

An interface for increasing users' understanding of smart home systems using gamification

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ABSTRACT

Smart home systems are becoming more and more popular as the technologies become more sophisticated and efficient. Despite this interest and popularity, the use and acceptance of smart home systems are still low. This is due to factors such as lack of understanding of how smart home systems work, as well as concerns about privacy and data protection. We created a concept of a smart home interface that is supposed to increase understanding of the functioning and data management of the system through gamification. Interviews were conducted with possible users, who were questioned about their experiences with and opinions about certain aspects of smart home systems, to further investigate the factors that impact acceptance. After that, the subjects were presented our concept, which is supposed to solve these barriers. Results show that most participants worry about a lack of transparency of data usage in a smart home but have mostly positive feelings about our concept. We conclude that our gamification approach has the potential to make people more aware of how personal data works and how it is handled.

CCS CONCEPTS

• **Human-centered computing** → **Interface design prototyping**.

KEYWORDS

smart home, gamification, technology acceptance, voice assistant

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1 INTRODUCTION

Smart home systems remain a trending topic with an abundance of research and innovation. Fields where smart homes are used include energy efficiency or assisted living of the elderly. There is a wide range of products and information in the media, but it can be observed that so far only a very small circle of people use these systems [3].

Studies show that people's acceptance of smart home systems is relatively low [3][14]. The reasons for this are, for example, the limited knowledge about smart home systems and how they work. Many people have limited or no knowledge about these systems, which negatively affects their experience [6]. Another major barrier to adoption is uncertainty about how personal data will be handled. As long as there is uncertainty about this issue, people might avoid using a smart home system [13]. These issues create mistrust and affect adoption. To this end, we looked at what methods and practices can be used to increase adoption. To meet the limited understanding of new technologies and mistrust, it was found from other researches [6][10] that by getting to understand and have knowledge about the system, the barriers can be solved. To be able to guarantee a learning process about the system for the users, we investigated how the learning process can be improved by using gamification elements. One study, for example, shows how different game elements can appeal to different motivational mechanisms [8].

To understand the acceptance of smart homes and what the reasons for low acceptance could be, we conducted a preliminary study. Our goal is to develop a gamified interface that increases the understanding of a smart home system and has a positive impact on adoption. This study is mainly intended to address people who do not own a smart home system but could imagine getting one and still have reservations. We also want to convince people who are critical of smart home systems that they can be useful.

In this paper, we first present our review of literature that has already addressed the topic. In the next chapter, we present our gamification approach to a more understandable smart home. We then describe our empirical research, where we conducted qualitative interviews in which we tried to identify people's acceptance

towards smart home systems and presented our approach to potential users to see how they perceive it and how it could be improved. The results are analyzed to see if our solution approach might be applicable. Based on the results, possible next steps are outlined.

2 STATE OF ART

In this chapter, we will look at research that has already been conducted and describe how it relates to our work. To provide an overview of the problems associated with the acceptance of smart home systems, we first looked at scientific papers that deal with this topic.

Reasons for the lack of acceptance for smart home technologies have already been attempted to be identified in research have investigated the following research question:

"Which factors influence the acceptance of smart home technologies in Germany?"

To answer this question, Gross et al. conducted interviews with users and non-users to obtain the subjects' assessments [6]. They found that both users and non-users often doubted the usefulness of the systems and saw no added value in their everyday life. The subjects also had doubts about the security of such systems. Above all, the question of how to handle their data was a barrier for the participants. Another important factor here was the limited knowledge about smart home technologies. This point influences the previously mentioned aspects. The majority of the subjects had limited or no knowledge about the various smart home systems. This also meant that no intention was seen in wanting to use such a system [6].

Another research [3] also dealt with the question of the acceptance of smart homes. This research aimed to investigate social barriers to the introduction of smart homes. For this purpose, the authors conducted deliberative workshops, expert interviews, and literature research to investigate the social barriers. Conversely, these social barriers provide lower acceptance. In the workshops that were conducted, it was discovered that the majority of the public has concerns about the following: Loss of control and apathy, reliability, the view that smart home technology is divisive; exclusive or irrelevant; privacy and data security; cost and trust. The reasons researched lead to a lack of motivation to use a smart home system. To overcome barriers such as data security, limited knowledge or trust, it is necessary to educate the users on these points [3].

