Making Software Humane: The Effects of Affective and Anthropomorphism on the Adoption of an M-Health Application

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ABSTRACT

With the proliferation of mobile devices, provision of M-health care services has become feasible even in the remotest villages of Africa. Research however shows that many M-health initiatives have not been adopted and used effectively especially in rural communities. Some of the factors contributing to this range from a lack of knowledge with regard the use of technology, literacy challenges, possible fear of technology, to a lack of information regarding these interventions.

In this paper, we demonstrate that an initiative designed to recognize usability as its core function plays a critical role in the use and adoption of M-health interventions in rural communities. Two versions of an M-health intervention were developed and two interface design principles that may have an impact on users' emotions applied, namely affective design and anthropomorphism.

Using the Sethakeng rural community in the Northern Cape (South Africa) as the case study, we were able to determine the extent to which both anthropomorphism and affective design influence the adoption of an M-Health application. Further, the research revealed that because of its ability to include human-like qualities to non-living objects, anthropomorphism is a more effective method for designing M-Health applications targeting rural communities.

CCS CONCEPTS

• **Human-Centered Computing** → Interaction Design • **Empirical Studies in Interaction Design**

KEYWORDS

Usability, interface design, affective design, anthropomorphism, emotion, M-Health, adoption

1 INTRODUCTION

Knowing how to use the computer and its software is a necessity in modern society, although knowledge of the internal workings of a computer is not essential for proper usage thereof. Thus, product design should be supported by user experience and it has become increasingly important to create products that are "user-friendly". Computer manufacturers and software designers have identified the benefits of creating usable products and argue that more people will purchase and use products if they are easy to use. As a result, user interface design has had a huge impact on the usability and effective use of applications. Usability is defined by The International Standards Organization (ISO) as the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments.

The design of interfaces involves arranging interface elements to enable users to interact with the functionality of the product or system [1]. Since learning to use a system or application can be quite overwhelming for users with different levels of experience, a user interface that is designed effectively will have a positive effect on how much effort the user puts in for an effective, efficient and a satisfying experience.

User-centred design (UCD) is a modern, widely practiced design philosophy rooted in the idea that users must take centre-stage in the design of any computer system. Users, designers and technical practitioners work together to articulate the wants, needs and limitations of the user and to create a system that addresses these elements [2]. Designers and software engineers need to adopt a user-centred approach to system design [3]. The modern computer is mostly interactive; this includes from multimedia workstations to hand-held PDAs, Virtual Reality (VR) headsets, network PCs and smart devices.

A usable product describes how well a product can be used and if it can be used for the intended purpose with a specific user group in mind. The functionality of a product and the design process thereof are associated with the usability of the user interface of the relevant product. It is therefore of the greatest importance that designers should consider the efficiency, effectiveness and satisfaction the users will experience when engaging with the product.

When it comes to the effective and comprehensive design of user interfaces, the role of user emotions when interacting with a product becomes an essential topic. An important question to ask, in this regard, is whether an interface can manipulate the user's emotions in such a way as to make the interaction efficient, effective and satisfactory, whilst improving contextual adoption of the artefact.

Two interface design principles that may have an impact on users' emotions were investigated in this study, namely *affective design* and *anthropomorphism* because of the fact that they deal with emotions and falls in the category of "emotional design". *Affective design* is an area of interest that allows users to experience different feelings and emotions when using applications since it aims to create and deliver affective interfaces [4]. An interface which has been designed affectively, may produce an enjoyable experience for the user while interacting with the application and, as a result, solicit some emotions from the user. In turn, this may lead to the user achieving his or her intended goals as well as that for which the application was designed.

Anthropomorphism is another usability design principle which are closely related and linked to affective design issues. Anthropomorphism is when designers attribute human-like qualities to non-living objects, for example Sonic the Hedgehog, a game released in 1991 that features a blue hedgehog as the hero or main character [5]. This series' characters are almost all anthropomorphic animals such as foxes, cats, and hedgehogs that can speak and walk on their hind legs like normal humans.

To assess the effects of the above-mentioned design issues, the principles needed to be applied to a domain, discipline or area of study. A domain that received a lot of world-wide attention over the last 6 years is the area of software applications. This study focussed on the effects of these design principles on software applications for mobile technology, including mobile applications. The primary method used for data gathering, distributing and receiving of information in this domain, namely Mobile-Health or M-Health, is by means of mobile technology.

