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Are serious games too serious? Diffusion of wearable technologies and the creation of a diffusion of serious games model

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ABSTRACT

Today globally, more people die from chronic diseases than from war and terrorism. This is not due to aging alone but also because we lead unhealthy lifestyles with little or no exercise and typically consume food with poor nutritional content. This paper proffers the design science research method to create an artefact that can help people study the diffusion of serious games. The ultimate goal of the study is to create a serious game that can help people to improve their balance in physical exercise, nutrition and well-being. To do this, first we conducted 97 interviews to study if wearables can be used for gathering health data. Analysis indicates that designers, manufacturers, and developers of wearables and associated software and apps should make their devices reliable, relevant, and user friendly. To increase the diffusion, adoption, and habitual usage of wearables key issues such as privacy and security need to be addressed as well. Then, we created a paper prototype and conducted a further 32 interviews to validate the first prototype of the game, especially with respect to the diffusion possibilities of the game. Results are positive from a formal technology acceptance point of view showing relevance and usefulness. But informally in the open questions some limitations also became visible. In particular, ease of use is extremely important for acceptance and calling it a game can in fact be an obstruction. Moreover, the artefact should not be patronizing and age differences can also pose problems, hence the title not to make the serious game too serious. Future research plans to address these problems in the next iteration while the future implementation plan seeks for big platforms or companies to diffuse the serious game. A key theoretical contribution of this research is the identification of habit as a potential dependent variable for the intention to use wearables and the development of a diffusion model for serious games. The hedonic perspective is added to the model as well as trust and perceived risks. This model ends the cycle of critical design with an improvement of theory as result contributing to the societal goal of decreasing Obesities and Diabetes.

1. Introduction

Mobile health solutions, including those with the ability to provide healthcare delivery, advice and access to healthcare information, are rapidly gaining prominence (American Diabetes Association, 2008). This is largely due to increases in computing power and developments with smart phone capabilities and technologies (Global mobile statistics, 2014). There are many benefits of mobile health solutions; namely convenience, a low or negligible learning curve, and they are accessible essentially 24/7 (Steinhubl, Muse, & Topol, 2015)). Mobile health technologies tend to support both health and wellness aspects across all age groups, genders and ethnicities and this makes them particularly popular especially with consumers (Markoff, 2011). Hence, we are witnessing mobile solutions to support diet and exercise activities, management and empowerment for people with chronic conditions such as diabetes as well as mental wellness and behaviour support (Global mobile statistics, 2014).

The use of self-tracking wearable technology has increased in popularity and is now being used as a means of optimising the health, fitness, and well-being of individuals and even groups. The widespread diffusion and adoption of wearables requires the development of rich and robust lenses to conceptualise and understand the drivers of their

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success (Benbunan-Fich, 2018). In this research, we define wearables as devices worn by individuals which monitor variables such as steps taken, heart rate, speed, pace, distance, calories burnt, hour slept, quality of sleep, and even dietary information. The sale of wearables is soaring and is set to grow by 27 % in 2020 (https://techcrunch.com/2019/10/30/wearable-spending-forecasted-to-increase-27-in-2020/). 23 million wearables were sold in 2016 worldwide and total sales are expected to grow to 213 million in 2020. While the diffusion of wearables is high the long term adoption of wearables and the apps on them is low. The rate of abandonment and usage of wearables and the apps on them respectively is substantial. Hence there is a strong need to investigate the users of wearables and find out (a) what would help make wearables and the apps on them a 'success' and (b) why the adoption of wearables and the apps on them is a 'failure' so far.

Serious Games is a term used to describe the development of games specifically designed to achieve some change in the player. This could be a change in knowledge, attitude, physical ability, cognitive ability, health, or mental wellbeing. McCallum identified three types of health games: games focussing on physical health, cognitive health and social and emotional health (McCallum, 2012).

As noted by Hamari and Keronen (2017) more and more games are increasingly being employed for a variety of purposes yet the literature is scattered and there is a lack of a clear and reliable understanding of why games are being used and what their benefits are. Moreover, it is still to be established how they are placed with respect to the utilitarian-hedonic continuum of information systems (Hamari & Keronen, 2017). Further, they note that on reviewing 48 studies they found that some believe that because games intended for instrumental use are rated high regarding enjoyment and usefulness games are thus multi-purpose IS which rely on hedonic factors and the pursuit of instrumental outcomes.

This paper proffers the design science research method to create an artefact that can help people to improve their balance in physical exercise, nutrition and well-being. Specifically, the wearable incorporates serious games to investigate the research question "How can we create a qualitative diffusion model for serious games?" This study will focus on the motivational purpose of serious games.

The paper is structured as follows: In the following section we first look at adoption and diffusion literature and then focus on the diffusion of wearables and thereafter on the diffusion of serious games. In Section 3 we explain our research method and Section 4 discusses the interview results. Section 4 mirrors the literature review and discusses the interview results in terms of diffusion of wearables and the adoption of serious games. In Section 5 we discuss the the theoretical and practical implications of our study and results. Section 6 closes with conclusions.

2. Background and literature review

In this section we first present relevant aspects of the adoption and diffusion literature to create the basis for the interview model. This is followed by specific wearable diffusion issues from literature and finally we discuss the diffusion of serious games from a theoretical perspective.

2.1. The determinants of ICT innovations adoption and success

For the interviews we made use of the USE IT model (Landeweerd, Spil, Ton, & Klein, 2013), a qualitative research model derived from the UTAUT model (Venkatesh et al., 2003), Diffusion of Innovation model (Rogers, 1983) and the IS Success model from DeLone and McLean (2003). Fig. 1 illustrates the USE IT model that integrates the four determinants of success of ICT.

The USE IT model makes a distinction between process and product of innovation as Rogers (1995) does. The domains are taken from Delone and McLean (2003) who show the net benefits of an information system in the User domain (relevance) and the information, system and service quality in the Information Technology domain.

USE IT		Domain	
		User	Information Technology
Innovation	Product	Relevance	Requirements
	Process	Resistance	Resources

Fig. 1. The USE IT model (Spil, Schuring, & Michel-Verkerke, 2004).

