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TACKLING DESIGN ISSUES ON ELDERLY SMARTPHONE INTERFACE DESIGN USING ACTIVITY CENTERED DESIGN APPROACH

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ABSTRACT

Activity theory is the conceptual framework that is derived from the socio-cultural tradition in Russian psychology. The foundational concept of the framework is 'activity', which is understood as purposeful, transformative, and developing interaction between subjects and the world. Activity theory used to enhance the understanding of the behavior and characteristics of the individual and how the relevant social entities interact with technology for daily activities. Reviews on the smart phone interface for the elderly is not something new and various research approaches were carried out to help the elderly to get use of the smart phone technology. Until recently, most of the interface design use user centered design as main methodology. Activity theory is seen as a potential method to help researchers to identify aspects where in activities that contribute to the inefficiency of the interface design activities. In the paper, we will explain why activity centered design (ACD) is selected from other Human-Computer Interaction (HCI) methodology commonly used to study the interface design. In addition, we will describe the challenges faced when using ACD as the main methodology of the study. The population selected for this study is populated urban area in Malaysia, a developing country in term of the use of technology.

Keywords: activity theory, design issue, smartphone, interface, elderly.

INTRODUCTION

Smartphone technology adoption in Malaysia has increased over the past ten years. However the widespread use of this technology can only be seen on teenagers, children and corporate groups. The elderly are often seen left behind in the technological advances (Naji, 2012). Previous studies indicate these people have several factors to be the constraints acceptance of new technology. Various services were provided primarily through smart phone devices to help increase the quality of life of senior citizens such as a navigational aid, an interactive diary, alarm systems and emergency services; however these services do not get much positive result due to the elderly perception complexity towards the technology and accessibility problems. Our study attempt to find out how to increase the acceptance level of the elderly towards Smartphone technology using activity centered design framework as an embodying methodology.

ELDERLY'S PROBLEM

Ministry of Health Malaysia defines elderly as those aged 60 years and above. Setting the rate at age 60 is lower than the age adopted by the World Health Organization (WHO) at 65 years. According to Berg (2000), Human aging causes a decrease in the number of functions in the body and mental health. Cognitive function is one of the functions to decline due to age. Cognitive is the ability to think, to focus on, generate ideas, and remembering. Aging causes a decrease in the level of intelligence, including mental speed of information processing, memory loss, and the ability to learn. Most of the elderly will have a declining in their vision and hearing perception ability. Stuen and Faye (2003) states the elderly often have vision problems such as difficulty focusing on things, decrease visibility in the dark, decrease sensitivity to color matching, and sensitivity to glare. In addition, the elderly are at risk for having a limited perception of color which has a shorter wavelength color like green and blue. Furthermore, the elderly are particularly at risk for eye diseases such as cataracts, diabetic retinopathy and glaucoma which is a serious vision problem. Arlene (2005) noted that hearing loss often occurs in the elderly as the ability to receive high-pitched voice consonants. They also have difficulty to distinguish whether the sound comes from the front or back. Aging also causes the muscle and nerve function cannot function efficiently over the age of consent (Chaparro *et. al.*, 2000). The combinations of these potential functional declines will affect performance of delicate motor tasks such as moving fingers and hand. Chaparro *et al.* (2000) state these functionality reductions is reflected based on speed, precision and consistency of movements by the elderly.

Most of smart phone latest models use touch screen technology as a primary input, thus we can see the evolution of the smart phone interface design in accordance with the touch screen. The use of touch screen-based input has been proven to increase the usability of computer technology, therefore, a lot of research carried out to adapt the touch screen technology to computer technology regardless of device size. Increasing age causes a decline of cognitive, perceptual and psychomotor function and the decline is capable of affecting the usability of a technology. Previous studies indicate touch screen technology can facilitate engagement by the elderly, but should be supported by interface design that appropriate for the type of device and user (Peter, 2007). This study believes to discover on how an appropriate interface design is capable to less the difficulties they were having with the declining of the perception and cognitive functionalities in using smartphone technology.

