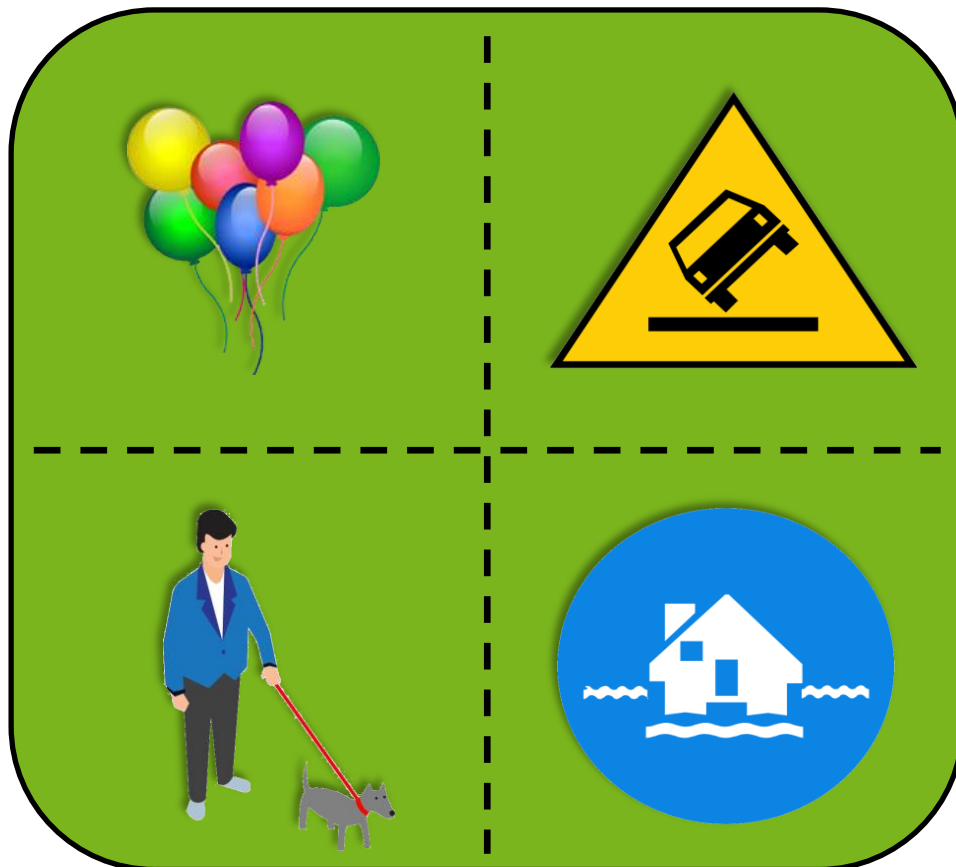


# Measuring the effect of gamification on user adoption of a software application



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MBI Master Thesis

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## Abstract

The focus of this research is on the intersection of user adoption and gamification. User adoption is important for both developers and buyers of new technologies, and it is a complex problem that involves many variables. A promising and relatively new way to increase user adoption is gamification, which is expected to increase user engagement and participation. Conventional wisdom tells that gamification affects user adoption via user motivation.

To be able to effectively influence user adoption via gamification, it is important to know if and how gamification can influence the motivation of users. There are few scientific studies that focus on this exact problem, and its underlying principles. Therefore, the goal of this research is to investigate the underlying motivational principles that play a role when using gamified software applications. Another goal is to discover how to implement gamification in a software application to increase user adoption.

The research approach includes assembling a conceptual model, on the basis of literature about user adoption, motivation and gamification. Next, we develop a strategy to implement gamification to increase identified regulation (a form of motivation) in users. Based on this strategy, we implement a gamified mockup version of an existing software application in Axure RP. We also develop a control mockup version of the application without game elements. The designs are evaluated in two ways: (i) interviews with experts from the fields user experience, psychology and communication, and game design; (ii) through a controlled experiment that measures the attitude and beliefs of participants after using one of the mockup applications.

The findings in literature suggest that using game elements other than points, badges, and leaderboards (PBL) could lead to a more sustainable kind of user motivation. However, the results of the controlled experiment show no significant effect of the gamification implementation on user adoption or the underlying variables we hypothesized to be influenced. The experts find the gamified application to be more suitable (than the control version) for onboarding new users of the application.

The main conclusions from this research are that the way gamification was implemented in this research does not lead to higher identified regulation, and higher hedonic motivation, and has no effect on intention to use, nor intention to recommend the application. However, the expert interviews lead to several recommendations for developers of gamified applications.

This thesis recommends to first thoroughly investigate the goal of the application, and based on that to devise a strategy on how to implement gamification to support this goal. An additional recommendation is to implement one or more elements that support the user in the transition into a game mindset.



## Acknowledgements

Conducting this research and writing my master thesis about it has truly been an educational experience. I enjoyed the variety of tasks I conducted; from researching literature from multiple disciplines, to creating a gamified prototype in Axure, to interviewing experts, to running a MANCOVA in SPSS.

During the nine months it took to devise the conceptual model, design the prototype applications, collect participant data, conduct interviews, analyze, and report the whole process, many people contributed to this research project. I could not have completed this thesis without their help and support.

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Enjoy reading!



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## 1. Introduction

The possibilities to create technologies that make people's life easier are endless. However, not all innovations are actually adopted by their intended users. The relation between the characteristics of an innovation and its adoption has been a classical problem in innovation literature (Tornatzky & Klein, 1982). In the Eighties, the adoption of technologies also caught the interest of information technology researchers, and technology adoption became a new line of research within the information systems field (Huff & Munro, 1985). Although there are multiple models that attempt to explain why certain information systems get adopted and others do not, this remains a complex problem (Dwivedi, Rana, Chen, & Williams, 2011) with many variables involved. To increase the user adoption of a software application, there are different options. When looking at models explaining user adoption (Agarwal & Prasad, 1998; Venkatesh, Thong, & Xu, 2012), some examples of ways to increase user adoption are: increasing the usability of the application, employing various marketing channels, or pricing the application competitively. We propose to employ gamification as an additional method for increasing user adoption.

Gamification is the concept of using game design elements in non-game contexts, and is hypothesized to have a positive effect on user engagement and user participation with software (Deterding, Dixon, Khaled, & Nacke, 2011). Gamification has been a trending topic since a few years, and is presented as the next generation method to increase customer engagement. Following the big hype of the concept in industry, gamification also attracted the attention of academic researchers (Hamari, Koivisto, & Sarsa, 2014). Although the body of research on gamification is growing, there is more research needed on different aspects of the concept. This research explores if, and in what way gamification can be applied to increase the user adoption of a software application.

### 1.1 Problem statement

Both organizations that build and organizations that buy a new technology hope to realize a return on their investment, in terms of either financial return or other key performance indicators, such as higher efficiency and improved processes. Whether or not an investment in a new technology generates the desired return depends heavily on the user adoption of that technology (Agarwal & Prasad, 1998). If the intended end-users do not use a new technology, the expected return for the buyer of the system will be lacking. In turn this could lead to lower revenues for the organization that built the new technology. Therefore, it is desirable for organizations to catalyze the user adoption in any possible way. To be able to influence this process an understanding of why technologies are adopted is needed. As stated above, this is a complex problem and multiple models exist that try to explain it (Dwivedi et al., 2011). However, knowing which variables influence user adoption is not enough, for the most useful knowledge is obtained by understanding how to influence these variables.