2.2. The diffusion of wearables

We used a grounded literature review using the approach of Wolfswinkel, Furtmueller, and Wilderom (2013). The key steps in the process are define, search, select, analyse and present. Appendix 1 illustrates the summarised metadata for this grounded literature review.

The main dissatisfaction when using a wearable is not being able to fulfil the expectations of the users in terms of fit, comfort, form factor, selectability, adaptability, and overall utility (Coorevits & Coenen, 2016). This could be due to the limited focus of designers and developers on the needs of the user. Nascimento, Oliveira, and Tam (2018) revealed that satisfaction affected intention to continue to use in particular those who were not power users but had a low level of habit. Consumers may actually 'have inflated expectations about the ability of wearables to change nutritional habits'. Furthermore they mention that consumers may have specific needs such as diet needs that are not captured well nor displayed by the dashboards of wearables (Canhoto & Arp, 2017). Buchwald, Urbach, and von Entreß-Fürsteneck (2018) speak about satisfaction as well as dissatisfaction as important metrics in understanding continuance and discontinuance of self tracking devices. They use the hygiene theory of Herzberg, and suggest that while hygiene factors can cause dissatisfaction, they may not necessarily cause satisfaction. For example, the unreliability of the system creates and fosters an intention to discontinue, but its absence does not contribute to the formation of an intention to continue. 'Experience with technology is a key parameter in consumers' adoption' (Kalantari, 2017, p. 301). In the context of self-tracking technology, Kari, Koivunen, Frank, Makkonen, and Moilanen (2016) found that critical experiences promote or hinder the adoption and thereby lead to rejection during the implementation. They also found that prior experiences on self-tracking technologies had an influence on the expectancy of performance of new technologies. In the context of post-adoption and sustained use, hands-on experience with the technology influences habit and use. And habit in turn influences behavioural intention and use behaviour (Venkatesh, Thong, & Xu, 2012).

Limayem, Hirt, and Cheung (2007) refers to habit as ''the extent to which people tend to perform behaviors (use IS) automatically because of learning'' (p. 705). They discuss four conditions that are likely to form IS habits: 1) frequent repetition 2) extent of satisfaction with outcomes 3) relatively stable contexts and 4) comprehensiveness of usage of the IS system. Prior frequency of behaviour is important for the habit strength. Rogers (1995) does not use the term habit but shows the importance of institutionalisation of a new innovation. While experience is necessary for forming a habit it is not in itself a sufficient condition (Venkatesh et al., 2012). Wearables have specific characteristics; due to novelty of a technology habit could be an important factor in technology acceptance (Polites & Karahanna, 2012). Users seem to have problems keeping activity trackers on their person. They remove them to engage in activities such as showering, washing dishes, etc (Shih, Han, Poole, Rosson, & Carroll, 2015). There also seems to be a trade-off in terms of size

of the wearable. Smaller ones are easy to wear and carry but also easy to forget and more fragile while larger ones cannot be forgotten but they are also inconvenient to carry and bulky. However respondents did not seem to have problems remembering to carry car keys, mobile phones, and wallets. Shih et al. (2015) believe that with longer adoption periods wearables will become a part of their daily (activity) routines. Individuals have to (a) prepare the wearable such as charging (b) make sure the GPS is working (c) turn them on and (d) finally remember to bring it (Lupton, Pink, Heyes LaBond, & Sumartojo, 2018). While some of these could become a part of a routine/habit there were other aspects that required constant attention and vigilance. Fritz, Huang, Murphy, and Zimmermann (2014) did a longitudinal study on fitness trackers using wearable devices in three different continents. The wearables became a part of them and they felt strange when they took it off. However most of them lost interest when the novelty wore off and the monitoring became routine. Once they crossed the learning curve and were able to estimate their steps and/or calories without the device by themselves, the wearables became obsolete.

2.3. The diffusion of serious games

Research interests in serious games have increased over the last decade and we now find a few similar definitions of serious games in existing literature: "Serious games are games that do not have entertainment, enjoyment or fun as their primary purpose" (Michael & Chen, 2005).

"Serious games have an objective to use the entertaining quality of the game for training, education, health, public policy, and strategic communication objectives." The combination of these two definitions is maybe the best way of defining serious games. The purpose differs from entertainment oriented video games but this does not mean that it cannot be fun or joyful to play. In addition, Marsh (2011) argues that not all videogame characteristics, such as challenge, fun and play, are appropriate descriptions or labels for all serious games. We define serious games as: "*playful acts that do not have entertainment, enjoyment or fun as their primary purpose but have training, education, health, public policy, and strategic communication objectives*".

Over the recent past gamification has increased in popularity (Koivisto & Hamari, 2018). Gamification refers to designing information systems to afford similar experiences and motivations as games do, and consequently, attempting to affect user behaviour (Koivisto & Hamari, 2018).

The authors reviewed 819 studies and found that while the results in general lean towards positive findings about the effectiveness of gamification, the amount of mixed results is sufficient to urge caution (Koivisto & Hamari, 2018). Furthermore, education, health and crowdsourcing as well as points, badges and leaderboards persist as the most common contexts and ways of implementing gamification (Koivisto & Hamari, 2018). Taken together their findings suggest that there is much room to design more suitable serious games to support specific goals. This would also suggest that more incorporation of co-design and user centred design in gamification for healthcare could prove to be a critical success factor in the update and continued use of this games in this context.

Deterding, Dixon, Khaled, and Nacke (2011) divide the world in *a playing world* and a *non-playing* context. In this paper we instead see an *entertainment-oriented* and a *goal-oriented* approach to game design. In-between we see entertainment games that are partially used for real-life purposes and real-life games that become more fun. Garris, Ahlers, and Driskell (2002) developed a game model in which they call the in-between group instructional games. They clearly describe a scale from video games to game-based learning and state that "there is little consensus on game features that support learning" (p.442). Hamari et al. (2016) focus on the challenge and skill (flow) and engagement and immersion of perceived learning. They conclude that serious games must challenge and engage the players for better learning. Kiili (2005) also focuses on flow. Flow is seen as challenges versus capabilities of the player. An interesting aspect is that feedback is both part of the flow task as well as the flow artefact indicating that adding feedback to entertainment games can give a learning effect. Transformational learning can be the bridge, communicating the power of games (Barab et al., 2012). Furthermore, the positioning of the person and content are closely linked (Sousa et al., 2018), where positioning context can be derived from dialogues and narratives.