Mobile-Health is when mobile devices are used to support the practice of medicine and public health by integrating mobile telecommunication and multimedia technologies to produce mobile and wireless, citizen-centred healthcare delivery systems. Electronic-Health or E-Health has several initiatives currently active throughout South Africa and Mobile-Health is an advancement in technology which forms part thereof.

A problem identified by the researcher is that there is evidence to suggest that only a small number of these initiatives has been successfully adopted by the intended audience. Rural communities especially, have not adopted and used available M-Health initiatives effectively. This is according to previous research done. The problem of lack of adoption and use, was identified by the researcher and it became clear that factors contributing towards the non-use of such initiatives may result from a lack of knowledge with regard the use of technology, literacy challenges, possible fear of technology and a lack of information regarding interventions that may improve quality of life. An initiative designed to recognise usability as its core function may play a critical role in the use and adoption of such.

A case community was selected in which the M-Health application was implemented. The study was conducted in Sethakeng rural community in the Northern Cape province of South Africa. Community members were engaged in the research study whereby the two design principles identified, were applied to re-design the current user interface of an existing M-Health application. These, with which the community members were already familiar with.

The purpose of the research was to prove that anthropomorphism and affective design could influence the adoption of Mobile-Health applications and to identify which was the more effective method to design Mobile-Health applications.

2 PROBLEM IDENTIFIED

In many cases, Mobile-Health initiatives in rural communal settings have not been adopted as expected. Attributing factors may include not knowing how to use the technology employed as the delivery mechanism, literacy challenges, and the fear of technology. Other contributing factors could be usability and design. The research aimed to apply the above-mentioned principles to an existing M-Health application and as such, anthropomorphic and affective usability design could be the answer since they aim to solicit an emotional or positively reinforced subconscious response from users. This, in turn, could lead to the adoption of Mobile-Health initiatives.

2.1 Design Principles and Mobile Usage

When designing interactive products and services, the designer is faced with many challenges and concerns. Three main categories of product requirements that cover all the aspects of the user's emotional experience with products are described by [6]. The product categories are:

- **Useful**: perform the tasks it was designed for;
- **Usable**: easy to use and interact with;
- **Desirable**: provide pleasure and create attention.

When it comes to products, websites and applications the emotional needs of users are very complex and multidimensional. The product must be easy to use, but it must also work in the way the users anticipates. The design of the product must therefore be useful to meet the goals and needs of the users. The interaction of the product should also be reliable, predictable and easy to understand. This is what contributes to the usability of the product.

Affective design is the design of a product to inspire certain emotional experiences and reactions from users, like happiness, pleasure, confidence and trust. The objective of affective design is to identify the emotional connection between users and products to create products that, in some way, provoke pleasure from the user [7]. The three main goals of affective design are efficiency, effectiveness and satisfaction. Achieving these goals may lead to certain outcomes that elicit enjoyment, involvement, trust and satisfaction [7]. The use of colour, visual layout, language used and images or pictures that allow the user to make a connection with

the product are factors that influence affective design. These factors have been applied to the re-design of the existing M-Health interface to determine the reactions of the case community.

Anthropomorphism is the term used when designers of new products assign human-like qualities, emotions or thought patterns to non-human or inanimate objects [8]. Adding life-like qualities to non-human objects can make a user feel more at ease and reduce anxiety when interacting with or viewing a product.

Several studies have demonstrated that visual judgments made by the user of a product influence perceived usability [9]. These studies have demonstrated that users perceived usability as "what is beautiful and useful" [10]. From a usability context, it may be that if a user sees a beautiful product, it is assumed that it will be easy and enjoyable to use and this can assist in the learning process as well as the success of the product.

2.2 Mobile Technology and Health

From its early stages in first-world countries the Internet being accessed via a desktop computer or laptop was the communication tool that was widely accepted. In South Africa, being a developing country, the mobile phone, however, became the dominant communication tool. According to Vodacom (2014) the number of mobile phone users in South Africa stands at 42 300 000, which is 92% of the South African population. Usability theories had a definitive influence on the design of mobile phones as well as on its software.