ELDERLY INTERFACE DESIGN

Several recent studies have found that mobile technologies that help based on the needs of older users are very necessary (Abdulrazak *et al*., 2013). Difficulties in adoption smart phone for the elderly were due to the complexity in term of interface design and navigability, the quantity of information displayed on the screen and the number of functions that do not suit their needs. Most previous studies indicate the accessibility is the main problem that hinders the acceptance and usability of an interface. Arab *et al*., (2013) he stated that very few studies conducted to identify the needs and difficulties of the elderly population during interaction with computer technology, especially smartphone technology.

Existing interface is one of the reasons why seniors are not comfortable to use software or computer. This is realized by a group of researchers Hunter *et al*. (2007) stated that a special interface is required for the elderly for more efficient daily use. This statement was further supported by Peter (2007) who states elderly and disabled people require different approaches in the use of computer interfaces. Numerous approaches and modifications can be done on the interface for the elderly. This modification is needed to overcome some of the problems often faced by this group.

The main problem faced by the elderly is in visibility. The majority of elderly has nearsightedness problems and blurred vision. Age factor causing the decline in their visibility compared to young people. Existing computer interfaces are designed based on the suitability of users who do not have any vision problems or cognitive decline. The characteristics of interface design for the elderly should in line with their level of visibility. Among the factors or characteristics that must come first is the text size, image size, and the choice of colors used.

The size of the text is dependent on the resolution of a display screen. Typically, the size of the text used is small but readable by the human eye that not having any problem. According to Niamh *et al*. (2010) for the elderly have the functional regression problems, the size of the text is too small and unclear. This interferes with the use of computers because reading a text is necessary to perform any function in the software. Therefore, text size should be larger in interface for elderly users. The size of the word must be set at least at a size 14 to help the elderly who have poor visibility to read. Murni *et al*. (2005) in her research state that the selection of text is also important to ensure that the use of the text type is not too confusing and can be clearly understood by elderly people.

In addition, the soft colors should be used because the elderly people prone to vision problems when dealing with colors that are too bright. The use of white color background should be avoided. Besides the color differentiation between the content and the background color should be chosen precisely to highlight the text wanted to be shown to the elderly user. Study by Lorenz *et al*. (2009) shows a dark background will result in fatigue and reducing reading ability among the elderly. In fact, the white background will give a better reading, but older people will feel uncomfortable due to the high brightness. Thus, Lorenz *et al*. (2009) stated orange or bright gray background color, black, white or turquoise text color, text size between 30 to 54 pixels, non-serif-Arial text type and 60 x 60 pixels icon is ideal for designing touch screen monitor interface.

Designing an interface for elderly user must accord to their convenience. Apart from the text and colors used, images or graphical content should be large and clear. Animation should be avoided because it would interfere with the focus of senior citizens to interact with the computer. Icon design should be simple to understand and refers precisely to the function of the icon (Murni *et al*., 2005). The interface should only display important content and the irrelevant element should be removed to facilitate their reading.

Most elderly users have problems to understand the function of interactivity of a computer interface. Instead of using interaction concepts such as scrolling and drag and drop, previous research proves that the elderly only likely to use traditional pressing button method. Based on the studies by Zhao *et al*. (2007), button size should be used at least 11.43 mm2 for single button and 16.51 mm2 for pairs. However, to enhance the ability of elderly visibility, button size of 19.05 mm2 will give a better impression. For horizontally arranged button the distance between buttons should be between 3.17 mm to 12.7 mm. Zhao *et al*. (2007). Larger gapsmore than 19.05 mm will reduce the efficiency in terms of the elderly to find a button. In addition, the study also shows that if there is no distance between the buttons, will give lowest accuracy and the preference, this however depends on how large the button size is. For the elderly who have a poor hand movement control, the size and spacing between buttons that proposed is 16.51 mm2 and 3.17 to 6.35 mm respectively. However, for the elderly who have weak hands, the button size and spacing between the buttons is better suited 19.05 mm^2 and 6.35 to 12.7 mm, respectively.

The elderly are not proficient in computer use, even hard to understand the functions that are available in an interface. Special assistance in terms of navigation should be given during the use of computer (Hunter *et al*., 2007). Navigation aid can come in the form of text or image that helps them choose the proper navigation such as required by the user.