Most researchers focused their study on different purposes of serious games. There has been a lot of research in the effectiveness of serious games in teaching-learning related processes. For example, Buchinger and Hounsell (2018) reviewed a list of collaborative-competitive serious games in the teaching-learning process. They mentioned 9 important design features: intra players interaction, synchronization, roles, resources, score, challenge, reward, Artificial Intelligence and operationalization. This study will focus on the motivational purpose of serious games to create consciousness and behaviour change. In the next section we introduce the adopted research method.

3. Research method

In line with the set of principles for conducting critical research in information systems as discussed by Myers and Klein (2011), our research consists of elements of critique as well as of transformation. We question the actual adoption and effectiveness of wearables and serious games - the principle of revealing and challenge prevailing beliefs and social practices - by making use of the IT adoption model as discussed in the previous section based on insights from innovation and adoption researchers like Davis, Bagozzi, and Warshaw (1989), DeLone and McLean (1993), Rogers (1983) and Venkatesh et al. (2003) - the principle of using core concepts from critical social theorists. We study how the adoption of serious wearable games can be improved - the principle of taking a value position - in order to help improve health on both an individual and societal level - the principles of individual emancipation and improvements in society - and try to improve diffusion models for serious games by identifying habit as a potential dependent variable for the intention to use wearables - the principle of improvements in social theories. We use elements of critique (Myers & Klein, 2011) such as the principle of using core concepts from critical social theorists dating back to Ajzen and Fishbein (1980) and Bandura (1977) leading toward the theory of planned behavior.

The emphasis on relevance in the interview method used leads to a value position critical theorists advocate. Finally the principle of revealing and challenging prevailing beliefs and social practices is well established in this paper by choosing a society problem (Obesities and Diabetes) and explore behavioral change with help of wearables and serious games. The Element of Transformation (Myers & Klein, 2011) are also studied in this paper. The principle of individual emancipation is studied with efficacy (Bandura, 1977) which is used in the UTAUT model (Venkatesh, 2003). This study is aimed at health improvements in society and provides a theory improvement with a new model for diffusion of serious games.

For attaining these research goals, a mixed method approach was adopted. In order to design our Mobile Health serious game, we made use of an adapted version of the Design Science Research Method (DSRM) Process Model, as based on the work of Peffers et al. (2007).

After performing the literature study, we conducted 97 semi-structured interviews with actual owners and users of wearables. The initial group of interviewees was very diverse with users of different ages, backgrounds and education levels. In order to make the results more generalizable and the interview sample more homogenous we made use of the so-called drilldown technique. This was accomplished by focusing on interviewees that can be regarded as the most active users, i.e. millennials (between 18 and 34 years old) who are far more likely to own wearables than older adults and who use wrist-worn wearables for general health and fitness purposes. In order to focus

our analysis on a homogeneous group of early adopters (Rogers, 1983; Yin, 2013), we developed a subset of 20 interviews which where analysed in-depth. The majority of the interviewees (a) were highly educated (b) had experience with technology in general and ICT in particular and (c) were willing to voluntarily adopt new technologies such as wearables. The other 77 interviews were used for the requirements of the wearables and the serious game for diabetes and obesities.

We analysed the qualitative interview data by doing a sentiment analysis through coding (Huberman & Miles, 1994). We divided our analysis into three different phases: data reduction, data display and drawing conclusions/verification.

After getting a better insight in the adoption of wearables based on a sentiment analysis, we designed a specific game artefact based upon interviews with 97 potential users in a wide age scale and demonstrated the artefact in a student environment during a 10 week testing period. Before doing a second iteration, we conducted another 32 interviews to validate the first prototype of the game, especially on diffusion possibilities of the game.

Our study can be regarded in sum as a qualitative study of diffusion of wearables and serious games; we did not focus on the specifics of the serious game itself (i.e. its user intertface).

4. Interview results

This following section describes the objective descriptive data as given by the interviewees. This is followed in the subsequent section by a sentiment analysis and comparison to literature.

4.1. Diffusion of wearable technologies

Around 50 % of the interviewees had a smartwatch and 'Apple' was the most mentioned brand. Around 25 % possessed some form of bracelet. Pedometers, sportwatches, Pebble and Fitbit made up the rest.

The primary purpose of using wearables seems to be for the monitoring of steps and heart rate (Fig. 2). Four out of seven respondents use the heartrate function for sport/movement, whereas running is the most mentioned sport. Analysis of sleep was mentioned by three interviewees, of whom two were interested in the amount of sleep while the third was interested in the rhythm of sleep.

Nearly twenty five percent of the interviewees mentioned that they would like to have an extension of their smartphone as part of their wearable. Two interviewees mentioned that they want to have a standalone device having its own internet access and own GPS. Two mentioned that they would like to be able to monitor blood pressure. The following items were mentioned as extra features that users would like to have: BMI, weight, scanning food instead of filling it in, body temperature, health app giving prescriptive advice about certain disease/disorder, monitoring health in order to change behavior, and amount of alcohol in the blood. A Fitbit user also mentioned wanting to have more functionality with regards to movement. Essentially there was consensus that wearables needed to be more comprehensive and standalone.

When queried on the crucial factors for the use of wearables nearly twenty five percent of the interviewees identified *additional value* and *ease of use* as being important (Fig. 3). Twenty percent of the respond mentioned *reliable data* and *personal interest* either in new technology or from a hobby point of view. Lifespan of battery was of importance to fifteen percent. Only ten percent mentioned *health*, *communication*, *behaviour change* and *stand-alone device* as being important.