In popular literature and business practice, gamification is labeled as a method for increasing customer engagement (Hamari et al., 2014). Conventional wisdom tells that gamification increases user motivation, which leads to increased engagement with the system. In turn, engagement should lead to usage activity and quality (Hamari, 2013). To know how to influence user motivation, it is important to



have an understanding of motivation theories. Research on motivation is grounded in psychology, and distinguishes between intrinsic and extrinsic motivation (Deci & Ryan, 1985). Gamification could be influencing either one of these or both, but several studies suggest that increasing extrinsic motivation undermines intrinsic motivation (Ryan & Deci, 2000a). This finding shows that it is important to know exactly how gamification influences motivation, so organizations can use gamification to cause the wanted motivational effect in users.

In scientific research there are few studies that focus on this exact problem. Hamari and Koivisto (2013) focus on social motivations to use a gamified application. However, most existing research on gamification focuses on the relation between gamification and engagement without measuring the underlying motivations of the users (Cheong, Cheong, & Filippou, 2013; Downes-Le Guin, Baker, Mechling, & Ruyle, 2012; Halan, Rossen, Cendan, & Lok, 2010). Though this is also interesting, it is scientifically relevant to search for the underlying principles of phenomena. Other researchers also recognize the need to look beyond user engagement and into why it is that gamification is effective (Amir & Ralph, 2014; Kappen & Nacke, 2013). From this we deduce that it is important to research the underlying motivational aspects that play a role when using gamified software applications.

Summarized, organizations want to increase motivation, user engagement and user adoption of software applications, by applying gamification. However, it is not entirely clear in what way gamification influences motivation, and thus it is not clear how gamification should be implemented in a software application to generate the desired effect.

## 1.2 Research questions

The described problem statement leads to the main question of this research:

### **How to determine the effect of gamification on user adoption of a software application?**

This main research question is split up in the following sub research questions:

- RQ 1** What variables play a role in user adoption of a software application?
- RQ 2** How could gamification be implemented to increase user adoption?
- RQ 3** What experiment could be used to measure the effect of the devised gamification implementation on user adoption?
- RQ 4** What effect has the devised gamification implementation on user adoption of a certain software application?
- RQ 5** How and to what extent can the outcomes of such an experiment be generalized to other software applications?

The first research question focuses on getting an overview of the current state of user adoption research, and the variables that play a role in increasing user adoption. The second research question is about mapping the various kinds of game elements that could be implemented and selecting the right ones to influence users in the desired way. The intention of the third research questions is to set up an experiment and measure the effects of the implemented gamification. The fourth and fifth questions evaluate the findings of the experiment.





### 1.3 Context and constraints

The problem this thesis tackles—how can gamification be implemented to increase user adoption?—is a problem that is experienced in a real world situation. This research is conducted in the context of a specific case company, Centric. Centric is a full service IT-provider that offers software solutions, IT outsourcing, business process outsourcing, and staffing services. The company was founded in 1992, as Sanderink group, and in the year 2000 the name was changed to Centric. While Centric is originally a Dutch organization, it now operates in eight European countries. In the Netherlands it operates in various markets, such as financial, construction, local government, supply chain, housing associations, and health care. Within Centric there are different divisions, and our research is carried out for the Solution Engineering division.

Centric Solution Engineering is developing a new software application in the domain of public order and safety, for three Dutch municipalities. The name of the application is ‘Omgevingsdashboard’ (ODB), which translates to ‘Environment dashboard’. The purpose of the application is to inform inhabitants of the municipalities about safety risks in their living environment, as well as to inform them during actual emergency situations. This distinction between communication about risks and communication about actual incidents is indicated with the terms ‘cold phase’ and ‘hot phase’. The ODB is a responsive web application, and the front page shows a map with icons indicating risks and/or incidents in the surroundings of the user. These icons are clickable to view more detailed information, as well as the action perspective of the user. The application can be used anonymously, but creating a user-account will give the user the opportunity to sign up for SMS-alerts. Those alerts are sent out to subscribers in the area of an incident. Users can select one or more areas for which they want to receive alerts, for example the area around their home, as well as the school of their children.

For the ODB Centric and the municipalities want to find ways to boost the user adoption when the application is launched. They are interested in using gamification for this purpose, and this research will therefore include creating a gamified version of the application that intends to solve this problem. Since the development of the application should go on as planned, this research project should interfere the least possible with the actual development. Thus we are creating a gamified mockup version of the ODB, which will be tested and evaluated before using the results to improve the actual ODB.

### 1.4 Structure

The structure of this thesis is the following. Chapter 2 gives an overview of the theoretical background concerning user adoption, engagement, motivation and gamification. Chapter 3 shows the conceptual model that depicts the variables we expect to influence user adoption, and the hypotheses we want to test. Chapter 4 presents the research methods we used to answer our research questions. Chapter 5 explains the design decisions we made while creating the gamified mockup ODB, and the strategies we used to increase user adoption. Chapter 6 gives an analysis of our experiment results, and Chapter **Error! Reference source not found.** summarizes our findings, and answers our research questions.



## 2. Theoretical background

The goal of this literature review was to gain an understanding of the variables and their relationships that play a role in user adoption and gamification. Therefore we conducted a so-called theoretical review of the literature. This form of literature study uses existing conceptual and empirical studies to uncover theoretical structure and relationships between concepts and constructs. The main goal is to construct a conceptual framework with corresponding hypotheses (Paré, Trudel, Jaana, & Kitsiou, 2015).

The search engine we used is google scholar, because it gives the most comprehensive results from all journals, conference and workshop proceedings, book chapters and books, etc. We started our search by using general keywords: user adoption, technology adoption, technology acceptance, gamification, user engagement, motivation. By selecting prominent articles, that are cited many times, and meta-analyses we first gained an overview of the field. While reading these articles we navigated back- and forward using references and citations, to gain a deeper understanding of the fields. We also used keywords we find in literature to search for articles we possibly missed during earlier searches, due to the use of different keywords. Based on our findings in literature we started composing a conceptual model. While creating this model we kept looking for literature in several incremental steps, to fill occurring gaps in the model.

The rest of this chapter gives an overview of our findings in the four topics we drew from while building our conceptual model. Section 2.1 gives an overview of models that are used to explain user adoption. Section 2.2 focuses on engagement. Section 2.3 investigates motivation, and finally Section 2.4 explains gamification and its related concepts.

### 2.1 User adoption

The concept of user adoption has been researched for more than half a century now, and has been indicated with different names throughout the years. Researchers in innovation studies were the first ones to analyze this concept, with a focus on the relation between the characteristics of an innovation and its adoption and implementation (Tornatzky & Klein, 1982). A well-known researcher in this field is Rogers, who first published a book containing a meta-analysis of 405 studies on innovation diffusion in 1962. Nine years later, he published a second edition, and the number of studies had already grown to 1500 (Rogers & Shoemaker, 1971). Rogers' research is not limited to ICT innovations, and based on his meta-analysis of innovation studies, he proposed five characteristics that influence the adoption rate of an innovation (Rogers, 1983). In subsequent years, many researchers have investigated these five characteristics. In the eighties the concept of user adoption gained attention in the MIS quarterly journal (Huff & Munro, 1985), and a new extensive model was proposed by another well-known researcher in the field: Fred Davis (1986). The model Davis proposes, the Technology Acceptance Model (TAM), focuses on investigating the mediating variables between system characteristics and actual system use (Davis, 1986). Just as with the innovation characteristics of Rogers, many researchers used Davis' TAM in later studies.

Unlike Rogers (1962), who uses the term adoption, Davis uses the term 'acceptance'. The terms adoption and acceptance seem to be referencing to the same concept; the use of a system by its

intended users. However, according to Renaud and Van Biljon (2008), their meaning is slightly different. Adoption refers to a bigger process that encompasses more aspects than only acceptance. While acceptance is ‘an attitude towards a technology’, adoption refers to the whole process in which a user becomes aware of the existence of the technology, up to and including the final stage in which the technology is intertwined with the life of a user (Renaud & Van Biljon, 2008). To explain both processes of adoption and acceptance, different models are proposed that extend Rogers’ and Davis’ work. This section describes the most prominent models and illustrates how they relate to one another.