In the study by Aldossari and Sidorova, the acceptance of IoT in the smart home context was investigated. For this purpose, a theoretical model was used that integrates the unified theory of acceptance and use of technology (UTAUT2). The results show that social influence and hedonic motivation are important factors influencing the acceptance and use of a smart home. Also, the factors of trust and security risks have a major influence on acceptance. [1]

With the help of this research, we can identify most of the reasons for low acceptance and use them in our work. To relate these factors to our approach, we looked at research in the gamification field.

Gamification in learning can increase motivation to learn, which was shown in research by Su and Cheng [12]. Gamified learning activities were used in schools, and it was observed how they were received by the students. Using a questionnaire, it was determined

that the students perceived the gamification elements, which were made possible via the smartphone, positively. The pre-test and post-test showed that the integration of mobile and gamification technologies resulted in better learning performance and a higher level of motivation than non-gamified mobile learning or traditional teaching.

In a study from Yildirim [15], the effects of gamification-based teaching practices in a university were investigated. For this purpose, an experimental design with pretest-posttest experimental and control groups was conceived. This was carried out with 97 students, and the results showed that gamification-based teaching practices have a positive impact on student's performance and students' attitudes towards teaching.

The paper by Strmečki et al. investigated the introduction of gamification elements in e-learning systems. Here it is explicitly about the use of game elements, game mechanics and game thinking. Gamification in e-learning systems is used to motivate and engage learners. For this purpose, the authors applied and compared a gamified and a non-gamified e-learning course. The results showed that students who participated in the gamified version of the e-learning course achieved greater learning success. Through this, the potential of gamification elements in the field of learning can be seen [11].

In the paper from Bahrini et al. the researchers also examined privacy and security issues. Many users find it difficult to acquire and apply security recommendations to protect themselves from malicious behaviour in smart home systems, causing users to lose interest in the topic. Game-based learning is a powerful way to engage users in a fun and intuitive way. In this paper, the authors investigated the effect of game premise on user motivation and performance in an educational game. For this purpose, a game was designed with the goal of educating users about smart security challenges. Two versions of the game developed with opposite gameplay were compared to each other in a cross-group experiment. The results show high motivational scores in both versions of the smart home security problem-solving game [2].

It can be seen here that gamification encourages learning, and this effect is what our approach aims at, as we think that by learning or getting to know the system, the user will become more receptive to the smart home system, and the issues such as privacy and concerns about security can be addressed.

That gamification can increase motivation to use the systems was investigated in this paper. Sailer et al. investigated how different game elements can appeal to different motivational mechanisms. This theoretical research shows that gamification potentially addresses motivational mechanisms and thereby promotes motivation. Important here are three factors that can lead to a motivational gamification approach:

- (1) Determination of the target group to be addressed by gamification.
- (2) Gamification environment. To create an effective environment, design guidelines help to analyze why certain gamification elements have a motivating effect.
- (3) Context. Here it is important to describe the context as the content or theme of a task.

To gain further knowledge on this topic, it is important to consider these points when designing a gamification environment [8].

In another research by Sailer, the impact of gamification on motivation and learning outcomes was investigated. Research findings on the effects of gamification on cognitive, motivational, and behavioural learning results were systematically summarized in this meta-analysis. Findings from random-effects models showed significant small effects of gamification on cognitive, motivational and behavioural learning outcomes. Because of the heterogeneity of effect sizes, moderator analyses were conducted to examine the inclusion of game fiction, social interaction, comparison group learning arrangement, and situational, contextual, and methodological moderators, namely time period, research context, randomization, design and instruments. Results of the sub-split analysis suggest that effects of competition, augmented utilizing collaboration, may also be valid for motivational learning outcomes [9].

Low acceptance can be caused by limited knowledge [6]. Therefore, our approach is to "teach" the user the system via gamification elements and thus eliminate the concerns in the points, data protection or worries about security, through explanation.