4.2. The diffusion of serious games

The adoption of serious games is predicated on a number of factors as illustrated in Fig. 4 below. Although the structured analysis is very positive, showing a high probability of diffusion, the emotional analysis shows some limitations that the next design must overcome. The emotional analysis is given in quotes:

- "I wonder why it cannot be a normal app and has to be a game"
- "I think it looks a bit childish"
- "I do not want the game to treat me like a child"
- "I already know that I need to exercise more"
- "Cheating is easy"

The analysis shows that the next iteration should take care of age

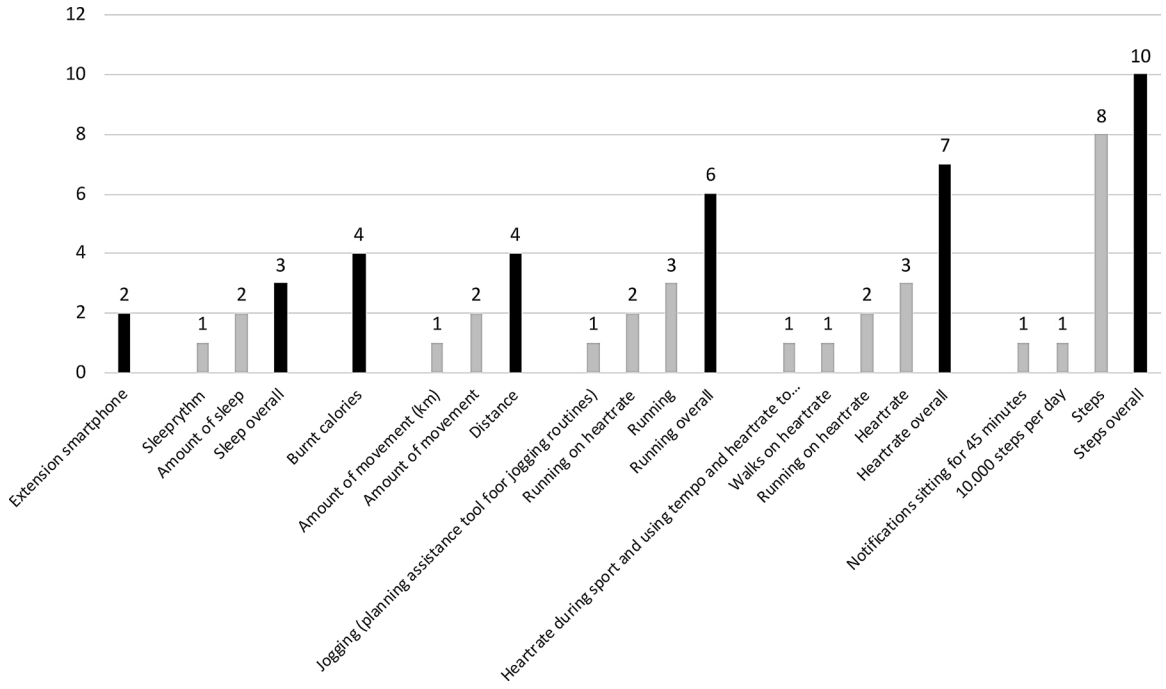

Fig. 2. The use of wearables.

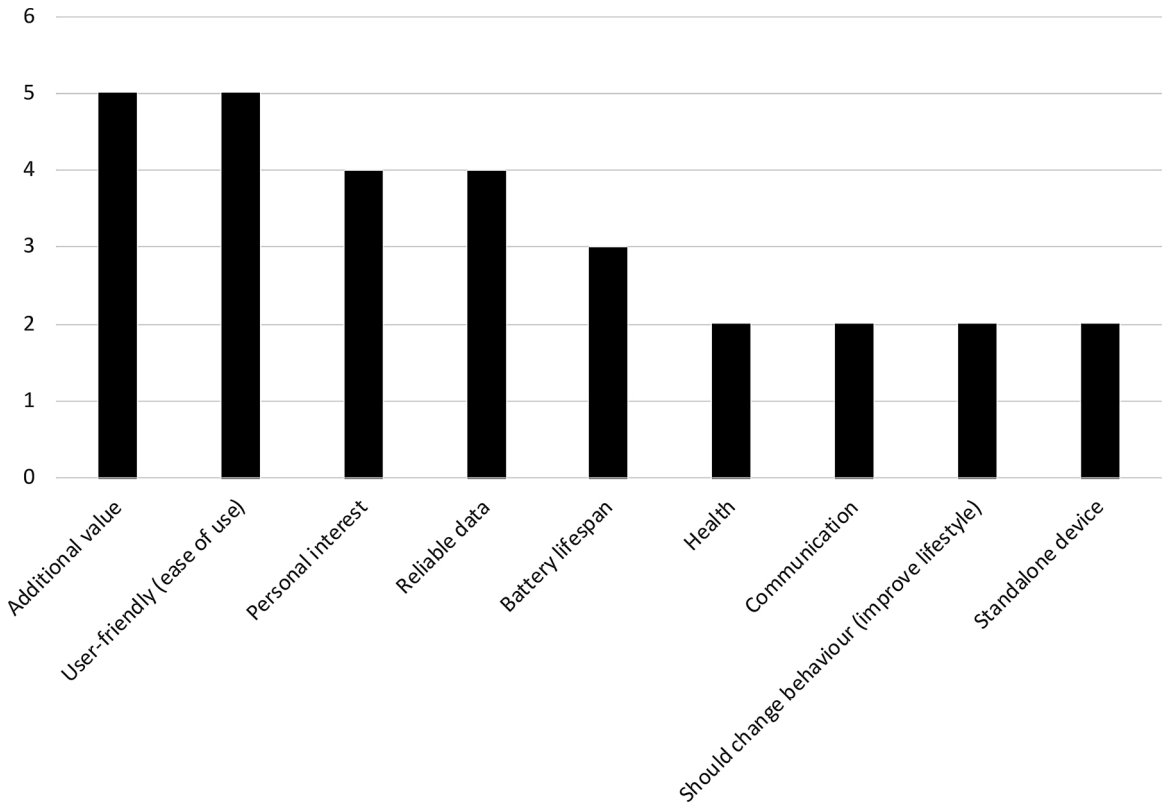

Fig. 3. Crucial factors contributing to the usage of wearables.