Many people previously did not have unrestricted access to services like free health care and by taking advantage of the increasing use in mobile technology, available applications may have a larger impact on helping improve the quality of life of these people.

By using mobile technology and the associated functionality, access to health care, emergency assistance, and other valuable services can be promoted and improved around the world. Moreover, applying interaction design principles, like affective design and anthropomorphism to the applications being developed, for instance mobile health applications, may lead to increased adoption and usage of these applications in communities across the globe.

2.3 Methodology

To enable the researcher to gain a deeper understanding of the problem identified, a qualitative research design approach was used. This approach could also assist in identifying possible obstacles facing rural communities in South Africa.

A singular case study was employed to explore and understand the relation between the case community and the phenomenon. The objective of the case study was to observe the phenomenon and describe it with regards to the case community; document the reactions of the case community to different instances and variations of the phenomenon and report on the most effective design principle based on the case reaction.

To collect the data, the following data collection techniques were applied:

- **Observation:** The systematic recording of the case groups' interaction with the phenomenon. Different age groups were identified and observations were held while interaction with the interfaces took place. Data was recorded for reflection and improvements to the interface.
- **Questionnaires:** Open ended questionnaires to allow respondents to elaborate on their experience with the phenomenon. Valuable data was collected from comments and suggestions recorded from the questionnaires.
- **Focus Groups/Group Discussions:** Informal and voluntary meetings between individuals and the researcher to exchange ideas, information, suggestions and needs regarding the phenomenon. Respondents were more willing to comment on their experiences with the phenomenon during these discussions.

2.4 A Brief Overview of the Case Community

As mentioned above, the Sethakeng rural community was selected as the case sample for this study. The researcher worked together with a healthcare professional who was already known to the community and also the PhD student who developed the original M-Health intervention. This made the study a convenience sample and eased the process of gaining the community's acceptance and the subsequent permission to work within it.

Sethakeng is located near Kuruman and Dithakong in the Northern Cape Province of South Africa. This area of South Africa is also known as the Kalahari. Culturally, the case community was a Niger-Congo or Bantu-speaking one, very traditionally Tswana community, which includes all the Sotho/Tswana clans living either in Botswana, Lesotho or South-Africa.

The community struggled with "information literacy" although the general level of literacy within the community was higher than expected. About 90% of the community owned mobile devices varying in specification level. A number of the older community members as well as a few of the middle-aged community members were not fully literate.

Roads leading to the community and connecting to other settlements were made of gravel, rendering the terrain that had to be crossed, challenging. Transport is limited to mainly donkey-carts, although a few community members own motorized vehicles.

The community members were therefore facing serious challenges, like poor road conditions, access to reliable transportation, etc., that directly hindered regular access to healthcare services. This resulted in a separate investigation into whether an M-Health intervention would be suitable to address some of the healthcare access and provision needs expressed by the community. Subsequently, an M-Health application was developed and introduced into the community and the re-design of the

interface of this intervention is what has formed the basis of this study.

A medical doctor, located in the nearby town of Kuruman, provides healthcare services to the community on certain Sundays of a given month by traveling to the community setting with what can be best defined as a mobile clinic. As mentioned earlier, transport was an inhibiting factor regarding access to healthcare. The community at large therefore welcomed the introduction of an intervention that could perceivably assist the community members with access to the services of the named healthcare practitioner.

3 RESULTS AND DISCUSSION

3.1 Overview of the existing M-Health Application

The M-Health application related to this study was developed to assist a rural community in gaining significant and consistent access to health services and information. These aims were based on the needs of the community as identified by them, as well as those of the healthcare provider mentioned previously.

The application included the following functionalities:

- GPS patient-location sharing ability to allow emergency response time;
- Instant messaging (IM) with voice and "chatroom" between connected patients as well as the healthcare professional;
- Image sharing between patient and healthcare professional;
- Remote diagnosis abilities via video-sharing and live video functionality;
- Virtual healthcare notice board to share information with patients and community members in general;
- A scheduler to indicate the personal visits of the healthcare professional to the community. Here, the application used visual and audible alerts for easy information dissemination.

Community members where trained to use the application over the course of three community case visits.

