HCI: Design Guidelines of Mobile Device Games for the Elderly

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Abstract

Design guidelines are an essential part of human computer interaction, for they provide an outlines of the requirements and needs of a user on how best to interact with technology devices. Our research project focuses on understanding how the elderly interact with current technologies (mobile devices and digital games) and how they can benefit from mobile digital games. The goal is to come up with interface design guidelines to be used by developers when designing mobile games for the elderly. The identification of the guidelines is carried out through a literature survey that includes a literature search based on outlined keywords, and a literature review of the selected research. The evaluation process of the guidelines involves user testing of a prototype based on some of the identified guidelines. Even with minor setbacks, the evaluation process indicates that the guidelines are beneficial for the development of mobile games for the elderly.

Keywords: Elderly, mobile devices, cognition, interface, design guidelines, digital games.
Popular Science Summary

Digital games are beneficial to the elderly population, for they help improve health fading abilities (including cognition) that occur as one ages. Digital games provide a sense of social interaction, entertainment and stimulation. Mobile devices on the other hand are usually kept for emergency calls or as memory aids by the elderly, they provide a sense of security. Implementing digital games specifically intended for the elderly in mobile devices would make the games easily accessible and available due to their mobility.

The goal of our research is to identify interface design guidelines for mobile digital games to be used by mobile game developers. Interface design guidelines of mobile games specifically intended for the elderly have not been defined. The guidelines are identified through a literature survey, for a lot of literature on how the elderly relate to technologies including digital games and mobile devices exists.

The identified interface design guidelines are evaluated using a prototype of an existing mobile game. The prototype is a recreation of the game using some of the guidelines not applied in the original game. The evaluation is carried out using a selected group of elderly people, and expert users. The evaluation process involves the comparison of the prototype response, to the original game features. Even with a couple of setbacks, the evaluation process gave us indications that the identified interface design guidelines can be beneficial when developing mobile games for seniors.
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1 Introduction

The increase in the number of seniors or elderly people in the world has led to the significant importance, and relevance to design and create technologies that cater for seniors as well. This is due to the continuous increase in the number of elderly technology user [1] [2].

Technologies such as mobile devices help elderly people keep in touch with friends and family. Mobile devices are also used to ensure safety, assist and facilitate the elderly in healthcare, bring new incitements into their lives, and provide more access to information [3]. The elderly are a group of users who can potentially benefit from engaging with technologies such as mobile devices. Unfortunately less attention has been given to the importance of senior citizens as technology users compared to the younger population [2]. The current technologies including mobile devices, have features that the elderly find difficult to understand and use [5].

The assistance and facilitation in healthcare for the elderly can be provided through mobile device features such as digital games. Mobile device games can be developed using interfaces that are easy to interact with and have good visual effects, with preventive and therapeutic value. This would allow the elderly to enjoy new opportunities for pleasure and entertainment, whilst improving their cognitive, functional and social skills. Gamberini et al. [3] states that according to Rauterberg [4] “entertainment technology has positive effects on human behaviour in areas including: general development, collaborative and pro-social behaviour, and healthcare and therapies ”[3] p.290].

Duh [2] also states that while elderly people are increasingly adopting technologies such as computers, the Internet and new electronic devices; mobile devices are rapidly becoming personal items for them. Adding digital games on mobile devices such as mobile phones means having access to games that can help improve the elderly people’s health at all times. Mobile phones are mostly kept for
emergency calls or as memory aids, and yet few games are currently being developed for this growing demographic.

With the increasing acceptance of mobile devices by the elderly, the functionalities of the devices should not only focus on their knowledge levels, but also on their misgivings. Misgivings or characteristics such as: the difference in motivation, lower levels of frustration, and the possibility of having to overcome previous, negative experience [12] must be considered when designing for the elderly.

1.1 Goal

Mobile device games can be very beneficial to elderly people. Digital games intended for the elderly help improve their cognitive, functional and social skills, whilst mobile devices such as phones provide a sense of security. The addition of digital games into mobile devices is something that is already in existence, except the design of mobile device games intended (specifically) for seniors is something that has not been emphasized. With that in mind the main aim of the research is to define the interface design guidelines for mobile device games for the elderly. This will be done by finding out:

- How can the interface design requirements of mobile device games for the elderly be obtained?
- What interface design characteristics/features of mobile device games are beneficial to elderly people?
- How are the identified design guidelines for mobile device games for elderly people to be validated?

The research process will mainly include qualitative methods, and mobile devices games that focus on the cognitive health factors of the elderly.

Previous research (surveys and case studies) has been conducted on the requirements of the elderly concerning mobile devices and mobile games, cognitive and physical health. A literature survey of the previous research will help us create a clear and better understanding of the elderly people’s interests and needs (in relation to
mobile device games). The survey will also help us define how the elderly can benefit from mobile device games.
2 Research Methodology

Interaction design for elderly users has to account for both the inconsistency in mental models of the elderly, and the motivation of the elderly to use the technology. As a result, researching the characteristics or contexts that will help understand how to encourage older adults to engage with technologies such as mobile device games might prove to be valuable.

2.1 User-Centered Design (UCD)

User eXperience (UX) is an Interaction design (and HCI) attribute that takes user’s needs into account at every stage of a project. UX can be defined as “A person’s perceptions and responses that result from the use or anticipated interaction with a product, system or service” [13, p.727]. User-Centered Design (UCD) is the design process used in UX.