### Diffusion of Innovations

Rogers was the first to publish a meta-study that incorporated research from different disciplines. His work synthesized other independent studies into a general model that explains innovation diffusion (Rogers, 1962). A simplified version of this model, the innovation-decision process, is shown in Figure 2.1.

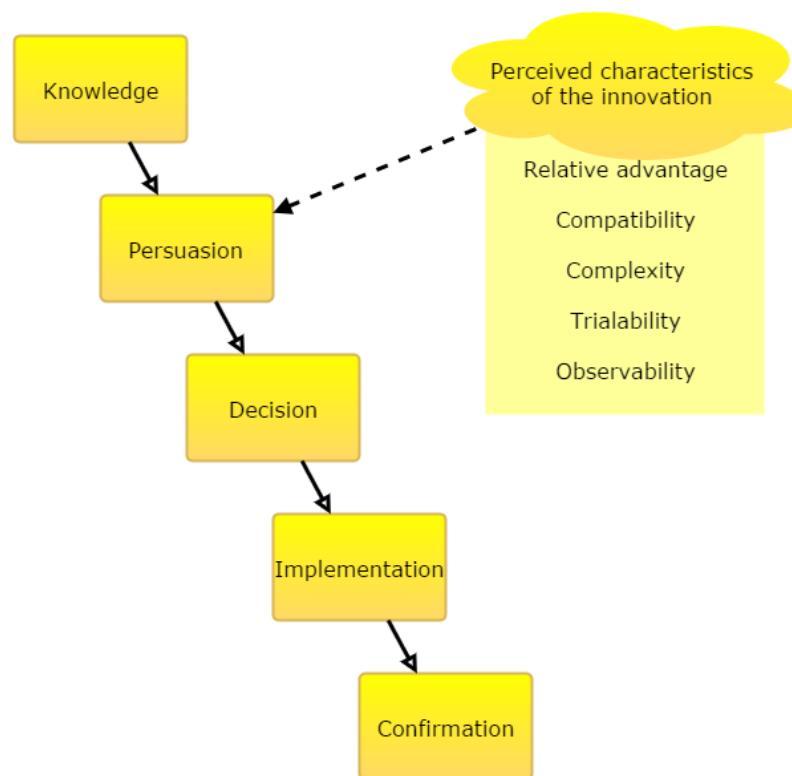


Figure 2.1. Rogers’ innovation-decision process model. Adapted from *The diffusion of innovations 1<sup>st</sup> edition*, by E. M. Rogers, 1962, New York, NY: The Free Press.

This model shows the five stages that a user passes through, that eventually lead to the adoption or rejection of an innovation. The model also shows five characteristics that influence the adoption rate. These five innovation characteristics are: relative advantage, compatibility, complexity, trialability, and observability. Rogers (1962) proposed the definitions of the concepts that are depicted in Table 2.1. The

higher the relative advantage, compatibility, trialability and observability of an innovation are, and the lower the complexity is, the more the adoption rate will increase (Rogers, 1962).

Table 2.1 Rogers' definitions of innovation characteristics.

Characteristic	Definition
Relative advantage	The degree to which an innovation is perceived as being better than the idea it supersedes.
Compatibility	The degree to which an innovation is perceived as consistent with the existing values, past experiences and needs of potential adopters.
Complexity	The degree to which an innovation is perceived as relatively difficult to understand and use.
Trialability	The degree to which an innovation may be experimented with on a limited basis.
Observability	The degree to which the results of an innovation are visible to others.

Figure 2.1 is a simplified version of the original model. The original model includes different other matters that also influence the innovation-decision process. These are 'communication channels', 'prior conditions', and 'characteristics of the decision making unit'. These matters are excluded from this research, because they are not influenced by our study, for the following reasons:

- Our gamification implementation will be built into the application, so the only channel influenced by our research is the application itself;
- The prior conditions, e.g. the previous practice or the norms of the social system, is expected to not be influenced by our experiment, since the gamification implementation only influences the system itself;
- The characteristics of the decision making unit; i.e. the characteristics of the intended users, is expected to not be influenced by our experiment, because the intended users are already defined and their characteristics are invariant (at least during the timespan of our study).

Concluding, we will only consider the (perceived) system characteristics, and exclude other invariant matters from Rogers' model.

### Antecedents and consequents of user perceptions

Agarwal and Prasad (1998) propose another model that focuses on the entire adoption process rather than only acceptance. They argue that in previous research the emphasis lies on the users' perceptions of an innovation, and that there is insufficient focus on antecedents and consequents of these perceptions. Their research model is shown in Figure 2.2. With the proposed model, the authors want to challenge the assumption – that in their opinion is the basis of many user acceptance models – that there are no moderating variables between user perceptions and the adoption decision (Agarwal & Prasad, 1998). Their model is based on Rogers' innovation-decision model, and retains most of its structure. The basis of the model is that the adoption process consists of different steps, leading to the adoption decision. However, they reduce the amount of steps to three instead of five; awareness,

perceptions, and adoption decision. The first step, awareness, is similar to the first step in Rogers' model, knowledge. The next step Agarwal and Prasad distinguish is perceptions, which covers all three Rogers' steps persuasion, decision and implementation. Agarwal and Prasad's model implies that these three steps are covered in the perception step, since the model depicts that step includes both perceptions that arise previous to the use, as well as perceptions that arise during or after the use (Agarwal & Prasad, 1998). The last step, adoption decision, is the same as Rogers' confirmation step, in which the user decides about future use of the system. In the model the influence of channel type is still present, and next to this they introduce the construct personal innovativeness, that moderates the relation between perceptions and the adoption decision.

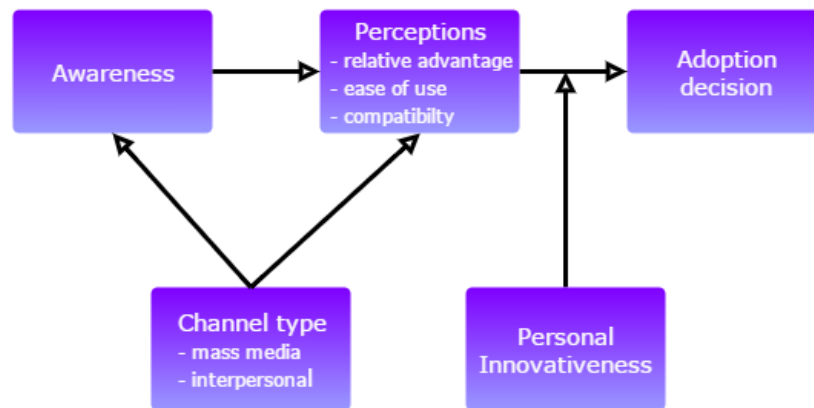


Figure 2.2. The antecedents and consequents of user perceptions. Adapted from “The antecedents and consequents of user perceptions in information technology adaption”, by R. Agarwal & J. Prasad, 1998, *Decision support systems*, 22(1).

As discussed in the section on Diffusion of Innovations, the variable channel type is excluded from our research, because it is expected to not be influenced by our experiment. The same reasoning applies to awareness and personal innovativeness, because:

- When users use our gamified mockup, they are already aware that the application exists, so this first step of the model is left out of our research;
- The mediating construct personal innovativeness is a relatively invariant characteristic of the user, and can therefore not be influenced by our experiment.

Considering that these matters are left out of our research because they are expected to not be influenced by our gamification implementation, we will only focus on influencing the user's perceptions of the applications; i.e. the relative advantage, ease of use, and compatibility. When we also take into account the conclusion about the innovation-decision model, we can generalize this statement. This research focuses on the system characteristics users perceive when they use the application, as opposed to prior conditions and other external influencers. In line with this intention of explaining user adoption based on (perceived) system characteristics, other researchers developed different models, for example the Technology Acceptance Model.