Previous studies also have acquired the target size for the appropriate contact with the large touch screen surface (Jennifer *et al*., 2009), PDA (Kunjachan, 2010), or recently to computer tablet and smartphone (Henze *et al*., 2011), including from elderly as the target user. It is commonly accepted that visual acuity, contrast sensitivity, visual search capabilities (Arthur *et al*., 2009), fine-motor skills, hand dexterity (Carmeli *et al*., 2003) and touch sensitivity (Wickremaratchi and Llewelyn, 2006) suffer considerable losses with age. Additionally, natural age-

related declines of the sensory and psychomotor systems can be further aggravated by diseases such as cataracts, glaucoma, osteoporosis, stroke and Parkinson's disease (Kurniawan, 2008). Movement can be severely affected by these diseases, causing symptoms such as weakness, numbness, loss of muscle coordination, pain, stiffness, tremors, rigidity and slow movement. Therefore, one cannot safely assume that target size that has been found to be adequate for younger adults will also provide a comfortable user experience for the elderly.

Research by Leitao and Silva (2012) revealed that their performance is best with targets between 14 and 17.5 mm while official guidelines recommend targets between 7 and 9 mm which are considerably smaller for older adults. In accordance, many interfaces developed specifically for older adults make use of large tap targets. The use of large taps targets makes it easier for older adults to see targets, to distinguish between adjacent targets, as well as allowing them to more accurately acquire tap targets. Larger touchable areas compensate for issues related to movement control and hand dexterity.

The relatively large size of these tap targets may raise issues related to the number of targets that need to be displayed and the available screen real estate to do so, which in turn may lead to the need to make certain compromises. One of the compromises might be to place all interface elements in a large scrollable vertical list, or to divide the content into several pages (Hoober and Berkman, 2011). However, opting for any of these solutions would either result in an increased number of necessary swipes to navigate a long list, or in a larger amount of navigation layers. In both cases, the complexity of the navigation system would increase and could in fact become an issue for older adult users, who have been found to have more difficulty in operating complex navigation (Ziefle, 2010). On the other hand, an alternative solution could be to reduce the number of functionalities or options in the interface, thus avoiding the long list of items or for an excessive amount of pages. However, while a reduced set of functionalities could be effective for the elderly population, whom are likely to have low levels of technology proficiency, it might not be suitable for younger users who could be expecting a broader range of services from the interface (Leitao and Silva, 2012).

Another crucial aspect to identify the object size on the interface is the gap or spacing between each interface element and this is important as it related to tapping accuracy. The most obvious example can be seen is on the virtual QWERTY keyboard which having a minimum distance between each key and this becoming a real constraint for users whom having a large fingertip. Abrahao *et al.* (2013) stated that decreasing spacing between interface elements and increasing of interaction complexity will only contribute to decreasing of accuracy especially for the elderly.

ACTIVITY THEORY

Activity theory is a conceptual framework originating from the socio-cultural tradition in Russian psychology. The foundational concept of the framework is "activity", which is understood as purposeful, transformative, and developing interaction between actors ("subjects") and the world ("objects") (Kaptelinin, 2013). The framework was originally developed by the Russian psychologist Aleksei Leontiev in the 1980s, later then a version of activity theory, based on Leontiev's framework, was proposed in the 1980s by the Finnish educational researcher, Engeström on 1987. Currently, variants of activity theory, as well as their combinations, are being widely used interdisciplinary, not only in psychology, but also in a range of other fields, including education, organizational learning, and cultural studies (Kuutti, 1996).

Activity theory is used to develop the most appropriate research methods to expose the relationship between human or user interaction and design activity in relation to smartphone interface. The objective of using activity theory is to better understand the behavior and relevant characteristics of individuals and how these social entities interact with the technologies they use in the activities of their daily life (Kaptelinin and Nardi, 2006).