UCD is a design process where product designs are influenced by the end-users’ perceptions and responses. “It is a flexible, collaborative process for software development projects that enables teams to more effectively meet the needs of users and customers” [14]. Based on the UCD design process, the interface design guidelines of our project are influenced by the elderly people’s needs.

UCD can be carried out using a number of different methodologies and tools. The method that our research project related to is demonstrated below:
Plan: This step involved determining all activities needed, the necessary resources and potential risks assessments. This is covered in the planning phase of the project (as shown in Appendix B).

Research: This step involves understanding the goals, tasks and needs. This is covered during the project definition phase which includes: the identification of the Problem and Motivation, and the definition of the Objectives and goals (research questions).

Design: This step involves defining the system from the user’s perspective. This is covered during the literature survey phase, where design guidelines relevant to the development of mobile games for the elderly are identified.
• **Adapt**: This step involves adaptation of changes discovered during development. This is covered during prototyping phase of the project where the design guidelines relevant to the users’ needs are implemented into an existing game.

• **Measure**: This step involves measuring usability, “which is comprised of effectiveness, efficiency, and satisfaction” [14]. This step takes place during the evaluation phase of the project. The identified design guidelines are demonstrated through a developed prototype. The evaluation process involves user testing of the prototype based on outlined criteria.

### 2.2 Literature Survey

A literature survey is one of the main research methods used in the project. A survey was selected because a lot of studies in-line with mobile device games for the elderly have been carried out. Studies concerning topics such as digital games, mobile devices, mobile device games for the elderly have been carried using a number of research methods including case studies and surveys.

A literature survey consists of two main components: a literature search and a literature review. A literature search “represents the mechanics of looking for, sorting, managing and digesting research materials that are available [16, p.83],” whilst a literature review “represents your written understanding, critical evaluation, conceptualisation and presentation of the material you have obtained [16, p.83].”

The literature search process involves the search of existing research literature based on the keywords: mobile devices, cognition, digital games, mobile device games and the elderly. The literature search also involves the search of the relationships between the keywords. The resulting literature would then be critically evaluated and sorted according to relevance: does it contribute to our research goal?, does it answer any of our research questions?
The literature review process involves a review of the literature search results (resulting literature that has been evaluated and found relevance to our research). The critical evaluation process helps us have a clear and better understanding of our topic area, and how we could come up with the necessary results. The literature review is a representation of our understanding of our area of interest in relation to existing literature.

The results (conclusions) of the research carried out during the different (previous) studies will be synthesized to come up with the solutions to the defined research questions. We aim to arrive at a more nuanced understanding of possible and recommended interface design guidelines for the mobile device games for the elderly.

2.3 Prototype

Prototypes are usually developed in cases where the requirements of a project are not clearly understood. A prototype is then used to capture the requirements (requirements capture) of the project product with the users of the final product, and to explore the feasibility of the project final product (experimental prototyping) [16].

We selected prototyping because a prototype can be used to explore the feasibility of the interface design guidelines identified during the review of the selected literature. We aim to create a prototype of a mobile device game, based on the identified guidelines. The prototype will be used as a form of validation of the design guidelines.

2.4 Expected results and Potential risks

The expected results of these methods are: to specify some of the best approaches to take when designing for elderly people, what has to be taken into account such as cognitive abilities that change with age “(perception, attention, memory, and other more specific)” [3, p.285], processes such as decision-making, defining the elderly people’s interests and dislikes with mobile devices, including the re-
quirements and challenges that one might face and how to avoid them when designing games for the elderly.

Some of the major risks of the research are: the possibility of missing vital information or misinterpretation of the research during the literature survey, the possible lack of interest and commitment by the elderly people during the research, and not being able to validate the defined design guidelines for mobile devices for the elderly. Risks can be prevented through the identification of all possible critical risks beforehand and try to avoid them, and the identification of possible solutions (optional paths of the project) if a risk were to occur.
3 Background Literature

Technologies for elders are often built on the assumptions and theories of their social connections, which usually indicates that elderly people are sometimes presented as a socially isolated group. The elderly are presented as a group that needs to strengthen connections with family, or could benefit from being monitored. In other cases, people who have a special role to play in the lives of their grandchildren [1].

In western countries elderly citizens are usually located in nursing homes and community centres. Due to the prevalence of impairments and other age related changes, it is often difficult to have the elderly people participate in physical or social activities. As a result the elderly are left with limited leisure activities, and this leads to loneliness, and eventually cognitive and physical decline [7].

Despite the assumptions, it is better to focus on the way elderly people approach their relationships with family and friends. As well as the problems of commitment and continuity, and the importance of interactive systems in domestic and private areas when designing for the elderly. The other factors to focus on are the recognition of seniors’ need for independence and the need to learn new things [1].

Technology is one thing the elderly have increasingly shown interest in. Technologies such as mobile devices can be very useful to the elderly. Mobile phones are currently being seen as a means of security due to their mobility and means of social interaction.

3.1 Mobile Devices

Some studies suggest that people over the age of 60 find the functions in mobile phones complex. This is due to: small displays that make it difficult to see, small buttons and characters that result in the frequent wrong pushing of values. This also includes: too many functions, non-user friendly menus, unclear instructions of features

and lastly expensive services [5].