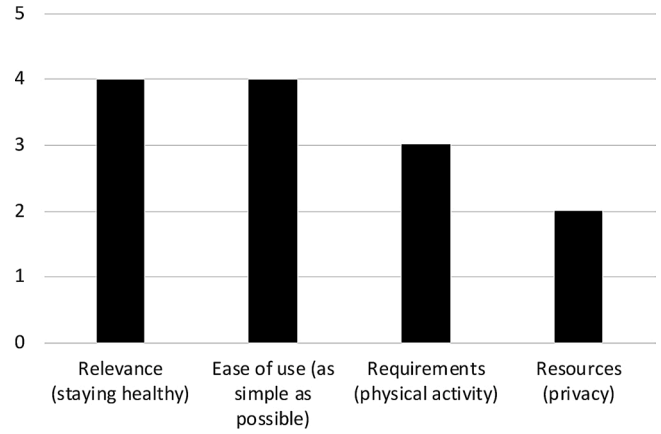

Fig. 4. Adoption of serious games.

differences and preferences and the interaction with the game should be as easy as possible. We should reconsider to call it a game or an app.

In Fig. 4 only the key areas are mentioned. Just like in most of the TAM (Technology Acceptance Model) studies perceived usefulness is important and in this case 80 % of the interviewees says that staying healthy is very relevant and if the game contributes to that they would use the game. Ease of use is on the same level (80 %) but is relatively more important because so many interviewees mentioned it more than once. Only 40 % of the interviewees was concerned with privacy. 60 % of the interviewees mentioned measuring and using physical activity in the game would be good and easy to accomplish. On nutrition and relaxation they were not that sure both in measuring and using it.

5. Discussion

The research question under consideration was "How can we create a qualitative diffusion model for serious games?" To answer this research question we did a systematic literature review that provided us with the confirmation of relevance as the most important determinant of diffusion of both wearables and serious games. What is unique and interesting about our research findings includes the notion of habit as a new determinant for the diffusion of serious games. The institutionalisation of the serious game is an important factor to make the serious game a lasting success. The dynamics of the game will improve the flow and will prevent the treatment to become boring. The first study on wearables confirmed the importance of the habit determinant and in Table 2 we build a new proposition for serious games. Next to that we propose perceived enjoyment as determinant for successful diffusion of serious games. Finally we use the concept of information quality of Delone and McLean to address the importance of learning and feedback in serious games.

Moreover our findings contribute to both theory and practice as follows.

5.1. Theoretical implications

Diffusion of wearables is hindered by the perception of a lack of relevance by users and a lack of relative advantage. There is the potential to add new features and / or functionalities to these wearables such as blood pressure, temperature, and even sugar level measurement in the future. This may enhance the perception of relevance. However, the more information is captured the more security and privacy issues arise. Currently wearables just provide descriptive facts. Yet, in the opinion of the authors, for wearables to be really effective, they need to go beyond descriptive information and provide prescriptive information that will allow users/wearers to take action. From a serious gaming point of view, we can conclude that staying healthy is the most relevant

factor and the perceived usefulness should address this for the user to adopt this serious game. The main idea from the interviews and first design cycle is to "improve health by having fun". The fun element is not elaborated yet because we think this is more the domain of professional game designers than e-health researchers. Still fun or enjoyment is of major importance for the game. The new diffusion model for serious games can help researchers to study if a specific serious game is likely to diffuse in the target group. In Section 5.2 is shown how this can be done in practice.

One of the key factors for discontinuing the use of wearables is the presence of errors and lack of reliability. While organizations can depend on IT-service departments and/or external contractors to solve bugs, errors and reliability issues, this is not the case for personal/individual ICT such as wearables. It is expected that personal ICTs are accurate and reliable and it is left to the individual to solve problems but unfortunately most individuals do not have the knowledge, will, or time to troubleshoot and solve problems and issues that may arise with personal ICT.

Overall, the results indicated that people were neutral to positive with regards to sharing information, body data, habits, addictions, and the living environment that the wearable provided for diagnosis and statistical research. The extent to which they are willing to share their data depended on several factors. While people believe wearables can be hacked, their opinion is divided with regards to their privacy being at stake. From a monitoring point of view, nutrition is the hardest factor to measure. It is subjective and cannot be done in an automated way. Suggestions from the literature and interviews are to use speech recognition and imaging to monitor as easy as possible.

When analysing the outcomes of the interviews, the specific reasons for why some people do not adopt or habitually use the wearable, is not very clear. However, what became clear was that users of simple, unsophisticated models did not develop the habit of using wearables every day nor throughout the day. In conclusion, from the literature and from the validation of the game design, one thing is very clear: the game (if we call it a game) should be simple and "stupid". The ease of use is mentioned throughout all interviews and is clearly warned for in literature as shown in the background section. Hence the title not making the serious game too serious and limit the amount of feedback.

Serious games increasingly blur the boundary between hedonic and utilitarian information systems (Berfine Koese, Morschheuser, & Hamari, 2019). In and of itself this may not be an issue but it does mean that users may perceive the purpose of the same system differently, ranging from pure utility to pure play (Berfine Koese et al., 2019). This could help explain why some of the serious games in healthcare are not so successful on a larger scale as initially expected. Further, it may indicate that ensuring a more consistent understanding of the purpose of the game amongst users could be significant in improving the success of the specific game with regard to its particular healthcare benefit. From 562 games reviewed by the authors, not all of which were healthcare focused (Berfine Koese et al., 2019), they found that the more fun-oriented users perceived the system to be, the more enjoyment affects continued and discontinued use intentions, and the less ease of use affects the continued use intention (Berfine Koese et al., 2019); hence, users' conceptions of the system are an important influential aspect of system use and should particularly be considered when designing modern multi-purposed gamified information systems which have a specific purpose or focus such as in healthcare contexts. Our study confirms that these user conceptions from the emotional analyses seems troublesome although from a quantitative analysis there seem to be no problems for diffusion. It is therefore important to take a qualitative perspective.

Our paper has also served to contribute to developing further the application of DSRM into healthcare contexts, in particular we have incorporated aspects around privacy/security which are essential considerations when designing healthcare related solutions. In Table 2 they are shown as trust and perceived risks. We have also included a consideration for hedonic aspects; i.e. perceived enjoyment (van der Heijden, 2004) with the game while still subscribing to its utilitarian goal of supporting a critical healthcare need. We note that to date these two aspects - privacy/security and hedonic aspects - have not been incorporated into DSRM. For example while Brooks and El-Gayar et al. (2015) adopted a DSRM approach to examine the implementation of electronic health records neither these two elements were part of their consideration. We suggest that due consideration to privacy/security and hedonic aspects are useful to incorporate as shown in Table 2 and Appendix 2 and thereby extend DSRM when applied in healthcare contexts but probably also in other contexts. The extensive and critical use of the DSRM method in this paper justifies a generalisation of the findings in both the diffusion of wearables and the future diffusion of a serious game for Diabetes and Obesities which is the ultimate goal of this study.