3 APPROACH

Considering the problems in smart home acceptance explored from the literature review, a concept for an interface was developed that could help to reduce these barriers. Our approach should include both gamification elements and serious game elements. Gamification focuses on the use of game elements in non-game environments [4]. Since serious games, on the other hand, focus more on the aspect of not having the main function as entertainment but a well-defined intention such as the educational purpose, the functions of our approach must be separated here [5].

For the gamification elements, we have taken a principle from video games. Here the smart home system interacts similarly to non-player characters in video games. Non-player characters interact with the player and have conversations with him. We transfer this to our approach by having the user "talk" to the smart home and get to know the system. Thus, the points are: (1) The request of functions, (2) answering questions about data protection and (3) controlling the house, which is explained in more detail below. Those elements of video games that can have a learning effect were investigated in this study [7].

We aim to use the serious-game element by incorporating learning games, which is clarified in point (4) and explains the functions with the help of games. In the smart home system, we imagine, firstly, the users can ask the smart home, as well as the individual devices implemented in the smart home, questions and to talk to it naturally. Secondly, games are implemented that support the understanding of the functions of the system

Speaking with the system should cover the following tasks:

- (1) The request of functions
- (2) Answering questions about data protection
- (3) Controlling the house
- (4) Explaining the functions with the help of games

- **The request of functions:**

In this part of the interface, the user can ask the individual devices in the house about the functions. A conversation could go

like this: The user goes to the refrigerator and asks "What can you do?". The refrigerator responds with, "I have a freezer compartment where you can store things below -7 degrees, as well as the main compartment with a temperature of 3 degrees. I can also blast freeze individual food items". Now the user has an overview of the individual functions of the refrigerator.

- **Answering questions about data protection:**

The user can ask any kind of questions regarding his data that is processed in the system. For example, he can ask a system what it has done with his data, where it has been sent and who has access to it. In addition, the user can ask the individual devices, as well as the entire system, to stop collecting and storing certain data.

- **Controlling the house:**

This is similar to existing concepts of voice-controlled smart home systems. The user issues a command ("Turn on the light," "Turn up the heating", "Change the TV program") and the system executes it.

- **The explanation of functions with the help of games:**

The user can play different games with his home. The games that are provided are designed creatively. For example, the user can play a "who and where am I" game. A device describes its features and functions, the user must guess where the device is "hiding" and exactly which device it is. Another variant is a role-playing game. The user is told a story in which different things happen, which can be influenced by using the different devices. For example, the user has to make various decisions within the story. To make the decision, different actions with different devices are suggested to him. Depending on which device he then chooses, the rest of the story proceeds differently.

4 STUDY

To investigate smart home acceptance issues and how possible users perceive our approach, qualitative guided interviews were conducted with 10 participants. Because of contract restrictions due to the pandemic, the interviews were conducted using an online video conferencing tool with each participant individually. Interviews took place between 10.05.2021 and 28.05.2021.

4.1 Study design

The participants interviewed all come from Germany and the immediate area. Care was taken to ensure that the participants were at least 25 years old and, in some cases, married with children. The oldest participant is 43 years old, 5 of them were male and 5 female ($M = 30.4$, $SD = 6.67$). In this case, we did not take into consideration whether the subjects had a fundamental dislike for smart home systems, since we wanted to form a general impression of the opinion regarding smart home systems and our idea.

First, we asked for their socio-demographic information regarding age and gender. Subsequently, we requested that the participants to rate their technical knowledge on a seven point Likert scale and also asked them what they understand under the term "smart home." After these questions, we presented our voice assistant approach.

Following the presentation, we asked questions about how familiar the subjects were with voice assistants and what advantages and disadvantages they saw in them. After that, we asked how they

Table 1: Asked Questions in the interviews

Questions
1. How high do you rate your technical knowledge?
2. What do you understand by the term "smart home"?
3. How familiar are you with voice assistants?
4. What advantages and disadvantages do you see in using voice assistants?
5. What do you think of the idea of being able to talk to any system in your home?
6. What do you think of our idea and would you use it?
7. What must be in place for you to want to use a smart home?
8. What general dangers do you see in using a smart home system? Do you see any dangers with our idea?
9. Would these dangers go down if you had a conversation with your system?
10. Would these dangers decrease if you can query the behavior of their system?
11. Which data (usage behavior, general data) would the system be allowed to store and which not?

would find talking to any smart home system in the house. To see how our approach was received by the subjects, we then asked them for their views on it.