Touch screen mobile devices are believed to be extremely difficult to use by the elderly. The difficulties stem from issues such as: making accurate movements that require fine motor skills or fast finger movements, and the sensitivity of the elderly to tactile feedback (short vibration with each touch) compared to the young generation. [12]

The complexity of mobile phones has the elderly limit the usage to features such as calling and texting, usually in emergency situations. The complexity of mobile devices can be resolved by considering the abilities of the elderly during design, and adding features that make the functionalities easy in the current mobile devices. This is because, although believed to be difficult to use, touch screens on mobile devices have been proven to be good for the elderly. The touch and gesture-based interaction methods of mobile devices have them (mobile devices) being defined as direct input devices. Devices such as personal computer keyboard and mouse are known as indirect devices [23].

Indirect devices are more precise and usually a preference for experienced, and long term users. Direct devices on the other hand are a preference for users with less demand for memorization of commands. Direct devices demand less training, and are a better choice for the elderly because of “their reduced coordination and cognitive demands, as their use requires little hand-eye coordination and minimal spatial demands” [23 p.3]. These characteristics make mobile devices suitable for the elderly.

3.2 Digital Games for the Elderly

Studies suggest that digital games may provide a means of social and physical engagement for the elderly [7].

Previous efforts have been made in designing games for the elderly in several formats using different approaches. However, little
has been done to explore the requirements of the elderly exclusively for mobile device games [2].

The designs of mobile digital games for elderly people have been investigated, in a number of research studies using different methods, including case studies, observations, questionnaires and interviews. The designs mostly aimed at making enjoyable games that motivate the elderly to participate in health behaviour improvement activities. One example is the ElderGame Project by Gamberini et al. [3] aimed at developing tablet based games for the elderly. The project focuses on using visualisation and interaction interfaces to improve the cognitive, functional and social skills of the elderly. The project combines two areas of study, health and social engagement.

Other examples include: the Walk2win, where players (the elderly) can use mobile phones to search a room for game artefacts [11]. The SilverPromenade is a Nintendo Wii video game designed for frail elderly people who require nursing. The Game enables the elderly to go on virtual walks, and allows the elderly players to pick different roles using the Nintendo Wii Remote and Balancing Board [7]. SqueeView is a game used during an empirical study aimed at enhancing “visuo-spatial cognition” capability of the elderly by Choi et al. [8].

These studies have proven that digital games can be very useful in elderly people’s everyday life, for digital games can be helpful in terms of healthcare and recreation purposes.

3.3 Design Guidelines for Games for the Elderly

Various game design guidelines for the elderly have been recommended. The guidelines focus on designing game for interaction paradigms suitable for rehabilitation therapy, entertainment and cognitive, interface design and visual adaptability. Despite the recommendations, very few games have been specifically designed to cater to elderly audiences [7].
With various research efforts being made in exploring seniors’ interest in digital games, compared to younger gamers, elderly users are more interested in playing games with a perceived meaningful purpose [2] [6]. The meaningful purpose is derived from the extent to which games are perceived to: “foster connectedness, cultivate oneself and others, and contribute to society” [15, p.1].

The rapid increase in the adoption of mobile devices such as mobile phones as personal items by the elderly generation proves that the elderly are a promising audience for mobile game developers. Designing games that the elderly will actually play and find enjoyable requires understanding how each component of a game impacts the player’s experience.

Studies such as the “Investigating Narrative in Mobile Games for Seniors” by Yew Yee et al. [9] address designing games for the elderly by using narratives. Narrative are “the representation of a series or sequence of events” [9, p.669]. The designing of mobile games for the elderly is addressed through the investigation of the role the narrative structure of mobile games play for the elderly [9]. Unfortunately this only covers one aspect of design and requires further validation.

Another example of a study based on designing mobile games for the elderly is the “Motivational Factors for Mobile Serious Games for Elderly Users” by De Carvalho et al. [10]. The study is based on the development of serious games with the consideration of the elderly people’s preferences, needs, and interests that motivate the use of the mobile games. Unfortunately the results presented in this paper are still preliminary [10].

3.4 Mobile Device Games Analysis

As people grow older the capacity of the cognition, vision and hearing fade. The design of technologies and software (mobile digital games) for the elderly are impacted by their fading functional ca-
pacity. Compared to young gamers, the usability and design problems are major obstacles for senior players. “Nevertheless, solid and tested design guidelines have yet to be proposed to inform developers interested in designing digital games for the elderly population” [2, p.2].

Our research will includes methods that consider the fading functional capacity of the elderly, and the complexities that the elderly find in the functions of mobile devices. The purpose of the research is to come up with the design guidelines of mobile device games that assist with cognition improvement. The design guideline are mainly focused on the interface design of the mobile digital games.
4 Literature Review

As stated in the earlier chapters, the purpose of this project is motivated by the lack of design guidelines for mobile digital games for the elderly. The guidelines were derived through a literature survey, for we discovered that literature has been published based on games for the elderly, how they relate to other technologies, and the benefits of digital games to the elderly.

Our main source of information during the literature survey was google scholar, and recommendations made by researcher carrying out similar research. The literature survey was carried out using a number of keywords including: Interface design, mobile devices, cognition, digital games, mobile device games and the elderly. The literature search also included the search of the relationships between the keywords. One other method used during the literature survey is the Snowball sampling form of research. This involved the selection of literature (articles) based on the reference list of some of the research articles found using the outlined keywords.

The filtration process of the literature was based on publications(of the document) and relevance: does it contribute to our research goal?, does it answer any of our research questions?