## Technology acceptance model

In 1986 Davis proposed the Technology Acceptance Model, in his PhD dissertation. This model intended to specify in what way system characteristics are related to actual system use (Davis, 1986). The TAM is based on the Theory of Reasoned Action (TRA), a theory grounded in psychology research that was developed by Fishbein and Ajzen (1977). The TRA hypothesizes that beliefs people have, lead to an attitude about certain behavior. In turn this attitude about a behavior leads to behavioral intention, which is a good predictor of actual behavior (Fishbein & Ajzen, 1977). The TRA also includes the variables normative beliefs and subjective norm, but these are excluded from the original TAM, because of the expected insignificant effect on behavioral intention (Davis, 1986). Figure 2.3 shows the first TAM model as proposed by Davis (1986).

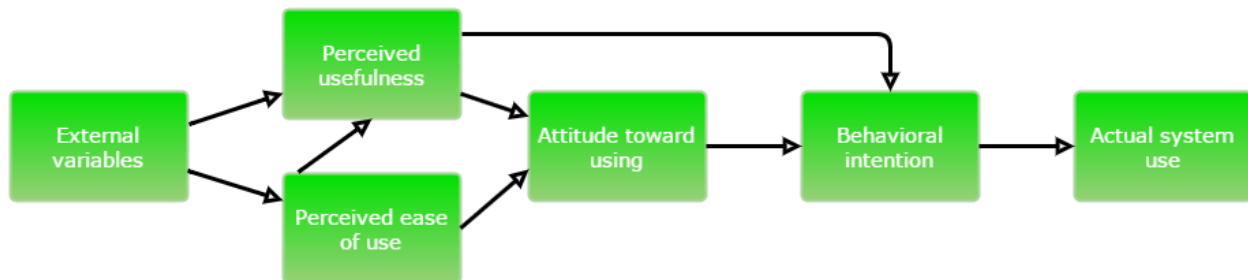


Figure 2.3. Davis' Technology Acceptance Model. Adapted from *A technology acceptance model for empirically testing new end-user information systems: Theory and results*, By F. Davis, 1986, PhD dissertation.

In this original TAM, Davis introduces the variables perceived usefulness, and perceived ease of use. These two concepts are the core of the model, and together they form the main concepts that explain technology acceptance. Since these two constructs can increase system acceptance, it is interesting to find out how to design a system that has high perceived usefulness and perceived ease of use. According to the model, both these variables are influenced by external variables. However, Davis did not specify which external variables influence perceived ease of use and perceived usefulness (Davis, 1986).

Fourteen years after proposing TAM, Davis and Venkatesh (2000) proposed TAM2. This model is changed slightly in a few ways, but the core remains the same. The most important change is that the external variables that lead to perceived usefulness are concretized. These variables are: result demonstrability, output quality, job relevance, image, and subjective norm (Venkatesh & Davis, 2000). This list of variables partly overlaps with the innovation characteristics Rogers proposed in 1962. Combining these two lists thus provides an overview of system characteristics that could be influenced to increase the user adoption.

After another thirteen years Venkatesh and Bala proposed TAM3, in a manuscript that is still in preparation (2013). The TAM3 however, is shown at Venkatesh' website and the important new contribution to the model is the specification of the external factors that influence perceived ease of use (Venkatesh, n.d.). Table 2.2 shows an overview of the added external factors in TAM3.

Table 2.2. Overview of the added external factors in TAM3.

Category	Factor
Personality traits	Computer self-efficacy
	Perceptions of external control
	Computer anxiety
	Computer playfulness
System characteristics	Objective usability
User-System interaction traits	Perceived enjoyment

From the list in Table 2.2 the only variable that can be influenced in our research is perceived enjoyment. The other variables are fixed characteristics of the system and of the user, which we expect to not be influenced by our gamification implementation.

Over the years many researchers used the TAM in their own experiments, and hence tested the relations between the internal variables. To test whether the combined results of all these empirical studies provide evidence that supports the TAM, King and He (2006) conducted a meta-analysis of TAM studies. In their study they review 88 published studies, and their general conclusion is that TAM is a powerful predictive model. However, parallel with the development of the TAM, other models that explain user acceptance were developed, leading to an abundance of models. An attempt to bring order, and possibly integrate the existing models, is the Unified Theory of Acceptance and Usage of Technology (UTAUT; (Venkatesh, Morris, Davis, & Davis, 2003).

### Unified Theory of Acceptance and Usage of Technology

In 2003 Venkatesh et al. reviewed eight competing user acceptance models that were proposed in literature. The goal of their review was to integrate the most prominent user acceptance model into one unified theory of user acceptance. The eight models that are compared are drawn from psychology, sociology, and information systems research. These models are:

- Theory of reasoned action (TRA), a fundamental theory on human behavior drawn from social psychology, proposed by Fishbein and Ajzen (1977).
- Technology acceptance model (TAM), a model that explains technology acceptance, tailored to information systems (IS) research, proposed by Davis (1986);
- Motivational model (MM), a generic motivational model, drawn from psychology research, comprehensively described in a review by Vallerand (1997);
- Theory of planned behavior (TPB), an extension of the TRA, proposed by Ajzen (1991);
- Combined theory of planned behavior and the technology acceptance model (C-TPB & TAM), an integration of the TAM and TPB, synthesized by Taylor and Todd (1995);
- Model of personal computer use (MPCU), a to IS contexts tailored model, proposed by Thompson, Higgins, and Howell (1991), derived from the human behavior model of Triandis (1977);



- Innovation diffusion theory (IDT), as proposed by Rogers' (1962), described in a previous part of this section;
- Social cognitive theory (SCT), based on Social cognitive theory as proposed by Bandura (1986), adapted to the IS context by Compeau and Higgins (1995). (Venkatesh et al., 2003).

Their review and integration led to the UTAUT model, shown in Figure 2.4.

The UTAUT model is somewhat similar to the TAM model, seeing that external variables are related to use through behavioral intention. However, the core constructs that influence behavioral intention – in TAM these are perceived ease of use (now called effort expectancy) and perceived usefulness (now called performance expectancy) - are accompanied in UTAUT by the variable *social influence*. Based on the comparison of the eight models, Venkatesh et al. hypothesize that those three constructs - performance expectancy, effort expectancy, social influence – complemented by the construct *facilitating conditions*, are direct determinants of user acceptance and usage behavior. The variable *facilitating conditions* has a direct influence on use behavior, unlike the other variables that influence use behavior through behavioral intention. The authors also identify four moderating variables; *gender, age, experience, and voluntariness of use* (Venkatesh et al., 2003). Besides proposing the UTAUT, Venkatesh et al. also empirically tested it. Their research shows that the model explains 56 percent of the variance in behavioral intention, and 40 percent of the variance in use behavior (Venkatesh et al., 2003). This shows the UTAUT model is a solid model for explaining a notable part of user acceptance; however, it could be improved upon.