3.2 Action-Research and Data Collection

Action research is described as "learning by doing". A problem is identified by a group of people who then perform some action(s) to resolve it, see how successful their efforts were, and if not satisfied, try again [11]. Action research is a spiral process that consists of *investigating a problem, acting and finding facts about the result of the action.* This kind of research is about both 'action' and 'research' and the relationship between the two [12]. The action research process consists of four steps or phases, namely plan, act, observe, and reflect.

For the purpose of conducting the research on differently designed interfaces involved several re-designing of the interfaces as well as the re-evaluation of these designs.

Furthermore, it made sense to investigate the effects of the differently designed interfaces in independent cycles. Action research was therefore applied during the course of this study. **Fig. 1** is a high-level depiction of the intended, inclusive course of action.
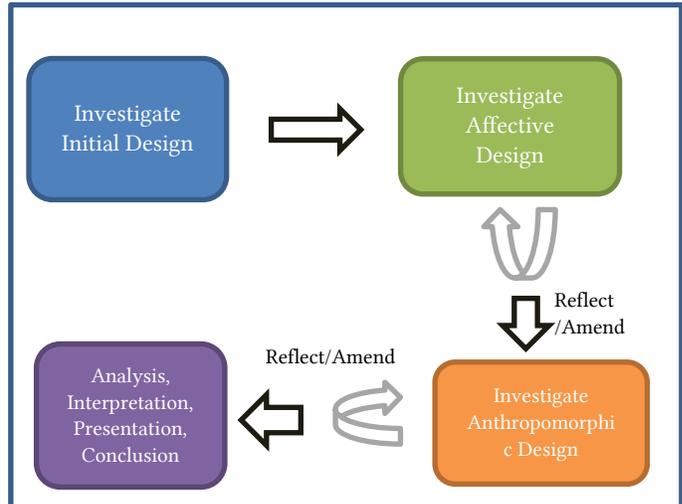

Figure 1: A high-level depiction of the intended action research cycles.

3.3 Data Collection Tools

Three tools for collecting data were employed, namely observation, interviews and focus groups. Data was also collected from the proprietary statistical analysis functionality of the cloud storage service, Cloudware, used by the intervention. The service permitted the request of data, within defined parameters, scrutiny of data as well as the reporting of subsets of data through a computer-generated analytics dashboard. The service also allowed the analysed data to be downloaded and stored on a local machine.

This functionality proved especially valuable as far as usage data was concerned. It allowed the researcher to query, for example, usage data between certain dates, related to certain users. If one deliberates that the different interface designs were introduced at different times during the study, one can appreciate the functionality of the relevant Cloudware and its usefulness to the data collection process.

During each of the action research cycles, the researcher aimed to make use of both qualitative and quantitative (Cloudware data) techniques and related tools to gather data, with members of the case community playing an active role in the process.

The community members were divided into groups of no more than ten people representative of gender, age and social standing within the case community. During the three action research cycles, the same approach was followed in each cycle to collect data from the community members.

Community members were observed while interacting with the interface and the observations were recorded for reflecting and taking action. Interviews were held with the different groups which included structured and non-structured interviews to enable the researcher to gain insight on the views and feelings of the community members regarding interacting with the different versions of the interface. The third data collection tool utilized was focus groups whereby the community members took part in interactive storyboarding sessions whereby group discussions were held to determine the feelings, attitude and views of the community members regarding the interface versions presented to them.

The action research steps mentioned previously were followed and applied respectively to each action research cycle involved in. Three action research cycles were executed and in each cycle, a different interface design was investigated. The community was exposed to three differently designed interfaces, the first design was the one with which they were familiar and had been using from the intervention's introduction. The second was based on affective design principles, and finally, the third design was created by employing anthropomorphic principles.

The three versions are discussed in the following sections.

3.4 Initial Interface Design

This version of the design did not consider the emotional aspects of design as is the case with the affective and anthropomorphism design approaches, but concentrated on addressing functionality as a prime design objective.

An interface based on the principles of the affective design approach was developed by incorporating the data related to the subjective emotional connections that existed within the community. This design was transferred to the second action research cycle.

Fig. 2 graphically portrays a collection of screenshots of the user interface of the first iteration of the M-Health application. One can consider the user interfaces in Fig. 2 as the representation of the interaction design portion of the M-Health application as this section of the application connects the user, the device and the application.