To find out how subjects feel about privacy, we asked the following questions: What must be given for you to want to use a smart home? What general dangers do you see in using a smart home system and whether they see any dangers in our idea? On the dangers, we also asked these questions to identify the subjects' concerns: Would these dangers decrease if you had a conversation with your system and if you could interrogate the behaviour of their system? Finally, we also asked which data (usage behaviour, general data) the system would be allowed to store and which it would not.

Since this is a qualitative analysis and the subjects often gave very detailed answers, a table listing all the inheritances is not convenient. Therefore, the results were summarized in the Results section.

4.2 Results

Most subjects stated that they had a medium understanding of technology ($M = 4.7$, $SD = 1.25$, $MD = 5$). There were no subjects who reported they had little knowledge of technology; instead, there were more subjects who were partly well versed. Most subjects said they would like to use a smart home system, but the most commonly mentioned counterpoint was the expensive purchase of such a system. Also, a disadvantage people mentioned was that implementation requires some knowledge and effort. Similar to other studies, privacy was a major issue [2][3]. There are various concerns that data obtained would be sold or used by hackers. This was also reflected in the opinions regarding the use of voice systems. Most respondents found voice systems to be very convenient and profitable but were afraid that they could be monitored throughout, and that data would be collected somewhere outside their home system. Part of our idea involves being able to talk to any system

in the house. The majority of subjects thought the idea itself would be good and very useful. These subjects saw more advantages in it than disadvantages. For example, one participant said that they would like to have a system that prepares breakfast with little effort and through voice control. The disadvantages of the presented system according to our participants coincide with those previously mentioned. Again, there is a concern that subjects will be permanently monitored.

Individual subjects also found it scary to be able to talk to any device and were concerned that the human element of action would be lost. When asked if privacy concerns would decrease if individual devices could be queried regarding the most recently stored and used data, all but one answered yes. Nevertheless, there was concern among individual subjects that there is still a risk and that it is not possible to monitor the system 24 hours a day. The opinions were divided regarding the idea of playing with the house. Some of the subjects found the idea funny and interesting. Most of them could imagine that by playing with the house some functions could be brought closer. Another group of people found it unnecessary and not profitable. The reason for this was that these subjects seemed very convinced that they would understand all devices without such a game and would therefore not even try it.

5 CONCLUSION AND FUTURE WORK

The acceptance of smart home systems is still relatively low, which is why this research was conducted. To identify the reasons, a literature review on the topic of smart homes was conducted. A smart home interface that could increase the low acceptance was conceptualized. For this purpose, interviews with 10 participants were conducted to find out their opinions towards smart home systems and to present our approach to get the first assessment of it. Based on the interviews, some insights could be gained. As was also evident in the literature, the main reasons for not using smart home systems were problems with data handling and a lack of transparency. Most of the subjects were concerned that a voice assistant would also listen if it was not addressed. A solution must now be found so that the subjects are not unsettled by this fear. This concern is partly justified because a voice assistant that is expected to function when the user calls out has to "listen" continuously. Some of the subjects found playing with the house interesting and thought that it could have potential. On the other hand, other participants considered it unnecessary. Possibly, such a function could be added as an add-on for users with little technical knowledge.

The knowledge we gained can be used for the continuation of this project. Parts of our interface design will now be restructured so that weaknesses are mitigated in the execution of our project. The next step will be to conduct an experimental study. We are planning to have subjects enter a prototypical smart home and then interact using various smart home devices. When interacting with the devices, the devices will not be controlled by voice, but each control will be initiated remotely by the research leaders (Wizard of Oz experiment). The procedure of the implementation is planned as follows: At the beginning, the subjects enter a smart home. Via speaker, the subject is welcomed by a "voice system", which is controlled by the research leaders. The voice system will have several pre-implemented potential answers that can answer

questions the users might ask. After the introduction, the user will be allowed to examine and try out the different systems. Following the familiarization phase, the user will be able to play various games that would help to understand that smart home system. Finally, another survey will be conducted to determine the user experience of the smart home system.

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