After reviewing 10 articles of the selected research literature, patterns started to emerge. This made it easy for us to start categorising the informations into topics based on relevance. The literature review process of the selected literature included the identification of recurring issues in current digital games faced by the elderly, and the identification of mobile game feature adjustments or inclusions that would cater for the fading health abilities experienced by the elderly. The review process also included the identification of digital game motivational factors for the elderly.
4.1 Problems faced with the current digital game

The current demography of the elderly has not been exposed to the same level of technology as the younger generation. A number of them (pensioner elderly) retired without having used computers or the Internet during their entire working lives. Besides the physical and cognitive challenges, the lower level of computer literacy and late adoption of technology results in less knowledge of the gaming domain, and increased access barrier towards gaming systems. These limitations introduce issues such as computer anxiety, and the limitations tend to have an impact on the elderly people’s confidence level when it comes to playing digital games as well.

In addition the challenges stated above and in the background literature, most elderly people usually association digital games with negative influences, including the violence in violent games. Some other negative influences may include the fear of failure, which may arise in situations where the games being played involve multiple players. The negative perception to multi-player games may also arise due to the unwillingness of being tied to specific times when other players would be available.

Some other problems include the high overall speed in digital games, and or the high speed at the end levels of the games.

4.2 Game Motivational Factors

Majority of the elderly people prefer casual games to hardcore (serious) games, for casual games are played for the main purpose of fun and relaxation. “Casual games are much more suited than hardcore games to meet the needs of an ageing audience in terms of content and interaction.”

Serious games are mainly designed for the purpose of improving certain aspects of learning. They are usually used in emergency services training, in military training, in corporate education, in health care, including other soci-
Besides fun and relaxation, digital games may provide a means of escape from reality especially in situations of experienced loss of loved ones and or loneness. Other motivation factors would include: the challenge or suspense to complete a game, beat high scores, and to improve one’s skills [21].

Digital games can have the elderly stay in touch with society, give meaning to the day, and be used for training of the brain. One other motivational aspect that digital games may provide to the elderly could be to teach others instead of being trained by the game. Teaching others could also promote social connectedness and interaction [21].

4.3 Ways on how digital games can be designed/improved

As mention digital games can be beneficial to the elderly, except current digital games are not designed to accommodate the challenges that come about as people age. A number of studies (research) have been carried out concerning the improvement on the features of the current digital games for the elderly. Our main aim is to define the possible improvement on features of digital games on mobile devices.

Issues such as computer anxiety can be decreased by including features that provide encouraging feedback and have the elderly experience some level of success during a game. Anxiety of inexperienced elderly users can be overcome by including features that provide enough time to learn basic skills and, encouraging feedback on the learning goals from the start [17] [22]. Unlike performance goals, learning goals focus on the progress and mastery of the game rather than the player’s playing abilities. This is likely to increase the player’s motivation and “persistence to engage in a task that is initially perceived as challenging” [17].

Allowing for the adjustment of features such as time or games that adapt to the player’s abilities is good design practice. The
time features could also include having the option of disabling the
time (on games that are timed) so as to allow the player have a
chance to play a game without worrying about the time. Having
a feature(s) that offers the option of setting the level difficulty of a
game could also be a good idea, this allows for flexibility [22].

The Clarification of the benefits of a game is an important factor
to consider, for the elderly would rather play games that are mean-
ingful and they find relevant. It’s also important that the game
provides entertainment. Another feature and motivational factor is
ensuring that the game has a story that motivates the advancement
of a level as well (not just the increment of the level of difficulty).
Monotonous and repetitive tasks that could discourage players from
playing a game for a long period of time should be avoided because
that could lead to motivation decline [22].

4.4 Elderly adapted interface
The Interface is one of the most important features in game design,
for it provides direct interaction to users (players) with digital game.
The implementation of design features that accommodate changes
experienced by the ageing elderlies as they interact with technology
systems could be rewarding. With that in mind, it’s very important
that the interface design for the elderly considers the fading abilities
of the elderly. This can be accomplished by testing different features
including icons and naming conventions, and accessibility options
[23]. Modification to the sensitivity of controls or the implication
of complex tasks such as the inputting of text could help alleviate
issues, including the frustrations experienced by elderly players [24].

Other issues and or features to consider when designing inter-
faces for the elderly include: instant feedback, the design for cogni-
tion challenges, motor features, customization, and the interaction
preferences/design.
4.4.1 Instant Feedback

It is good practice to design digital games that provide instant feedback, for feedback allows for users to be aware of the impact of their actions. With the instant information, the players are able to improve on their skills, and remain motivated by their actions’ outcome at the same time [23].

As stated by Gerling et al [7] digital games could include visual adjustment features (e.g. regarding the fonts and windows size, colours and contrast settings) that deliver multiple modes (multimodal) feedback other than a single communication channel.

Generally, multimodal feedback can be provided in a number of ways. In mobile devices for instance, multimodal feedback can be provided through: in-game sound effects and tactile (vibration) feedback as a way to call for attention, or deliver vital information. However, online social play could support both voice and text messaging as means of communication (feedback provision) [22] [17].

4.4.2 Design for Cognition Challenges

Age related changes in cognition of the elderly affect the requirements of the interface design of digital games. The cognitive functions (processes) that decline as one ages include: the “attention processes, working memory, discourse comprehension, problem solving and reasoning, and memory encoding and retrieval” [17]. With that in mind, from the interface design point of view the focus should be on: the simplicity and intuitiveness, provision of appreciate affordances and overview. This results into the minimization on the memory and cognitive processing load [17].