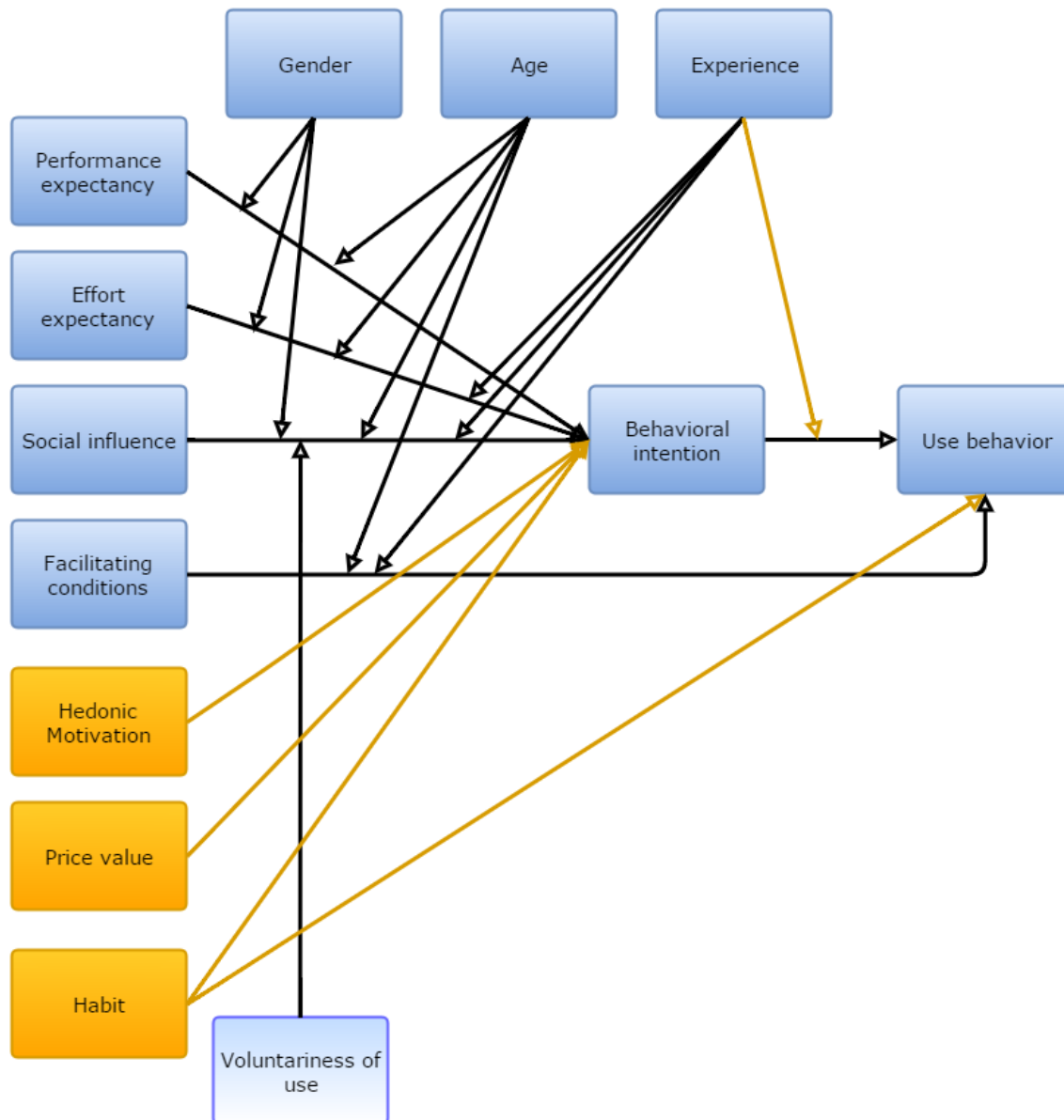


Figure 2.4. The UTAUT model. Adapted from “Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology”, by V. Venkatesh, J. Y. Thong, & X. Xu, 2012, *MIS Quarterly*, 36(1).

Such an improvement is made with the proposal of the UTAUT2 model in 2012 (Venkatesh et al.). The basis of UTAUT2 is the same model as the original UTAUT, with three extra determining variables; *hedonic motivation* - the fun or pleasure derived from using a technology, *price value* – tradeoff between perceived benefits and monetary costs, and *habit* – automatically performing behavior. The moderating variables are reduced to only three from the original UTAUT, where voluntariness of use is omitted in UTAUT2 (Venkatesh et al., 2012). The added variables and relations from UTAUT2 are depicted in Figure 2.4. The blue parts depict the variables that were proposed in the original UTAUT.

Orange parts depict the variables and relations that were added to the UTAUT to form UTAUT2. The light-blue colored variable voluntariness of use, was present in the original UTAUT but absent in UTAUT2. For clarity Figure 2.4 only depicts one of the moderating relations that are added in UTAUT2 – the orange arrow that originates from the variable experience. For this literature review it is not necessary to depict all moderating relations that are proposed in UTAUT2, since it aims to provide an overview of which variables are involved in user acceptance. The predictive power of UTAUT2 increased to explaining 74 percent of variance in behavioral intention, and 52 percent of variance in use behavior. Next to this improvement in the amount of variance that is explained by UTAUT2, the authors state that UTAUT2 is focused at a consumer use context, instead of an organizational setting (Venkatesh et al., 2012).

Overviewing UTAUT and UTAUT2, the identified constructs that can be influenced to increase user adoption are: performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit. Variables that moderate the effects of these constructs are: gender, age, and experience. Of the seven constructs that influence behavioral intention, three can be influenced by our gamification implementation: performance expectancy, effort expectancy, and hedonic motivation. The other constructs are expected to not be influenced by our gamification implementation for different reasons. An overview of the constructs, their definitions (Venkatesh et al., 2003; Venkatesh et al., 2012), and the explanations why they are not influenced is shown in Table 2.3.

Table 2.3. Overview of UTAUT constructs and reasons for their exclusion.

Construct	Definition	Not influenced because
Social influence	The degree to which an individual perceives that important others believe he or she should use the new system.	Venkatesh et al.(2003) found that the effect of social influence is only significant in mandatory settings. Since the use of application we are researching is voluntary, we will exclude this construct from our research.
Facilitating conditions	The degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system.	Since our experiment is built into the application, it will not influence the surrounding infrastructure, and therefore this construct is left out of our research.
Price value	Consumers' cognitive tradeoff between the perceived benefits of the applications and the monetary cost for using them.	The use of the application we are researching is free for anyone; therefore this construct has no influence on the user adoption of it.
Habit	The extent to which people tend to perform behaviors automatically.	Because our experiment only uses gamification in the mockup (and not in the real application) it will not influence the habit-forming of the users, and is therefore left out of this research.

The moderating variables age, gender, and experience, will be included in our research, to examine how the effect of our gamification implementation differs between user groups. Next to the list of models that were evaluated and integrated into the UTAUT model, there are still other models that explain user acceptance. These models and their variables are discussed in the next paragraph.

### Other models and concepts

One model that was left out of the UTAUT integration attempt is the end-user computing satisfaction model (Doll & Torkzadeh, 1988). This model is relatively old, but it was one of the first models to focus on the end-user computing environment. The model they propose explains end-user computing satisfaction. Although this construct is no direct conversion of system usage, the authors indicate that end-user satisfaction with a system and the use of that system are closely related (Doll & Torkzadeh, 1988). The model they propose is depicted in Figure 2.5.

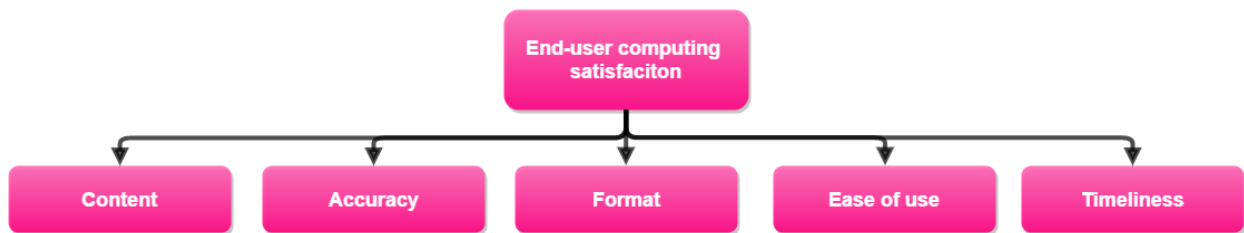


Figure 2.5. The end-user computing satisfaction model. Adapted from “The measurement of end-user computing satisfaction, by W. J. Doll & G. Torkzadeh, 1988, *MIS Quarterly*, 12(2).