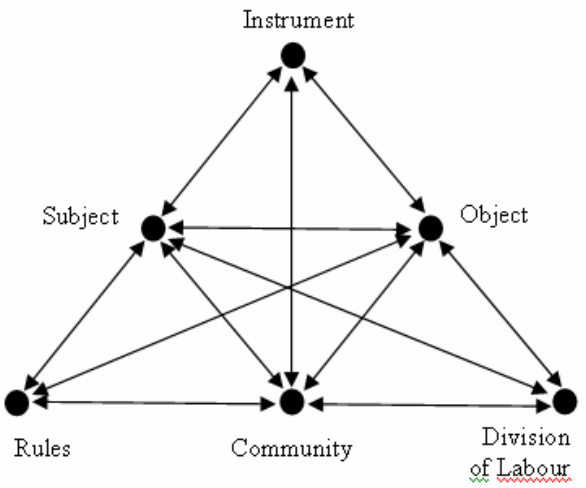

Figure-1. Engeström's diagram of activity analysis to communication and learning.

This research has adopted the structure of the Activity Theory Diagram above to analyze the activities and mediating relationships between the subject (elderly people), object (the current standard smartphone interface), the division of labor (the authorities involved in smartphone interface design), and community which overall encompass all of the key stakeholders. The rules indicate government laws, organizations and policies developed around Smartphone interface design, including several research disciplines through the implementation of assisting technology for rising amount of elderly user.

Figure-2 shows how this research uncovered a disturbance or disconnection in the current smartphone interface design implementation. The framework shows that the communication and relationship between stakeholders are often disconnected in the current

implemented system. Disconnections imply a lack of functionality and reveal that system participants are operating under false assumptions if they are operating as if the linkages are complete. Activity theory helped the researcher to identify which areas in the systems create problems that lead to inefficiency (Gay and Hembrooke, 2004). Figure-2 shows that a disturbance or disconnection clearly exists between the function of accessibility to control the smartphone interface and the elderly whom use the smartphone technology. Problems that occur in the implementation of this activity system is an element that must be improved to meet the objectives of this study.

Activity theory framework has enabled the research to identify the relationship between the tools used, existing rules in the activity environment and the people involved. Besides, the framework helps to understand the cultural, physical and social phenomena of the current situation as those are the foundation for understanding activity systems. Although the study was conducted through the disciplines of design, activity centered design with the use of Engeström's activity theory analysis was used to develop research strategies. Different levels of stakeholders were identified according to particular professional and social roles, responsibilities, qualifications and cultural beliefs. The hierarchy of actions and the identification of the different components of an activity system provide helpful guideposts for articulating and examining the complexity of the content (Gay and Hembrooke, 2004).