Hence our research results serve to build a new theoretical model that can be used to predict whether a serious game will diffuse in society and start to reach behavioural and motivational objectives. We use Kalantari's (2017) perspective to study wearable technologies. Table 1 shows the comparison and analysis of both interview studies. It is followed by building a new model for diffusion of serious games specifically.

Finally we can build upon this analysis to develop a new model for qualitative design science studies of the diffusion of serious games. From theory (Section 2.3) we derive the horizontal axis with fun, feedback and flow. Next to perceived usefulness (Davis et al., 1989) we add the hedonic perceived enjoyment (van der Heijden, 2004). From Section 2.2 we add the determinant Habit. This determinant is specific for innovations that have to be used many times and should be validated in a future quantitative study in an extended TAM or UTAUT. A proposition would be:

Habit has a positive and significant impact on user intention to use a serious game in healthcare. For requirements we did not use new notions but used the IS success model of Delone and McLean (2003) and the TAM model (Davis et al., 1989). We determined an overlap between resources and resistance and took these elements together and renamed it reliability. Trust and perceived risks were already added in the USE IT model (Landeweerd et al., 2013). It can be a relevant addition to the UTAUT model, Yu (2012) labelled it perceived credibility. The results in this table should not be compared with evaluation studies of serious games where learning and behaviour play an important role (Petri & Gresse von Wangenheim, 2016), the table is focused on diffusion of serious games in a qualitative way. In Appendix 2 we elaborate the content of this model toward interview questions. We start the interview with process questions to check the compatibility (Rogers, 1983) of the new serious game and to get to know the interviewee.

The interview model in Appendix 2 addresses all factors found in Table 2 above. This interview model can be used by practitioners who want to develop a new serious game in healthcare environments. The interview will take approximately one hour and the amount of interviews will depend on the variety of the user (player) group. For each homogeneous group at least one interview should be done but preferably two or more.

5.2. Implications for practice

Serious games have evolved from being 'games' to just being 'serious'. They have become so serious that they are devoid of fun. This has had a significant impact on the adoption and use of serious games. To address this problem we have proposed a model for the adoption of serious games whose central tenets are fun, feedback, and flow. Equally important are three more elements of the model namely: relevance, reliability, and fulfilments of requirements. These six elements together will enhance enjoyment, usefulness, trust, quality, and ultimately lead to the diffusion and adoption of serious games. But the most important outcome that the model hopes to achieve is the design of serious games

Table 1
The success factors analysed with the USE IT construct.

USE IT construct	Success factors expected to be measured	Results Diffusion Wearables	Results Diffusion Serious Games
Process	Perceived compatibility	All interviewees have either a smart watch, sports watch, fitbit or pedometer. All interviewees have Internet online.	All interviewees use a digital device on which an app can function. All interviewees have Internet online.
Relevance	Perceived usefulness Perceived usability	Sport is at the top. This is closely followed by health. Relevance or additional value is a big theme and mentioned by 50% of respondents.	Staying healthy is the most relevant subject that the interviewees mention in 80 % of the interviews. Ease of use is mentioned in more than 80 % to be important for the success of the game.
Requirements	Information quality	Among younger people, the primary appeal is fitness optimization. Older people are seeking to enhance their health and wellbeing and also to extend their life. Most respondents were positive with respect to their enhanced insight and ability to monitor their health indicators. However they were divided regarding the enhancement of their personal health because of wearables.	Measuring physical activity is the most mentioned functionality that already 60 % of the interviewees do. They want it to be easier and the other 40 % expects to use it if provided. Measuring nutrition is seen as difficult and only useful if it can be done in an easy way. Measuring sleep and stress was done by just a few of the interviewees and is a topic that needs further study.
Resources	Service quality System quality Perceived risks	Privacy and security on wearables does not appear to be a serious concern for the developers of the wearables and the apps on them nor for the users of the wearables and apps. Reliability is a big theme which was mentioned by almost 50 % of the respondents.	Most interviewees think they are going to use the game when it improves their health. Only 20 % see privacy risks. Nearly all interviewees state that they want to spend some time for using the serious game.
Resistance	Trust Social and personal influence	However a minor theme concerns the willingness of people to provide health data.	They think it is more a personal tool for their personal use than a healthcare system tool. Many interviewees state that peer pressure might help them to stay on track with their health objectives.

that will lead to the transformation of individuals, reduction of bad habits and instilling of good habits.

When we consider the various stakeholders in this space it becomes quite clear that at the heart of it is/should be the customer, namely the end users of the serious game (Fig. 5). Influencing the end user and being influenced by the end users are the game development studios, designers of serious games, and researchers of serious games. We also recognise the mutually reinforcing roles of all 4 stakeholders (Sein et al., 2011) and the reciprocal shaping of both the artefact as well as the stakeholders.

Table 2
A Diffusion model for Serious Games.

Diffusion of Serious Games	Fun	Feedback	Flow
Relevance	Perceived enjoyment	Perceived usefulness	Experience and Habit
Requirements	Information Quality	Information quality	Ease of Use
Reliability	Social influence and Trust	System Quality	Trust and perceived risks

Fig. 5. Reciprocal Shaping of Stakeholders.

The practical implications of our research apply to all four stakeholders.

5.2.1. *End users of games*

What we have witnessed in the COVID-19 pandemic has underscored more than ever the importance of health and wellness but mostly about keeping healthy. Moreover, it has shown that individuals need to take more responsibility in monitoring and managing their health and wellness supported by mobile and wearable technology aids. Currently there are over 300,000 apps to support and assist patients with diabetes, however all these solutions have poor uptake and even less sustained use (Jimenez, Lum, & Car, 2019). A key reason for this is around the engagement of the user and the ability of the solution to sustain behaviour change. Gamification has been shown to assist with increasing user engagement and sustained usage but incorporating aspects of gamification for health and wellbeing is still in its infancy (Johnson et al., 2016; Spil, Sunyaev, Thiebes, & Van Baalen, 2017).