The model shows the five variables of which end-user computing satisfaction is composed: Content, accuracy, format, ease of use, and timeliness. Of these five variables, our experiment is expected to only influence the construct ease of use. The other four are characteristics inherent to the actual application, and are not changed by our gamification implementation.

Another model that explains user adoption by means of user perception of the application, is the instrument developed by Moore and Benbasat (1991). Their paper describes the development of this instrument, and identifies six constructs that play a role in user adoption of applications. Their starting point is the list of innovation characteristics of Rogers (1962), and they rigorously validate and complement this list (Moore & Benbasat, 1991). Their final list of user perceptions that influence the adoption decision, and their definitions are described in Table 2.4.



Table 2.4. Moore and Benbasat's user perceptions.

Construct	Definition
Relative advantage	The degree to which using the innovation is perceived as being better than using its precursor.
Compatibility	The degree to which an innovation is perceived as being consistent with the existing values, needs and past experiences of potential adopters.
Ease of use	The degree to which an individual believes that using a particular system would be free of physical and mental effort.
Result demonstrability	The degree to which an innovation results are able to be measured, observed and communicated.
Image	The degree to which use of an innovation is perceived to enhance one's image or status in one's social system.
Visibility	The degree to which an innovation is visible.
Trialability	The degree to which an innovation may be experimented with before adoption.
Voluntariness	The degree to which use of the innovation is perceived as being voluntary, or of free will.

Of these variables, two can be influenced by our gamification implementation: ease of use and result demonstrability. For the others the following applies:

- Relative advantage, compatibility, and image are characteristics that are inherent to the actual application;
- Result demonstrability, visibility, trialability and voluntariness are not influenced by our experiment, because the application is free to use for anyone and not mandatory.

Another concept that is associated with user adoption and acceptance models is intention to recommend the system to others. According to Hamari and Koivisto (2013) attitude towards a system leads to intention to use as well as intention to 'word of mouth' (WOM). Intention to WOM corresponds to intention to recommend the system to others. For this research intention to WOM is also an interesting construct to measure, since it is suggested to predict system success (Reichheld, 2003). This construct is since 2003 measured with the Net Promotor Score (NPS), which consists of one question, asking how likely it is that the respondent will recommend the system (Reichheld).



## Overview of applicable constructs

Based on the findings described in the previous part of Section 2.1, we can draw some preliminary conclusions. In terms of the distinction between user adoption and acceptance, our experiment will only influence the acceptance of the application; i.e., we focus on the actual use of the system, and how this is influenced by characteristics of the system that are perceived by the users while interacting with it. The variables *actual use* of a software system and *system characteristics* are connected via the construct *behavioral intention*.

Deducing from the models described in the previous part of this chapter we can compose a list of constructs that influence the attitude of users towards a software application, and that could possibly be influenced by a gamified mockup. As also described, there are several variables left out of this research. This is the case because the models we draw from are developed to describe and/or predict user adoption. Therefore these models also comprehend variables that are invariant, and thus cannot be influenced by our experiment. The remaining application characteristics that can be influenced by our gamification implementation are:

<b>Effort expectancy</b> (previously referred to as perceived ease of use)	The degree of ease associated with the use of the system (Venkatesh et al., 2003).
<b>Performance expectancy</b> (previously referred to as perceived usefulness)	The degree to which an individual believes that using the system will help him or her to attain gains in job performance (Venkatesh et al., 2003).
<b>Hedonic motivation</b>	The fun or pleasure derived from using a technology (Venkatesh et al., 2012).

The next step in this research is to identify possibilities to influence these constructs.

## 2.2 Engagement

While searching for possible relations between gamification and the three constructs identified at the end of Section 2.1, a construct that attracts attention is user engagement. User engagement is defined as: “a quality of user experiences with technology that is characterized by challenge, aesthetic and sensory appeal, feedback, novelty, interactivity, perceived control and time, awareness, motivation, interest, and affect” (O'Brien & Toms, 2008). A less technical explanation of engagement is: “something that ‘engages’ us is something that draws us in, that attracts and holds our attention” (Chapman, 1997). Engagement is associated with increased system use (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011; Deterding et al., 2011; Zhang, 2008). There is also research conducted on how engagement influences system use. Different studies found that a specific form of engagement, cognitive absorption (CA), leads to higher performance expectancy and lower effort expectancy of a system (Agarwal & Karahanna, 2000; Lin, 2009; Saadé & Bahli, 2005; Zhang, Li, & Sun, 2006).



## Cognitive absorption

Agarwal and Karahanna (2000) introduce the construct cognitive absorption that is based on psychological research on absorption, flow, and cognitive engagement. The definition of CA they propose is "a state of deep involvement with software", and it manifests itself through the five dimensions: temporal dissociation, focused immersion, heightened enjoyment, control, and curiosity (Agarwal & Karahanna, 2000). The authors also stress that while some have hypothesized that low effort expectancy leads to cognitive absorption, they conceptualize this relation vice versa, following the results of Venkatesh (1999). The results of their experiment show the factor loadings of the five variables that cognitive absorption is composed of. Factor loadings are the relative contributions a variable makes to a factor. Factor loadings vary between -1 and 1 and the closer a factor loading is to one of these extremes, the more the variable affects that factor (Field, 2009). The factor loadings on cognitive absorption Agarwal and Karahanna (2000) found are:

- Curiosity - .83;
- Control - .64;
- Temporal dissociation - .70;
- Focused immersion - .74;
- Heightened enjoyment - .87.

Cognitive absorption in turn explains 59% of the variance in effort expectancy (which they term perceived ease of use), and 52% of the variance in performance expectancy (which they term perceived usefulness). Saadé and Bahli (2005) also researched the relation between cognitive absorption and performance and effort expectancy. Due to the nature of their experiment design they omitted the factors of curiosity and control. They found that cognitive absorption explains 36% of the variance in performance expectancy, and 24% of the variance in effort expectancy (Saadé & Bahli, 2005). Based on the results of these experiments we conclude that engagement in the form of cognitive absorption does lead to increased expected performance and decreased effort expectancy.

## 2.3 Motivation

Both Saadé and Bahli (2005), and Agarwal and Karahanna (2000) indicate that cognitive absorption is related to intrinsic motivation. Intrinsic motivation is a form of motivation that refers to doing something because it is inherently interesting or enjoyable. It is opposed to extrinsic motivation, which in classic literature is hypothesized to be a weaker form of motivation (Ryan & Deci, 2000a). Instead of motivation being a binary variable, Ryan and Deci (2000b) hypothesize that different kinds of motivation can be plotted on a spectrum, as shown in Figure 2.6. Their theory that proposes this relation is called self-determination theory (SDT).

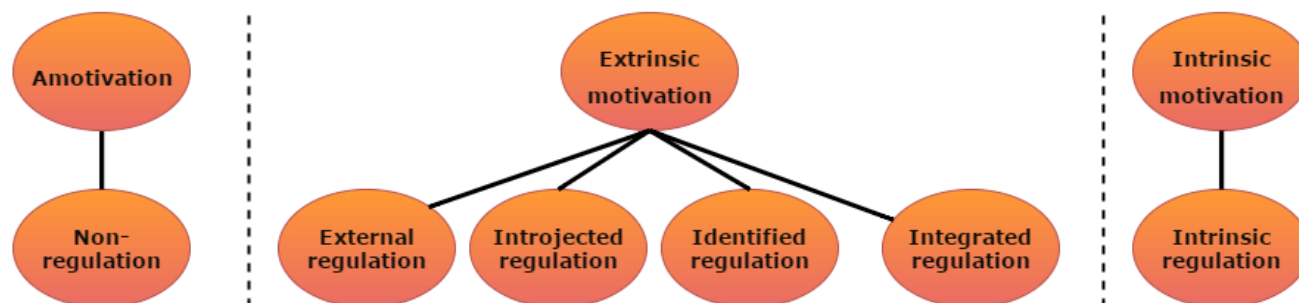


Figure 2.6. The motivation-continuum. Adapted from “Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being”, by R. M. Ryan & E. L. Deci, 2000, *American Psychologist*, 55(1).