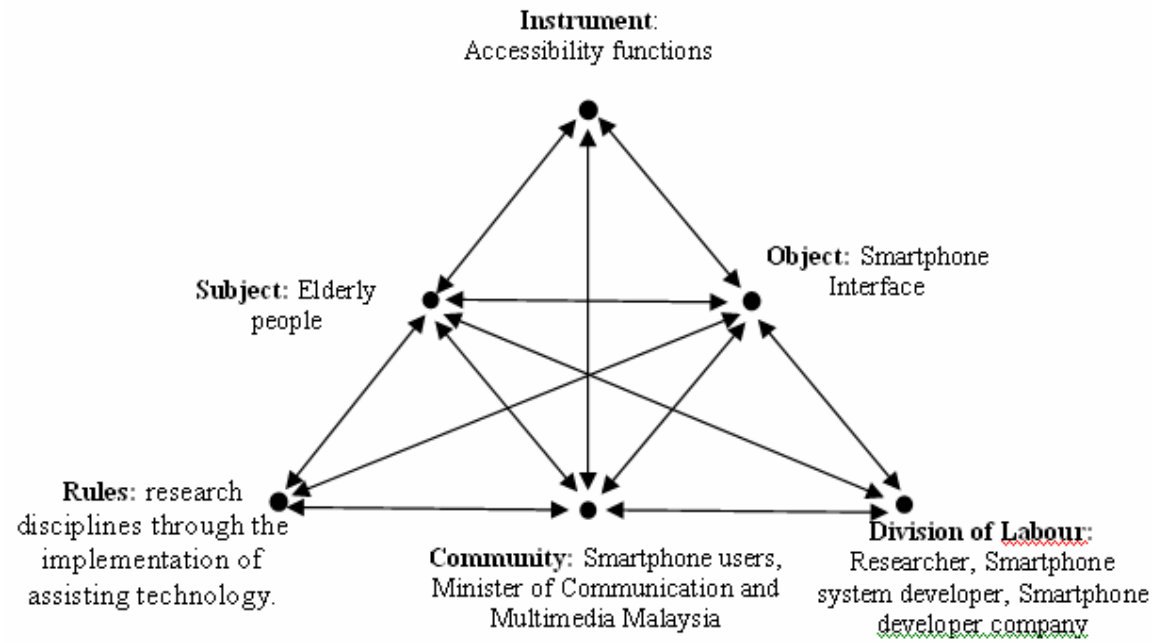

Figure-2. Activity diagram adapted to accommodate the implementation of the elderly Smartphone interface design.

ACD vs UCD

User centered design (UCD) appear to focus on the same unit of analysis as activity centered design on interaction between human beings (users) and objects (interactive systems).However, while the "user-system" interaction can be considered a component part of the activity, the purposeful interaction with the world cannot be limited to interaction with the user interface of an interactive system. UCD models deal with lower-level interaction limited to "task". Tasks are typically described in terms of the functionality of a system rather than their meaning for the subjects. However, using a system does not normally have its own purpose. The meaning of "task" is determined by a larger context of human activity carried out to accomplish things that are important regardless of the technology itself (Kaptelinin and Nardi, 2006).

Activity theory requires that the scopes of analysis be extended from tasks to a meaningful context of a subject's interaction with the world, including social context. The boundary of the interaction objective is not limited by the user interface. Making a meaningful activity the unit of analysis means that not only an interaction between people and technology is considered, but also the objects in the world with which subjects are interacting via technology.

Another difference between the activity theory perspective and traditional HCI is that while traditional HCI models focus on abstract, formal representations of individual component parts of interaction which is the user and the system. Activity theory emphasizes the importance of studying the real-life use of technology as a part of unfolding human interaction with the world.

Finally, traditional approaches and models in HCI pay limited attention to developmental changes, with some exceptions, such as attempts to provide an account of differences between novice and expert computer users

while activity theory take into account changes in user development, technology interaction and the overall context of the long-term reviews.

SCOT MODEL

Activity theory is described as having an ecological perspective. Ecology recognizes the complexity and interconnectedness of systems. Ecology also acknowledges that human must be managed and studied over time in order to gain an accurate perspective on their function and comprehensiveness. (Gay and Hembrooke, 2004).

It is crucial to understand the process of how social interaction plays a large role in design development. Therefore, the SCOT (Social Construction of Technology) model used to consider the many social perspectives that surround the development of design or technology to meet the need of social groups (Zulisman, 2012).

The SCOT (Social Construction of Technology) model encourages the designer to consider the interactions, ambiguities and complexities within and between various groups that are defining and developing digital or conventional technological environment. These multiple social perspectives that surround the growth of new technologies help develop a more holistic approach, which contrasts with standard practices in technological development (Gay and Hembrooke, 2004).

In this study the SCOT model is used to help the researcher identify the interactions involved between the stakeholders and the ambiguities that exist in the current interface design processes and to understand the complex issues that surrounding the current smartphone interface design. The establishment of expert driven systems was once seen as a sufficient model of design development but increasingly designers are proactively addressing the particular needs and challenges of their intended users. Therefore, different versions of design and media delivery must be considered and resolved, resulting in a better community consensus and better communication overall. The main SCOT concepts are interpretive flexibility, closure and evaluation.

Interpretive flexibility

Interpretive flexibility means that each technological artifact has different meanings and interpretations for various. Different interpretations can produce a solution to a particular problem and can produce expectations that lead to the modification of the design artifact.The basic social groups are the target users and groups that develop the technology. Besides, social groups can differ not only in terms of experience, technical expertise and goal but also in their ability to influence the final project. (Zulisman, 2012).

In this study, the involvement of various social groups with different levels of hierarchy such as target users, standard users, smartphone interface designers and HCI expertisefor elderly user will help bridge the gap between actual user's needs and the design develop to serve them. The data gathered from interviews, surveys and observation with the involved social groups are used to decipher the different interpretations, idea, understandings and expectations that will help in the design process.