5.2.2. *Designers of games*

Our study has served to highlight critical aspects that need to be considered when designing the specific serious game that focus specifically on the reliability of the game, its requirements and relevance combined with ensuring the solution is fun, provides the correct level of

feedback and the flow is appropriate. Educating the users regarding the purpose of the game seems to be crucial in the success of the game in terms of health benefits. Obviously ease of use perceptions of usefulness are also critical in adoption of the games. Thus, our developed model provides a suitable rubric for game designers so that they can develop wearable and mobile solutions to address a specific health or wellness aspect with confidence, knowing it will have a high likelihood of uptake and sustained use.

5.2.3. Game development studios

From the perspective of practice of equal importance is the business or financial angle, since the cost of designing and developing games which have poor uptake and even poorer sustained use are not financially viable for developers and companies and do not help to address escalating healthcare costs either. The diffusion, adoption, and retention of serious games by end users is of great concern to the game development studios. Working together with all stakeholders, leading to the transformation of individuals, families, and communities should be their primary goal and vision. Depending on the health system the studios need to work collaboratively with insurance companies as well as the health sector (public and private) to reduce the cost of health, improving health and wellbeing outcomes, and enhancing their enjoyment. Considering the security and privacy concerns involved, a key challenge for the studios is to gain the trust of the stakeholders and in particular the end users and sponsoring or funding agencies such as the government and health sector.

5.2.4. Researchers of serious games

Finally the artefacts we have created as part of this research: the prototypes, the models, and the instruments themselves can become the foundation for future research by other researchers of serious games. These were enumerated in Section 5.1 above.

5.3. Limitations and future research

Finally, we want to stress that designing a serious game is not the holy grail for making the world healthy. Staying healthy is multifaceted in many ways and only a game is not going to solve the many health related problems ahead. In combination with many other initiatives, it can help though to make the world a little bit better. Moreover, to make wearable devices more relevant, more reliable and easier to use the adoption of serious games is beneficial. A limitation of this paper is that the study is done in a well developed country and although the authors are confident the model can be used in less developed countries, this has not been tested. A first validation of the interview framework is done with 32 interviews and a specific prototype of a serious game on obesities and diabetes. Future study is needed to for validating use for a serious game in general and also for using serious games in underdeloped countries.

6. Conclusions

The identification of habit as a potential dependent variable for the intention to use wearables and the development of a diffusion model for serious games based on this insight can be seen as the most important theoretical contributions of our research. More specific, we found during our interviews and validation design cycle that serious health games should “improve health by having fun”. This aspect seems to be a critical design issue and therefore we proposed to include hedonic aspects, like perceived enjoyment, next to privacy/security related aspects into the diffusion model for serious games, the artefact made in this Design Science Research Method. We think that focusing on these aspects when developing a health related serious game may improve its diffusion and as a consequence may help to improve health on both an individual and societal level as well.

Our research question was: How can we create a qualitative diffusion model for serious games? With the critical elements found in the section above we created a new diffusion model for serious games and tested it with 32 interviews. We are confident that this model can improve diffusion of serious games in healthcare and hope it will be applied in many successful future projects.

CRediT authorship contribution statement

Ton A.M. Spil: Conceptualization, Investigation, Validation. **Vincent Romijnders:** Writing - review & editing. **David Sundaram:** Writing - review & editing. **Nilmini Wickramasinghe:** Writing - review & editing. **Björn Kijl:** Writing - review & editing, Methodology.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.ijinfomgt.2020.102202.

References

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.

American Diabetes Association. (2008). Nutrition recommendations and interventions for diabetes: A position statement of the American Diabetes Association. *Diabetes Care, 31*(Supplement 1), S61–S78.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 122–147.

Barab, S., Pettyjohn, P., Gresalfi, M., Volk, C., & Solomou, M. (2012). Game-based curriculum and transformational play: Designing to meaningfully positioning person, content, and context. *Computers & Education, 58*(1), 518–533.

Benbunan-Fich, R. (2018). An affordance lens for wearable information systems. *European Journal of Information Systems*, 1–16.

Berfine Koese, D., Morschheuser, B., & Hamari, J. (2019). Is it a tool or a toy? How user's conception of a system's purpose affects their experience and use. *International Journal of Information Management, 49*, 461–474.

Brooks, P., El-Gayar, O., et al. (2015). A framework for developing a domain specific business intelligence maturity model: Application to healthcare. *International Journal of Information Management, 35*(3), 337–345.

Buchinger, D., & Hounsell, M. D. (2018). Guidelines for designing and using collaborative-competitive serious games. *Computers & Education*, 133–149.

Buchwald, A., Urbach, N., & von Entreß-Fürsteneck, M. (2018). *Insights into personal ict use: Understanding continuance and discontinu-ance of wearable self-tracking devices*.

Canhoto, A. I., & Arp, S. (2017). Exploring the factors that support adoption and sustained use of health and fitness wearables. *Journal of Marketing Management, 33* (1–2), 32–60. https://doi.org/10.1080/0267257X.2016.1234505.

Coorevits, L., & Coenen, T. (2016). *The rise and fall of wearable fitness trackers*. Academy of Management.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982–1003.

Delone, W. H., & McLean, E. R. (2003). The DeLone and McLean model of information systems success: A ten-year update. *Journal of Management Information Systems, 19* (4), 9–30.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: Defining gamification. In *Proceedings of the 15th international academic mindtrek conference: Envisioning future media environments (MindTrek '11)* (pp. 9–15).

Fritz, T., Huang, E. M., Murphy, G. C., & Zimmermann, T. (2014). Persuasive technology in the real world: A study of long-term use of activity sensing devices for fitness. April. In *Proceedings of the SIGCHI conference on human factors in computing systems* (pp. 487–496).

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & Gaming, 33*(4), 441–467.