The interface was designed with simplicity of use in mind, not taking any emotional aspects of the user experience into account. The basic technological literacy of the community members was taken into consideration from the start of the development of the interface and therefore the application does not require a lot of text-based input. Certain sections of the application, however, allow for text-based communication amongst the healthcare provider and the community members who have a higher level of literacy.

Fig. 8 portrays the data collected with regards to the reactions of the community members to the initial interface. Averages from the feedback of the different age groups were used in visually depicting the results.

Figure 2: Interface design on the initial version of the M-Health Application

3.5 Affectively Designed Interface

During action research cycle one, the researcher explored colours and images in the context of the case community to re-design the interface affectively to bring about emotions from the community members. Core emotions such as enjoyment, involvement, satisfaction and trust were of specific interest and through the data collection process, the researcher could identify such colours and images. The interface was re-designed utilizing the data gathered and the outcome was an affectively re-designed interface as shown in Fig. 3. The functionality of the interface was not affected at all although it was based on the input and co-design efforts of and succeeding scrutiny by the community members.

The objectives of the second research cycle were to investigate the effects of an affective designed interface in terms of intervention adoption and usage as well as to improve the interface design. Furthermore, the second round of this action research cycle was employed to explore issues that could be useful when considering anthropomorphic interface design within the community.

In any environment where interaction with an application or product takes place, there are affective design elements at work. These include the use of colour, images, photographs, shapes and visual cues. The purpose of implementing these elements in an interface is to provide the user with a sense of beauty, a positive impression and emotional appeal when interacting with the product [7, 13]. The initial version of the M-Health application aimed to achieve this goal, although after the initial investigation of the

application, variables of positive emotions were not fully accomplished. Fig. 8 indicates the results of the data collected in terms of the core emotions identified. The comparison of the data point out that interaction with the affectively designed interface was received with more confidence than with the initial interface version.

Figure 3: Affectively re-designed interface screens

The aim of the affectively designed interface design was to incorporate colours, images and patterns to which the community members could relate. Fig. 3 portray traditional colours like earthy browns, sunset yellows and grass-like greens. The designs also included patterns related to what was observed in traditional homesteads and images like the acacia tree and the leopard.

A concern regarding the design of the interfaces were the emotions that the mobile application relevant to the study wanted to elicit from the users interacting with it in the milieu for which the application was designed, namely healthcare. Context could also not be ignored as the application wanted, from an emotional design perspective, to address emotions related to engaging a healthcare professional or facility positively. The core emotions identified in this regard was the feeling of dignity, hope, involvement, self-worth, trust and other relevant emotional responses.

On completion of the second action research cycle of the affectively designed interface, the only criticism received was that, holistically, 39% of the interviewees were of the opinion that the login screen representation of the senior and middle-aged group designations was too Western. The interviewees believed the user experience and overall emotional responses would improve if this issue was addressed successfully

3.6 Anthropomorphically Designed Interface

The third research cycle introduced an interface design based on the principles of anthropomorphism and presented four software agents, based on the investigation regarding this topic during round two of action research cycle two. The objective of the specific design was to increase the user experience, and at the same time aiming to cause emotional responses from the participants.

During the data collection process a mythical or legendary character relevant to the community was revealed. Of those interviewed, 52% of the interviews mentioned a fabled healer with magical healing powers through a doll-like conduit. Software agents depicted in Fig. 4 was developed representing the traditional characters but unfortunately, 68% of all the interviewees found the

design unsettling whilst 57% of the interviews reported a negative emotional experience.

Figure 4: Traditional characters relevant to the community

Another design attempt was made and an agent represented as a talking stethoscope, presented in Fig. 5, was developed with the same functionality as the "healer agent", but 64% of the interviewees experienced a negative response to these agents. The response from the users were that they did not identify with the agent and felt confused by it.

Figure 5: The interactive agent "Stetti" failed to prove effective as an elicitor of emotions

A succeeding session of interviews was motivated by the fact that the attempt to assign human-like characteristics to an inanimate object was not successful. A third round of interviews were held during a visit of the healthcare provider related to the study to the case community. While observing the interaction between the healthcare provider and community members, it became obvious that the community members had respect and love for the healthcare provider and his pharmacist. The result of this observation was the development of interactive agents depicted in Fig 6, in the form of the healthcare provider and the pharmacist.