“Cognition is the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses [27].”

The design of appropriate cognitive challenges of a game could in-
clude interface features that make it neither too simple nor complex for the player. The player should feel confident to play and proud of his or her ability “Therefore, the importance of the encouraging feedback, even in the most simple stages” [22, p.27].

Games for the elderly should be meaningful, as a result if a user-friendly interface only provides access to games that are uninteresting for the elderly user, they are likely to not engage with the content [17].

4.4.3 Motor Features

The effects motor impairments are quite diverse in nature and cause. Motor impairments may have different levels of impact. As with cognition, motor skills also tend to change (decrease) with age. As a result, it becomes a challenge to be steady with features such as the mouse, or any other control device. Features such as small targets and moving interface elements which are found to be difficult use by the elderly, are best avoided when designing for the elderly [17].

“Motor Skills is the ability to perform complex muscle-and-nerve acts that produce movement” [28].”

The design of digital games for the elderly should allow for the adaptation of different motor skill levels, and feature therapy appropriate requirements regarding a player’s range of motion [7].

4.4.4 Customization

As stated by Vasconcelos et al [23, p.8] “Games that can be adapted to a specific individual through the use of familiar pictures, videos or sounds are expected to enhance the user experience.” Interfaces that include customizable features (fonts or icons) can accommodate a wider range of users.

As mentioned earlier, elderly game players should be with provided game features that allow for adjustment of level difficulty,
game speed and the sensitivity of input devices. Challenging experiences for wide audiences equally account for individual preferences. For instance, in a study carried out by Nap et al. [21], the elderly female participants preferred cartoon-like graphics, whiles the male preferred realistic graphics.

In some cases, it has proven that time management is of great importance with some elderly people, as they are often on tight schedules with activities well planned out in advance. As a result, they are forced to balance playing digital games with other activities. For that reason, it could be useful to include time management tools as a feature to the design of digital games [18].

One important aspect which seems to be a problem with a number of non-English speaking elderly player is the language support. English is used as the primary language in most digital games and other languages are not always supported. The language barrier can be a hindrance to meaningful play. The language support issue can be resolved through the inclusion of features such as automated translation tools, and or an option to select the preferred language as the interface and in-game language [18, 21].

It’s very good interface design practice to include features that allow for the customization of digital game interfaces for the purpose of accommodating the different needs of a wide range of elderly players. It’s also good practice if the adjustments do not exceed appropriate boundaries for the playability of a game, for instance “a 200 point-size font on a portable game device will not increase readability” [17, p.18]. The players could also be allowed to undo the adjustments with a single click [17].

4.4.5 Interaction preferences/design

As mentioned earlier, interfaces provide game interaction for the elderly. The design of digital games should focus on basic interaction mechanism, and provide the elderly players with constructive
criticism to help avoid frustration, and introduce enjoyable player experience instead. This is due to the lack of previous gaming experience of the elderly players [7].

The interaction mechanisms of games for the elderly can be implemented in a number of ways. This can be through techniques that involve the engagement of players into a game. The engagement can be achieved through clear definition of the goals of the game, and immediate rewards based on the player’s performance. Rewards can be used for progress tracking or social interaction through healthy competitions. Social interaction can also be implemented through the implementation of features that allow for multiplayer gaming [23] [18].

Another engagement or social interaction factor would be vicarious (secondary) players. A vicarious player is a one who play along side the primary player (the game controller). Game design could include features that immerse the vicarious player by, for instance including hints in the corner of the screen, or having the vicarious player search the Internet for clues [18].

In situations where multiplayer games involve different age groups (such as teenagers and adolescents), it’s could be advisable to balance the playing field through handicaps or including different skill sets as a requirement.

4.5 Review Conclusion

The review results explained above make up some of the most important ideas to consider when designing mobile digital games for the elderly. The results are based on the literature survey study that was carried out during the research process of this thesis. A literature survey was selected because a number of studies (including case studies and surveys) have been carried out based on digital games for the elderly. The studies emphasize on the improvement of the health challenges experienced by the elderly. As a result, the

analysis of the documents produced in the studies helped us get a clear understanding of the elderly, and how they relate to current technology and digital games.
5 Game Interface Design Guidelines for the Elderly

The literature review chapter describes the results of the literature survey. The review describes some of the important ideas that could be useful to game developers, when they are designing for the elderly. We illustrate the ideas in the form of interface design guidelines. The guidelines focus on the feedback, motor skills, customization and interaction preferences of the elderly.

5.1 Feedback and Motor Skills

- Instant feedback on the player’s action should be included. This allows for the elderly players to be awareness of their actions.

- The instant feedback should be multimodal. It should include sound, vision and tactile (vibration) effects.

- The game skill instructions and interactive areas should be basic, clear and easy to follow.

- The learning goals should be the focus of the game, and they should be emphasized.

- Game features that require steady motor skills should be avoided. It is acceptable if they allow for the adoption of different motor skills.

5.2 Customization

- The design of the game should include customizable features including font and icons, level difficulty, game speed and the sensitivity of input devices. The adjustment of the features should be as simple as a click of a button.

- The game design could also include customizable features such as schedules reminders, which could be beneficial for the elderly who have a planned out day.
• Language options or translation tool is one important feature to be considered when designing for the elderly.

