individual differences research," Int. J. Human-Computer Stud., vol. 45, pp. 619–637, 1996.

[45] C. Chen, "Individual differences in a spatial-semantic virtual environment," J. Am. Soc. Inf. Sci. Technol., vol. 51, no. 6, pp. 529–542, 2000.

[46] A. G. Fisher, "Assessment of Motor and Process Skills (AMPS)," User Manual. Fort Collins, CO Three Star Press., vol. Vol. 2.

[47] N. Benson, D. M. Hulac, and J. H. Kranzler, "Independent examination of the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV): what does the WAIS-IV measure?," Psychol. Assess., vol. 22, no. 1, pp. 121–130, 2010.

[48] W. N. Morris and P. P. Schnurr, Mood: The frame of mind, vol. XII. Springer-Verlag Publishing, 1989.

[49] H. Bless, N. Schwarz, G. L. Clore, V. Golisano, C. Rabe, and M. Wölk, "Mood and the use of scripts: does a happy mood really lead to mindlessness?," 1996.

[50] E. Law, A. Vermeeren, M. Hassenzahl, and M. B. Eds, "Towards a UX Manifesto COST294-MAUSE affiliated workshop," Structure, vol. 2, no. September 2007, pp. 205–206, 2007.

[51] S. B. Andrews, F.M., & Withey, "Social indicators of well-being: New York: Plenum.," 1976.

[52] J. D. Mayer and Y. N. Gaschke, "Brief Mood Introspection Scale (BMIS)," Psychology, vol. 19, no. 3, pp. 1995–1995, 2001.

[53] R. E. Mayer and R. Moreno, "A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory.," Journal of Educational Psychology, vol. 90, no. 2. pp. 312–320, 1998.

[54] D. Kahneman, "Objective Happiness," in Well-being: The foundations of hedonic psychology, D. Kahneman, E. Diener, and N. Schwarz, Eds. Russell Sage Foundation, 2003, p. 608.

[55] N. Schwarz and G. Clore, "Mood as Information: 20 Years Later," Psychological Inquiry, vol. 14, no. 3. pp. 296–303, 2003.

[56] T. S. da Silva, A. Martin, F. Maurer, and M. Silveira, "User-Centered Design and Agile Methods: A Systematic Review," 2011 Agil. Conf., pp. 77–86, 2011.

[57] R. W. Robak and P. R. Nagda, "Psychological Needs: A Study of What Makes Life Satisfying," N. Am. J. Psychol., vol. 13, no. 1, pp. 75–86, 2011.

[58] K. M. Sheldon, A. J. Elliot, Y. Kim, and T. Kasser, "What is satisfying about satisfying events? Testing 10 candidate psychological needs.," J. Pers. Soc. Psychol., vol. 80, no. 2, pp. 325–339, 2001.

[59] G. E. Burnett and D. Ditsikas, "Personality as A-Criterion for Selecting Usability Testing Participants," 2006 ITI 4th Int. Conf. Inf. Commun. Technol., 2006.

[60] A. B. Naumann, I. Wechsung, and J. Hurtienne, "Multimodal interaction: A suitable strategy for including older users?," Interact. Comput., vol. 22, no. 6, pp. 465–474, 2010.

[61] R. L. John, O.P., Donahue, E.M., Kentle, "The Big Five Inventory--Versions 4a and 54.," Berkeley, CA Univ. California, Berkeley, Inst. Personal. Soc. Res., 1991.

[62] P. T. Costa and R. R. McCrae, Professional manual: revised NEO personality inventory (NEO-PI-R) and NEO five-factor inventory (NEO-FFI). Psychological Assessment Resources, 1992.

[63] B. Rammstedt and O. P. John, "Measuring personality in one minute or less: A 10-item short version of the Big Five Inventory in English and German," J. Res. Pers., vol. 41, no. 1, pp. 203–212, 2007.

[64] C. Ardito, C. M.F., R. Lanzilotti, and M. F., "Towards the evaluation of UX," Int. Conf. HCI 2007, no. September 2007, pp. 6–9, 2007.

[65] M. Doh, L. I. Schmidt, F. Herbolsheimer, M. Jokisch, and H. Wahl, "Human Aspects of IT for the Aged Population. Design for Aging," vol. 9193, pp. 177–188, 2015.

[66] M. Zajicek, "Aspects of HCI research for older people," Univers. Access Inf. Soc., vol. 5, no. 3, pp. 279–286, 2006.