Global mobile statistics. (2014). *Global mobile statistics 2014 Part A: Mobile subscribers; handset market share; mobile operators* [16 May 2019] http://mobiforge.com/research-analysis/global-mobile-statistics-2014-part-a-mobile-subscribers-handset-market-share-mobile-operators.

Hamari, J., & Keronen, L. (2017). Why do people play games? A meta-analysis. *International Journal of Information Management, 37*(3), 125–141.

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in Human Behavior, 54*, 170–179.

Huberman, A. M., & Miles, M. B. (1994). *Data management and analysis methods*.

Jimenez, G., Lum, E., & Car, J. (2019). Examining diabetes management apps recommended from a google search: Content analysis. *JMIR MHealth and UHealth, 7* (1), e11848.

Johnson, D., Deterding, B., Kuhn, K.-A., Staneva, A., Stoyanov, S., & Hides, L. (2016). *Internet Interventions, 6*, 89–106. https://doi.org/10.1016/j.invent.2016.10.002.

Kalantari, M. (2017). Consumers' adoption of wearable technologies: Literature review, synthesis, and future research agenda. *International Journal of Technology Marketing, 12*(3), 274–307.

Kari, T., Koivunen, S., Frank, L., Makkonen, M., & Moilanen, P. (2016). Critical experiences during the implementation of a self-tracking technology. In *PACIS 2016: Proceedings of the 20th Pacific Asia conference on information systems*. ISBN 9789860491029.

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and Higher Education, 8*(1), 13–24.

Koivisto, J., & Hamari, J. (2018). The rise of motivational information systems: a review of gamification research. *IJIM, 45*, 191–210. https://doi.org/10.1016/j.ijinfomgt.2018.10.013.

Landeweerd, H. R. A., Spil, Ton, A. M., & Klein, R. (2013). The success of google search, the failure of google health and the future of google plus. In Y. K. Dwivedi, H. Z. Henriksen, D. Wastell, & R. De (Eds.), *Grand successes and failures in IT. Public and private sectors: IFIP WG 8.6 international working conference on transfer and diffusion of IT, TDIT 2013, Bangalore, India, June 27–29, 2013. Proceedings (IFIP advances in information and communication technology, 402)* (pp. 221–239).

Limayem, M., Hirt, S. G., & Cheung, C. M. (2007). How habit limits the predictive power of intention: The case of information systems continuance. *MIS Quarterly*, 705–737.

Lupton, D., Pink, S., Heyes LaBond, C., & Sumartojo, S. (2018). Personal data contexts, data sense, and self-tracking cycling. *International Journal of Communication, 12*, 647–666.

Markoff, J. (2011). *The iPad in your hand: As fast as a supercomputer of yore* [9 May 2011]. New York Times http://bits.blogs.nytimes.com/2011/05/09/the-ipad-in-your-hand-as-fast-as-a-supercomputer-of-yore/?_php=true&_type=blogs&_r=0.

Marsh, T. (2011). Serious games continuum: Between games for purpose and experiential environments for purpose. *Entertainment Computing, 2*, 61–68.

Michael, D., & Chen, S. (2005). *Serious games, games that educate, train, and inform*. Muska & Lipman.

McCallum, S. (2012). Gamification and serious games for personalized health. *Studies in health technology and informatics* (pp. 85–96). https://doi.org/10.3233/978-1-61499-069-7-85.

Myers, M. D., & Klein, H. Z. (2011). A set of principles for conducting critical research in information systems. *MIS Quarterly, 35*(1), 17–36.

Nascimento, B., Oliveira, T., & Tam, C. (2018). Wearable technology: What explains continuance intention in smartwatches? *Journal of Retailing and Consumer Services, 43*, 157–169.

Peffers, K., et al. (2007). A design science research methodology for information systems research. *Journal of Management Information Systems*, 45–78.

Petri, G., & Gresse von Wangenheim, C. (2016). How to evaluate educational games: A systematic literature review. *Journal of Universal Computer Science, 22*(7), 992.

Polites, G. L., & Karahanna, E. (2012). Shackled to the status quo: The inhibiting effects of incumbent system habit, switching costs, and inertia on new system acceptance. *MIS Quarterly*, 21–42.

Rogers, E. M. (1995). Lessons for guidelines from the diffusion of innovations. *Joint Commission Journal on Quality and Patient Safety, 21*(7), 324–328.

Rogers, E. M. (1983). *Diffusion of innovations*. Free Press.

Sein, M., Henfridson, O., & Purao, S. (2011). Action Design Research. *MIS Quarterly, 35*(1), 37–56.

Shih, P. C., Han, K., Poole, E. S., Rosson, M. B., & Carroll, J. M. (2015). Use and adoption challenges of wearable activity trackers. *IConference 2015 proceedings*.

Sousa, F., Rasmussen, I., & Pierroux, P. (2018). Zombies and ethical theories: Exploring transformational play as a framework for teaching with videogames. *Learning, culture and social interaction, 19*, 40–50.

Spil, T. A. M., Schuring, R. W., & Michel-Verkerke, M. B. (2004). Electronic prescription system, do the professionals USE IT? *International Journal of Healthcare Technology and Management, 6*(1), 32–55.

Spil, T., Sunyaev, A., Thiebes, S., & Van Baalen, R. (2017). *The adoption of wearables for a healthy lifestyle: Can gamification help?*.

Steinhubl, S., Muse, E., & Topol, E. (2015). The emerging field of mobile health. *Science Translational Medicine, 7*(April (283)), 283rv3. https://doi.org/10.1126/scitranslmed.aaa3487.

van der Heijden, H. (2004). User acceptance of hedonic information systems. *MIS Quarterly, 28*(December (4)), 695–704.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly*, 157–178.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems, 27*(3), 425–478. https://doi.org/10.2307/30036540.

Wolfswinkel, J. F., Furtmueller, E., & Wilderom, C. P. (2013). Using grounded theory as a method for rigorously reviewing literature. *European Journal of Information Systems, 22*(1), 45–55.

Yin, R. K. (2013). *Case study research* (5th ed.). SAGE Publications.

Yu, C. S. (2012). Factors affecting individuals to adopt mobile banking: Empirical evidence from the UTAUT model. *Journal of Electronic Commerce Research, 13*(2), 105–121, 2012, Accessed: Jun. 21, 2020.