Figure 2.6 shows that the motivational spectrum lies between ‘no motivation at all’ – so called amotivation, and ‘intrinsic motivation’. In the middle of the spectrum are four styles of extrinsic motivation. The difference between intrinsic and extrinsic motivation lies in the presence of an identifiable motivator (Ryan & Deci, 2000a). The different forms of external motivation function in different ways. The more they are positioned to the right in the spectrum in Figure 2.6, the more they resemble intrinsic motivation, and the more sustainable the motivation is. Ryan and Deci (2000b) describe which relevant processes support the different forms of external motivation; an overview of these processes is given in Table 2.5.

Table 2.5. The processes supporting different forms of external regulation.

Form of external motivation	Supporting processes
External regulation	Compliance, external rewards and punishments
Introjected regulation	Self-control, ego-involvement, internal rewards and punishments
Identified regulation	Personal importance, conscious valuing
Integrated regulation	Congruence, awareness, synthesis with self

There are numerous papers on human motivation, its different forms, and ways to influence it. Concerning the difference between internal and external motivation, there is a debate about how they interact (Cerasoli, Nicklin, & Ford, 2014). Several studies found that providing rewards in order to increase extrinsic motivation undermines the intrinsic motivation. In an attempt to derive a coherent conclusion from the large amount of studies on the subject Cerasoli et al. (2014) conducted a meta-analysis. Concerning the differences and interactions between intrinsic and extrinsic motivation they draw several interesting conclusions. They found that intrinsic motivation has more influence on *quality* of performance, where extrinsic motivation influences *quantity* more. However, when intrinsic motivation is high, this also influences *quantity* to a certain extent. They also conclude that external



motivators in some cases decrease intrinsic motivation. To be specific, when external incentives are more salient and controlling, the intrinsic motivation decreases (Cerasoli et al., 2014). Salient and controlling external incentives are incentives that are clearly directly linked to a specific task. Lombriser, Dalpiaz, Lucassen, and Brinkkemper (2016) researched the effect of a gamified application that supports requirements elicitation. The application they studied did include external incentives (Points, Badges and Leaderboards; PBL), and they suggest this as one possible reason why their results show no significant emotional and cognitive differences between the experimental and the control group (Lombriser et al., 2016).

Combining these two insights leads to the conclusion that for our experiment it would be optimal to use incentives that are least controlling and salient. This would lead to a form of motivation that lies as far as possible to the right of the motivation spectrum as show in Figure 2.6. This, in turn, will lead to more qualitative interactions of the users with the application. A study of Hyunghim Jang (2008) provides an interesting insight in how to motivate people in a non-controlling way, and thus evoking an increase in identified regulation. In her study she motivated students by providing a rationale for a task in a non-controlling and autonomy-supportive way, in order to increase their identified regulation. The results of her experiment provide evidence that identified regulation increased, and that in turn that form of external motivation resulted in increased task engagement (Jang, 2008). We expect that we can motivate the users in our experiment in the same way: by providing a non-controlling and autonomy-supportive rationale to use the application. The next step is to determine how this can be implemented into the dashboard using gamification.

## 2.4 Gamification

To gain a clear understanding of what gamification exactly is, we examine different definitions found in literature. Prominent definitions of gamification are those of Deterding et al. (2011), Hamari and Huotari (2012), and Burke (2014). Deterding et al. define gamification as “the use of game design elements in non-game contexts” (2011). In their article they also thoroughly describe how they perceive the different keywords in this definition. Firstly they clarify that gamification refers to game, and not to play. Play is a looser category that contains games, among other things. Game is a category of play that describes a form of play that is “structured with rules and competitive strife towards goals” (Deterding et al., 2011). Secondly they stress the distinction between gamified applications and serious games. Serious games are ‘full-fledged’ games for non-entertainment purposes, while gamified applications only incorporate ‘elements’ of games. These elements are defined as “elements that are *characteristic* to games – elements that are found in most (but not necessarily all) games, readily associated with games, and found to play a significant role in gameplay” (Deterding et al., 2011). Thirdly, concerning the word ‘design’, they indicate that gamification only refers to using design elements - of any level of abstraction, as opposed to game-based technologies, e.g. a game controller. Lastly they state that with the phrase non-game-context they explicitly only exclude the context of actually ‘designing a game’, and put no other restrictions to the usage context, purpose or scenario gamification is used in or for (2011).





Hamari and Huotari (2012) propose another definition of gamification which defines gamification in a less systemic way, and focuses more on the goal of gamification. Their definition is formulated from a service-marketing (as opposed to marketing of physical goods) perspective. Their definition is “gamification refers to a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation” (2012). With their definition they want to evade defining gamification by which methods are used, because they argue there is no clearly defined set of game elements. Therefore they define gamification by the effect it is intended to produce. An *affordance*, in their definition, is any quality of a service that contributes to the emergence of a *gameful experience* (2012). A gameful experience is not strictly defined, but they refer to it as an experiential condition that emerges from a combination of different conditions, that varies between different persons. The goal of gamification is the emergence of such a gameful experience, and they argue measuring the success of gamification should be done by measuring this emergence (2012). This *gameful experience* itself is valuable to the user, and therefore the emergence of this *gameful experience* supports the users’ overall value creation (Huotari & Hamari, 2012).

Burke (2014) points out that there is no widely accepted definition of gamification (yet), but he does identify common characteristics. He describes those common components of other definitions relying on Gartner’s definition of gamification: “The use of game mechanics and experience design to digitally engage and motivate people to achieve their goals”. Firstly he defines *game mechanics* as key elements that are common to games (Burke, 2014). This corresponds to the *game elements*, as defined by Deterding et al. (2011). Secondly Burke defines *experience design* as the journey players take, which broadly corresponds to the *gameful experience* described by Hamari and Huotari (2012). However, where Hamari and Huotari believe the emergence of this *gameful experience* is the end-goal of gamification, Burke takes his definition a step further, to where the emergence of a *gameful experience* is merely a means to an end. He also describes what this end-goal of gamification is, by indicating that both the *game mechanics* and the *experience design* are used to *digitally engage and motivate people to achieve their goals*. He thus defines *engaging* and *motivating* people as the goal of gamification (Burke, 2014). He also specifies that gamification happens digitally, meaning that it is implemented in applications used on computers, smartphones, or other digital devices (Burke, 2014).

Reflecting on these three definitions of gamification, we deem the definition of Hamari and Huotari is the least applicable to our research, due to their service-marketing perspective. With our gamification implementation we do want to evoke an effect beyond the emergence of a *gameful experience*. The definition of Deterding et al. is applicable to our situation, however, rather unspecific. The more specific definition of Burke is not too strict, and therefore still applicable to our research. Thus we use the definition of gamification as proposed by Burke: “Gamification is the use of game mechanics and experience design to digitally engage and motivate people to achieve their goals”.

## Game elements

Although Hamari and Huotari (2012) argue there is no clearly defined set of game elements, others do describe overviews of elements that can be used to gamify an application. Werbach and Hunter (2012) describe a framework that gives a high level overview of different elements that can be used in gamification. Their framework consists of three layers, and is shown in Figure 2.7.