[67] Y. S. Lee, "Older Adults' User Experiences with Mobile Phones: Identification of User Clusters and User Requirements," Virginia Polytechnic Institute and State University, 2007.

[68] S. Engl and L. E. Nacke, "Contextual influences on mobile player experience - A game user experience model," Entertain. Comput., vol. 4, no. 1, pp. 83–91, 2013.

[69] V. P. de Almeida Neris, K. R. da Hora Rodrigues, and R. F. Lima, "A Systematic Review of Sustainability and Aspects of Human-Computer Interaction," Human-Computer Interact. Appl. Serv. SE - 71, vol. 8512, pp. 742–753, 2014.

[70] M. Bergaus, Design Issues for Service Delivery Platforms, no. 1991. 2015.

[71] U. Hoehne-Hueckstaedt, S. Keller Chandra, and R. Ellegast, "Ergonomic Requirements for Input Devices," Ergon. Heal. Asp. Work with Comput., vol. 4566, pp. 216–224, 2007.

[72] M. Penha, W. Correia, M. Soares, F. Campos, and M. Barros, "Ergonomic Evaluation of Usability with Users – Application of the Technique of Cooperative Evaluation," pp. 379–388.

[73] S. A. Douglas and S. L. Limited, "4 . A Survey ofErgonomic Studies," pp. 63–84, 1997.

[74] B. Shackel, "Usability - Context, framework, definition, design and evaluation," Interact. Comput., vol. 21, no. 5–6, pp. 339–346, 2009.

[75] R. W. Picard, "Affective computing: Challenges," Int. J. Hum. Comput. Stud., vol. 59, no. 1–2, pp. 55–64, 2003.

[76] T. Technologies, Part 5.7.

[77] J. Y. Han, "Low-cost multi-touch sensing through frustrated total internal reflection," Proc. 18th Annu. ACM Symp. User interface Softw. Technol. - UIST '05, pp. 115–118, 2005.

[78] H.-C. Jetter, H. Reiterer, and F. Geyer, "Blended Interaction: understanding natural human–computer interaction in post-WIMP interactive spaces," Pers. Ubiquitous Comput., vol. 18, no. 5, pp. 1139–1158, 2014.

[79] M. Haller, P. Brandl, C. Richter, J. Leitner, T. Seifried, A. Gokcezade, and D. Leithinger, "Interactive displays and next-generation interfaces," Hagenb. Res., pp. 433–472, 2009.

[80] C. Müller-tomfelde and M. Fjeld, "Tabletops - Horizontal Interactive Displays," pp. 1–24, 2010.

[81] A. Seffah, "Patterns of HCI Design and HCI Design of Patterns," pp. 59–80, 2015.

[82] F. Karray, M. Alemzadeh, J. a Saleh, and M. N. Arab, "Human-Computer Interaction: Overview on State of

the Art," Int. J. Smart Sens. Intell. Syst., vol. 1, no. 1, pp. 137–159, 2008.

[83] A. Bellucci, A. Malizia, and I. Aedo, "Light on Horizontal Interactive Surfaces - Input Space for Tabletop Computing," ACM Comput. Surv., vol. 46, no. 3, pp. 32–42, 2014.

[84] U. Reiter, K. Brunnström, K. De Moor, M. Pereira, A. Pinheiro, J. You, and A. Zgank, "Factor Influencing Quality of Experience," 2014, pp. 55–72.

[85] L. Nacke and A. Drachen, "Towards a Framework of Player Experience Research," Proc. Second Int. Work. Eval. Play. Exp. Games FDG 2011, Bordeaux, Fr., 2011.

[86] G. Cockton, "Putting Value into E-valu-ation," in Maturing Usability, 2008, pp. 287–317.

[87] A. Al-Azzawi, "Chapter 2: Theories of Experience," in Experience with Technology Dynamics of User Experience with Mobile and Media Devices, 2014, pp. 7–29.

[88] D. Seminar and D. U. Experience, "User Experience White Paper," Seminar, pp. 1–12, 2011.

[89] V. Roto, E. Law, and A. P. O. S. Vermeeren, "User experience white paper," 2011.

[90] E. Karapanos, Quantifying Diversity in User Experience, vol. 93. 2010.

[91] D. A. Norman, The Design of Everyday Things, vol. 16, no. 4. 2002.