5.3 Interaction preferences/design

• There should be a clear definition of the goals of the game, and immediate rewards based on the player’s performance.

• The game design could include features that immerse the vicarious (secondary) player. For instance, including hints in the corner of the screen or searching the Internet for clues.

• Multiplayer (different ages) game designs could include handicaps or different skill sets as a requirement to balance the playing field.

A summary of the guidelines is illustrated in the table below:

<table>
<thead>
<tr>
<th>Interface Design Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instant Feedback</td>
</tr>
<tr>
<td>• Action awareness for improvement and motivation</td>
</tr>
<tr>
<td>• Multimodal feedback (sound, vibration, vision)</td>
</tr>
<tr>
<td>Motor Features</td>
</tr>
<tr>
<td>• Different motor skill levels</td>
</tr>
<tr>
<td>Customization</td>
</tr>
<tr>
<td>• Level difficulty, speed, timer, sensitivity of input devices</td>
</tr>
<tr>
<td>• Time management</td>
</tr>
<tr>
<td>• Language selection</td>
</tr>
<tr>
<td>Interaction preference/design</td>
</tr>
<tr>
<td>• Goals and rewards</td>
</tr>
<tr>
<td>• Vicarious (secondary) players</td>
</tr>
<tr>
<td>• Different age multi-play</td>
</tr>
</tbody>
</table>

Table 1: A Summary of the main outlined interface design guidelines
6 Evaluation

We were able to identify a couple of important design guidelines for mobile games for the elderly based on the information we acquired during the literature survey. The evaluation process of the design guidelines will involve testing of a current mobile device games popular with the elderly, select one of the games, and develop a prototype based on the selected game. The prototype design will include some of the identified interface design guidelines that are not met in the game. User testing of the prototype will then be carried out with a couple of users who are part of an ongoing research project that involves the introduction of technology to the elderly through digital games.

6.1 Ongoing Research project

We partnered with an ongoing research project which aims at familiarising the elderly with current technology through digital games and the contribution to the design and development of new technologies/games through active participation and engagement. The team also aims to use the digital games engagement and the design process as tools of social interaction encouragement between the elderly and other demographics including family and members of staff.

The research is being carried out of in an elderly care home and two centres for daytime activities for people with dementia. The research mainly involves the elderly and the members of staff who are with the elderly on a daily basis. The research is being carried out by observing the elderly play a number of casual games every week. The games are played on touch-pads (ASUS pads and Apple Ipads) screens that provide direct input which is essential for the elderly (see chapter 3). A number of games are used during the observation include simple games such as puzzles, card games (Klondike), bingo and bowling. Some other games used that have proven to be difficult include: candy crush, angry birds and Hidden Objects.
6.1.1 Game design issues

Most of the casual games played during the observation have features that the elderly don’t usually approve of (some more than others). Popular games such as Ruzzle [29] which is an interactive game that involves multiple online players. Some of the major properties of Ruzzle that are good for the elderly are that it’s a socially interactive game, and it allows for players to choose opponents. Some of the drawbacks that we discovered include the lack of control on the timer, lack of information for new players on the rules of the game, and an interface that could take some time for new elderly players to follow. The drawbacks go against the interface design guidelines identified in chapter 5 including customization and interaction preferences. By applying the interface design guidelines to some of these drawbacks, it would make the game more suited for elderly players.

One other game that has some design issues is Math Bingo (Figure 1.). Math Bingo is a game that has players hit bingo once they solve a number of mathematics problems in a line. In terms of design the game has a number of good features, including: clear icons and font, difficulty level selection option, and in-game sound and picture feedback that meet some of the identified interface design guidelines. Some of the major drawbacks of the game are the lack of customization options, not so much information about the games is provided, no language options other than English, and the delay.
in feedback has the players making mistakes during the game. With that in mind, we decided to create a prototype of the Math Bingo game, and use it as the evaluation tool in the elderly care research.

6.2 Prototype Design Process

As stated above, we identified some design issues with the Math Bingo game. Using some of the good Interface design guidelines identified earlier (Chapter 5), we created an interactive prototype of the Math Bingo game. We first identified the major design features met by the game design that make it suitable for elderly players, these include:

- clear icons and font, which is useful for visual-impaired elders.
- level difficulty options of the game. Which ensures that the game accommodates a wider range of users (customization).
- in-game sound and picture instant feedback. Which is essential for multimodal feedback and player encouragement.

After the evaluation of the Math Bingo against the identified design guidelines of mobile games for the elderly, we came up with some ideas of how the prototype is to be designed. The following features were then added to the design of the prototype:

- Customization.
  - Language options and translation.
  - Timer on/off.

- Feedback and Interaction.
  - Increased text and icon size.
  - central display of response.
  - option to try a failed question again.
  - option to see the answer to the failed question.
The selection of these features was done with the elderly in mind who experience a number of health fading abilities, as a result we ensured that the changes were prominent and simple. We created the prototype using an interactive prototyping tool called Justinmind Prototyper [30]. We used this tool because it is used to create interactive mobile application prototypes that are close to the finished product, and we wanted to keep the design of the prototype close to the original game (Math Bingo) for a clear and easier evaluation process.