Emotional responses of enjoyment and trust were pointed out as apparent by the psychologist who assisted the researcher with the data analysis of the video recordings. The average results collected from the different age groups are indicated in Fig. 8. In total, 72% of the interviewees responded positively to these agents. Finally, the most desired agent was the healthcare provider and this agent was incorporated to the anthropomorphically designed interface.

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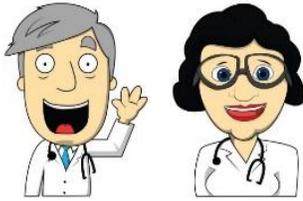
Figure 6: Interactive agent representations of the healthcare provider team proved most successful

The application was re-designed implementing anthropomorphic design principles while using the data collected from the case community regarding their needs. Fig. 7 depicts interface screens from the anthropomorphically designed interface of the third version of the M-Health application.

Figure 7: Anthropomorphically re-designed interface

After investigating the data collected, it revealed that, in total, the anthropomorphic design proved to be the most successful, although over a three-month period, in imploring the core emotions from the users in question. Fig. 8 clearly indicates that the interface version that received the most positive feedback was the anthropomorphic interface design. This fact can be attributed to strong feelings of involvement and trust that the other designs were not able to produce as successfully. This, together with the high level of enjoyment and satisfaction experienced, caused the community members to associate with and respond to this design on a deeper level than with the other designs.

4 CONCLUSION

The aim of this study was to investigate the effects that a mobile interface which was re-designed using two emotionally driven design methodologies, namely affective design and anthropomorphic design would have on the adoption and use of named application within a rural community setting. The fundamental design principles on which these two design approaches are founded were applied in the re-design effort of an existing interface of an M-Health application for evaluation purposes.
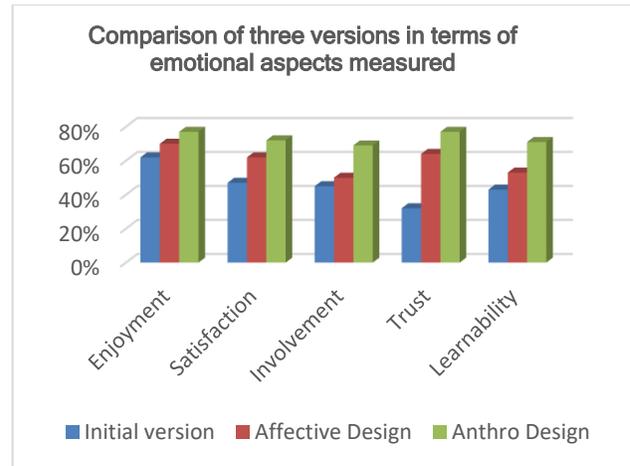

Figure 8: Comparison of the three versions of the M-Health interface using average responses from community members.

A rural community in the Northern Cape province of South Africa was identified as a suitable case community in which to conduct the research related to this project. The sampling was convenient in nature as a healthcare professional known to the researcher was already working within the community. The re-designed interface versions of the application were introduced to the community in different phases during plotted action research cycles.

From the data presented it was found that the anthropomorphic design was superior to affective design in the minds of the community members. Furthermore, the results of the study also provided insights into the role emotional connections and interface design plays in terms of the adoption and use of an application, although contextually limited.

5 FUTURE WORK

Although research has generally considered the impact of design principles such as colour or images, website design elements and their modification across cultures have enjoyed considerably little attention. This is the case, despite the importance of the cultural sensitivity of website and software application design. Consequently, it would be beneficial if both researchers and practitioners were to investigate website localization and the impact it has on insights and emotions in diverse cultures. Other characteristics, such as age or gender, equally, deserve attention concerning the use of colour and imagery.

Further research could be conducted to expand on some of the features of the M-Health intervention to include more advanced technology relating to the E-Health context. Implementing the intervention in a wider environment may be a possibility and

investigating the results of such an exercise could prove very insightful. This may have a huge impact on other communities faced with similar challenges as the community used in this study.

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