Closure

Closure is a process whereby some sort of consensus in finalizing the process to reach an agreement is made through the design of the systems and solution. To achieve closure, the systems developed must take into account the various interpretations gathered in the research and investigation process. The concept of closure occurs when a consensus emerges, that is a kind of truth has been winnowed from a various interpretations and so the problems move towards resolution (Zulisman, 2012).

In this research, the proposed design solutions have come from a consensus between different levels of stakeholders and various issues relating to target users in relation to their experience of using mobile phone technology.

Evaluation

Activity centered design and user-centered design methods often adopt a circular iterative process in which evaluation is a critical component of a design. After several design iterations it is expected that the design will incorporate perspectives from each group or be specially tailored to meet particular needs (Zulisman, 2012).

Evaluation is used throughout the research process in order to identify gaps, disturbance and weakness of the current smartphone interfaces for the use of elderly people. Evaluation is also used to gather information relating to actual user's problems and their needs and to get opinions from the stakeholders of modification to be done.

CONTEXTS AND SETTING

Research investigation was conducted in order to observe and gather information for an objective understanding of an actual situation. This was necessary to move towards a more accurate assessment of the situation. One of the purposes of the investigation was to identify any issues relating to the acceptance of Smartphone technology by the target users. It was also intended to fully identify the environmental cause, affection by the social element and to analyze how the actual user handling the current existing smartphone interfaces. Identifying and analyzing the above factors would help to raise up the design issues on the smartphone interface for elderly users. The study prescribes all data collection conducted specifically in the urban area due to the lack of smartphone adoption by the elderly in Malaysia. It is very difficult to collect data on the elderly smartphone usage, especially in rural area. High technology adoption by urban communities is a factor which helps increase technology adoption, including smart phones by a small percentage of the elderly who reside in the urban (reference, 2013). Data collection was done in two phases which are Preliminary Data Collection Phase and Design

Phase. Among the methods used for data collection process is a survey, interviews and observations.

As the research developed within the structures of Activity Theory, a research investigation was designed to fit the parameters of the framework. Preliminary data collection phase involved three stakeholders: elderly user whom own and use smartphone with touch screen, and the elderly who do not have experience using smartphone; adult smartphone user (age between 40-60 years old); and experts from few fields such as HCI experts, smartphone interface designer, optometrist. Questionnaires were distributed to the elderly smartphone user and the adult smartphone user to obtain information about smartphone usage, what factor influence those groups to change from an old mobile phone or feature phone to current smartphone with touch screen and their opinion on the existing smartphone interface.An observation was done with a number of elderly whom no experience in using touch screen based smartphone but do have some experience in using feature phone. Several interviews were conducted to get feedback and relevant opinions about criteria of elderly smartphone interface that should be concerned and suitable with the elderly acceptance and their interactivity ability.

Questionnaires and interviews are used repeatedly in the design phase for the completion of the design activity according to schematic interface design. Stakeholder involved in the preliminary data collection was used again (except the optometrist) in order toensure the accuracy of the information obtained. While the preliminary data collection shows different information were gathered from different groups of social elements, design phase gave all stakeholder the same sets of questionnaire to collect different sets of idea about the icon and interface design that suits target user. The idea gathered from different respondents with different experience and background will then be analyzed to produce the final design.

Table-1. From "user-system" interaction to activity (Kaptelinin and Nardi, 2006).

	Unit of analysis	
	User-system interaction	**Subject-object interaction**
Context	Users and systems	Subjects in the social world
Level of analysis	System-specific tasks	Meaningful goal-directed actions
Methods	Formal model, lab studies	Studies of real-life use
Time span	Limited time span	Developmental transformation

SUMMARY

Activity centered design theory is a research framework that provides a template for research methods chosen to accomplish this research activity. This theory helped in mapping the complexity of the topic and also provided an understanding of the effectiveness of the current smartphone interface design towards elderly users. The activity centered design theory also helped to identify the turbulence that exists in the current activity systems. This methodology minimizes any error or any overlooked issues that may arrive as it gives a clear universally applicable framework for research content and structure. Activity centered design theory illustrates above all the centrality of design to whole activity in smartphone design interface as it provides basic organizing principles that link the diverse levels of contribution.

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