6.2.1 Customization

The customization of the Math Bing game prototype involved adding a new interface that displays the option of selecting either the English or the Swedish language for the entire game. We then created an entire game session that displays response text in the Swedish language. We focused on the Swedish language because most of the elderly in the home and daytime centres communicate in the Swedish language, and not so much in English. As has been mentioned, customization allows for the accommodation of a wider range of players.
Figure 3: Language selection Interface.
6.2.2 Feedback and Interaction

The alterations on the feedback and Interaction of the Math Bingo game prototype involved centralizing the instant feedback (response to the player’s input). This helped resolve the issue of giving a wrong answer to the next question due to the delay in feedback. The centralization of the response also helps the elderly players see the response in a much clear and easy way. The clarity of the response was also emphasize with large buttons and clear font. This was done for easier interaction. Interaction was also made easier by making the interactive response area larger during the creation of the prototype.
Figure 5: Central display of instant feedback (see Appendix A for original home page).

Figure 6: Interactive area (design view).

Other interactive alterations to the game involved adding the option of retrying a failed question by adding a return button, and or having the option of going straight to the answer of the failed question.
The additions and alterations of these features is aimed at making the game much more enjoyable, have the elderly engrossed in playing the game and reducing the amount of frustrations experienced in the original Math Bingo game. These are the objectives of the Instant Feedback and Interaction preferences design guidelines.

6.3 Evaluation Proceedings

An interactive prototype of the Math Bingo game has been made with features that include the customization options of the language in the game, and edited interaction and feedback features and added options. The prototype will be used during the observation sessions of the partnering research, and an expert user testing session, which was introduced as another tool to enhance the results of the evaluation process. The results will be recorded and compared against the results collected in previous observations and the outlined guidelines.

We plan on using the results of the evaluation process to clarify or have some concrete assurance that the design guidelines identified
during the literature survey can be useful to game developers when designing for the elderly.

6.3.1 Evaluation process

The evaluation process used in our research is the heuristic evaluation process. We selected this method because it’s a type of evaluation method that focuses on the interface of a design, and doesn’t require advanced planning [32]. Most importantly, evaluators can evaluate independently, which was very beneficial in our case since the observation process with the elderly in the care centres was carried out by the partnering project due to communicate barriers.

“Heuristic evaluation is done by looking at an interface and trying to come up with an opinion about what is good and bad about the interface. Ideally people would conduct such evaluations according to certain rules, such as those listed in typical guidelines documents.” [31, p.155]

In the context of our research, we evaluated the interface of the prototype based on the identified design guidelines of mobile devices for the elderly. The evaluation was carried out using two groups: 2 interaction design experts and 5 elderly people from the elderly care centres.

6.3.2 Interaction design experts

The evaluation process with the interaction design experts involved having them looks at the original Math Bingo game, then have them understand the identified guidelines and the aim of the evaluation process. Finally the experts had to give their insight.

The drawbacks of the prototype testing experienced by the expert subjects included the delay in understanding how to start the game and the flower icon form of instant feedback. These are features of the original game that are only experienced by first time players. The bothersome aspect of the prototype was having to click the next button after every response, though beneficial for the el-
derly, the young experts found it cumbersome.

The positive aspects of the prototype testing included the explicit clarity of the prototype, this made it easy to follow. The fact that the prototype design looked like the original game, and still had the same interaction experience was also a positive aspect. The overall implementation of the interface design guidelines (stated above) into the prototype seemed beneficial for the elderly.

6.3.3 Elderly Users

The evaluation process of the elderly users at the care centres involved observing their interaction with the prototype and answer the following question:

1. Do the players understand the purpose of the prototype?
2. Does the language option make a difference (make the game easier to play)?
3. Is the game fun and easier to play, with the options of retry questions and being able to go straight to the answers?
4. Is the new display of instant feedback better, does it help make the game less confusing?
5. What features do the players have a problem with, or would like changed/removed?

On average, the players did understand the prototype and the language option made the game easier to follow. The option of retrying a question was beneficial, except the option of going straight to the answer made it confusing as to how the player got a flower without giving a correct answer. This was a prototype design issue (though not much of a problem to the player), and it was taken into account as features that needed changing (answering question 5). The new instant feedback displays make the game much easier to play and less prone to errors.

The drawbacks experienced during the prototype testing as with the expert test subjects included, the delay in understanding how to
start the game and the flower icon form of instant feedback. These are features of the original Math Bingo game.

6.4 Evaluation conclusion

Unforeseen setbacks of the evaluation process included the delay in Internet connection which caused problems during the user testing with the elderly, as the prototype was running online. Not being part of the observation meant not being able to give immediate response to questions or misunderstandings of the prototype by the elderly users. One feature we could not change because of keeping the prototype close to the original, was the look of the prototype which was more fitted for female players. As stated in chapter 4 (Customization: paragraph 2), “in a study carried out by Nap et al [21], the elderly female participants prefer cartoon-like graphics, while the male prefer realistic graphics.”

Even with a few setbacks during the prototype user testing, the evaluation process did indicate that the Identified Interface Design Guidelines for mobile devices for the elderly make a difference in the gaming experience of the elderly. The evaluation results indicate that the design guidelines are beneficial when design mobile games for the elderly.
7 Conclusion and future work

The increase in the number of elderly people in the world has lead to the increase in the number of elderly technology users. Technologies such as mobile phones have been identified as devices that provide a sense of security.

Previous research has established that digital games are beneficial to the elderly population. As people age, changes occur that affect their health. The changes include decrease in cognition and motor skills. Playing digital games has proven to be helpful in the improvement of these health defects. Digital games can also be used as a means of social interactions and recreation purposes.

Devices such as mobile devices are defined as direct input devices. As a result less effort is required when learning how to use mobile devices due to their ease of use. This makes it a good platform for digital game for the elderly.

A number of digital game for the elderly have been developed in the past. Unfortunately, there seems to be no specific interface design guidelines defined for the development of mobile digital games for the elderly. Our research aimed at identifying these design guidelines. This was done through a literature survey of past research studies. The identified guidelines were then evaluated using a prototype of an existing game. The prototype was based on some of the identified interface design guidelines. Even with a number of setbacks, the prototype indicated that the guideline made the elderlies’ gaming experience better.

Although the design guideline for mobile digital games for the elderly have been identified, formal validation is required.

7.1 Future work

Regarding future work, proper evaluation of the design guidelines is to be carried out. Future work also includes the use of the identified interface design guidelines by game developers for the development
of a mobile digital game for the elderly. This could also provide a platform for the formal validation of the design guidelines.
References


Appendix A  Math Bingo Features

The images below show some of the main good design features of the Math Bingo game that are beneficial for when designing for the elderly.

Figure 8: Home page with clear font and icons.
Figure 9: difficulty selection options.
Figure 10: The figure above is an example of image feedback (circled).
Appendix B  Project Plan

Figure 11: Project Tasks and Gantt Chart

<table>
<thead>
<tr>
<th>Resource Name</th>
<th>Type</th>
<th>Material Label</th>
<th>Initials</th>
<th>Group</th>
<th>Max. Units</th>
<th>Std. Rate</th>
<th>Ovt. Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Internet</td>
<td>Material</td>
<td>I</td>
<td></td>
<td></td>
<td></td>
<td>£0.00</td>
<td></td>
</tr>
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<td>2 Mobile Device</td>
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<td>M</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>4 Researcher</td>
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<td></td>
<td>100%</td>
<td></td>
<td>£0.00/hr</td>
<td>£0.00/hr</td>
</tr>
<tr>
<td>5 Supervisor</td>
<td>Work</td>
<td>S</td>
<td></td>
<td>100%</td>
<td></td>
<td>£0.00/hr</td>
<td>£0.00/hr</td>
</tr>
<tr>
<td>6 Laptop</td>
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<td>L</td>
<td></td>
<td></td>
<td></td>
<td>£0.00</td>
<td></td>
</tr>
</tbody>
</table>

Figure 12: Project resources list

B.1 Risks

B.1.1 Risk Identification

They are a number of risks that are likely to take place during the course of the project. Some of the major one include:

*Technical*

- No access to Internet.
- Laptop crashing.

*Non-technical*

- Not enough time for completion of prototype/validation of design guidelines.
- Misinterpretation of research results.
- Research already been done before.
B.1.2 Risk Impact Assessment

<table>
<thead>
<tr>
<th>Risks</th>
<th>Risk Likelihood</th>
<th>Score</th>
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</thead>
<tbody>
<tr>
<td>No Internet</td>
<td>Low</td>
<td>1</td>
</tr>
<tr>
<td>Laptop Crash</td>
<td>Low</td>
<td>1</td>
</tr>
<tr>
<td>Prototype/validation Completion</td>
<td>Medium</td>
<td>3</td>
</tr>
<tr>
<td>Result misinterpretation</td>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td>Research already done</td>
<td>Low</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 13: Risk likelihood scores [16]

<table>
<thead>
<tr>
<th>Risks</th>
<th>Risk Consequence</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Internet</td>
<td>High</td>
<td>4</td>
</tr>
<tr>
<td>Laptop Crash</td>
<td>Very High</td>
<td>5</td>
</tr>
<tr>
<td>Prototype/validation Completion</td>
<td>Medium</td>
<td>3</td>
</tr>
<tr>
<td>Result misinterpretation</td>
<td>Very High</td>
<td>5</td>
</tr>
<tr>
<td>Research already done</td>
<td>Low</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 14: Risk consequence scores [16]

The assessment of the risks is carried by using the following formula [16]: \( \text{Risk impact} = \text{likelihood} \times \text{consequence} \)

The likelihood of each risk is indicated in figure 15, and the consequence of each risk is indicated in figure 16. The result impact of each risk is indicated in figure 17.
Using the results of the risk impact formula, the risks ranging from the most critical of the project to the list critical include:

- Prototype/validation Completion.
- Laptop Crash.
- Result misinterpretation.
- No Internet.
- Research already done

### B.1.3 Risk Alleviation

The potential risk of the project can be prevented or dealt with in a number of ways:

- **No Internet:** This risk can be avoided with through *Contingency Planning*. Contingency planning can involve ensuring that there is more than one form of internet connection available.

- **Laptop crash:** This risk can be avoided through *Contingency Planning and Avoidance*. Contingency planning can involve arranging for an alternative computer. Avoidance can involve storing project information in the cloud.

- **Prototype/validation Completion:** This risk can be avoided *Contingency Planning and Deflection*. Contingency planning can involve completion of certain tasks ahead of time, thus allowing
for unexpected delays. Deflection can include the involvement of other developers during the prototyping phase.

- **Misinterpretation of research results**: This risk can be avoided with through *Contingency Planning*. Contingency planning can involve the use of proper research methods and models to analyse and interpreted the results.

- **Research already done**: This risk has been avoided with through *Contingency Planning*. Contingency planning involved carrying out literature search before deciding on the topic and research question.