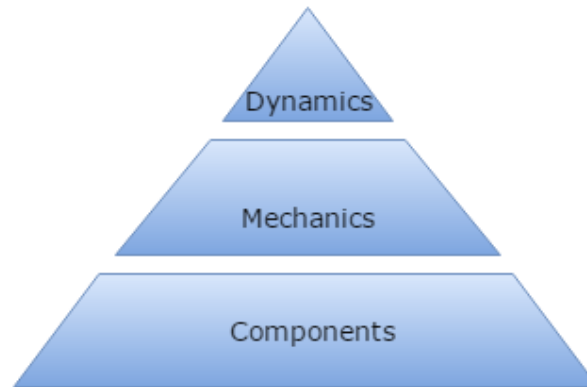


Figure 2.7. Game element framework. Adapted from *For the win: How game thinking can revolutionize your business*, by K. Werbach & D. Hunter, 2012, Philadelphia, PA: Wharton Digital Press.

The highest level of game elements that Werbach and Hunter (2012) define is the level of game dynamics. Game dynamics are abstract, and they are never directly implemented into an application. The most important dynamics are: constraints, emotions, narrative, progression, and relationships. Dynamics can be implemented into an application by using elements of the lower levels of the framework (Werbach & Hunter, 2012). The middle level of the framework are the game mechanics. These are basic processes that ensure the game proceeds forward. The ten game mechanics Werbach and Hunter describe as the most important, are presented in Table 2.6. All of these game mechanics can be incorporated in an application to evoke a gameful experience in the user. Each mechanic that is implemented is tied to one or more dynamics (Werbach & Hunter, 2012). The lowest level in the framework consists of game components. These are still more concrete ways to gamify an application. Werbach and Hunter describe the fifteen important game components that are shown in Table 2.7. Similar to the mechanics, these game components can be used to have a player experience one or more mechanics and dynamics. Other sources also describe lists of game elements; however, Table 2.6 and Table 2.7 already contain variants of the elements and mechanics that are found there (Boller, 2013; Reeves & Read, 2013).

Of these lists of game mechanics and elements that could be used, some are more salient and controlling than others, which is important to notice for our gamified design. As described in Section 2.3 we will focus on using the least salient and controlling motivators, to evoke identified regulated motivation in the users of our mockup application. In Chapter 5, where we describe our gamified design, our considerations and choices for different game elements will be discussed in detail.

Table 2.6. Overview of game mechanics.

Number	Mechanic	Description
1	Challenges	puzzles or other tasks that require effort to solve
2	Chance	elements of randomness
3	Competition	one player or group wins and the other loses
4	Cooperation	players must work together to achieve a shared goals
5	Feedback	information about how the player is doing
6	Resource acquisition	obtaining useful or collectible items
7	Rewards	benefits for an action or achievement
8	Transactions	trading between players, directly or through intermediaries
9	Turns	sequential participation by alternating players
10	Win states	objectives that make one player or group the winner – draw and loss states are related concepts

Table 2.7. Overview of game components.

Number	Component	Description
1	Achievements	defined objectives
2	Avatars	visual representations of a player's character
3	Badges	visual representations of achievements
4	Boss Fights	especially hard challenges at the culmination of a level
5	Collections	Sets of items or badges to accumulate
6	Combat	a defined battle, typically short-lived
7	Content Unlocking	aspects available only when players reach objectives
8	Gifting	opportunities to share resources with others
9	Leaderboards	visual displays of player progression and achievement
10	Levels	defined steps in player progression
11	Points	numerical representations of game progression
12	Quests	predefined challenges with objectives and rewards
13	Social Graphs	representations of players' social network within the game
14	Teams	defined groups of players working together for a common goal
15	Virtual goods	game assets with perceived or real-money value

### 3. Conceptual framework

Based on the findings in literature that are described in Chapter 2, we devised a conceptual model that depicts the relations between the concepts that play a role in increasing user adoption. The model we created is depicted in Figure 3.1.

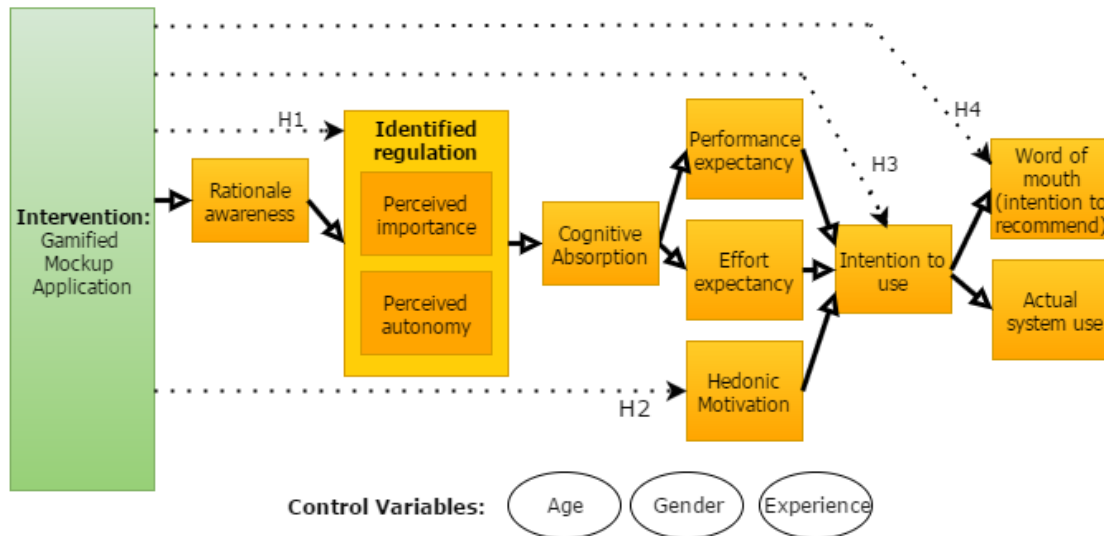


Figure 3.1. Conceptual model of our research.

The model shows the desired outcomes at the rightmost side: actual system use, and the intention to recommend the service to others; word of mouth. These outcome variables are expected to be influenced by intention to use, which in turn is expected to be influenced by performance expectancy, effort expectancy, and hedonic motivation. As described in Section 2.1, most of these relations are derived from UTAUT2 (Venkatesh et al., 2012), except the relation between intention to use and intention to recommend, which is based on the findings of Hamari and Koivisto (2013). Performance expectancy and effort expectancy are expected to be influenced by the construct cognitive absorption, as found by Agarwal and Karahanna (2000) as well as Saadé and Bahli (2005). The results of their researches and the concept of cognitive absorption are described in Section 2.2. Cognitive absorption in turn is expected to be influenced by identified regulation, which in turn is expected to be influenced by rationale awareness. Both these expected relations are based on the findings of Hyungshim Jang (2008), as described in Section 2.3. At the most left side of the model the intended intervention is depicted; a gamified mockup of the application, that we will design for this research. This gamified mockup should be designed in such a way, that it increases the rationale awareness of the users, as well as the hedonic motivation. At the bottom of the model three other variables are shown: age, gender and experience. These variables are not dependent on the independent variable (the intervention). However, based on UTAUT2 (Venkatesh et al., 2012), we expect that they do influence the outcome variables. Therefore they are controlling variables.

The expected relations between variables as depicted in the conceptual model will be tested in this research, via the research method described in Chapter 4. The main subject of this research is increasing the (intention to) use (of) the system, and the intention to recommend the system, by



gamification. Our conceptual model depicts two parallel paths that lead from the gamified mockup to the desired outcomes. One path via increasing the motivation of users by increasing their identified regulation, the other path via hedonic motivation. To simplify the data collection we will omit measurement of some of the intermediate variables. The variables we will measure are: identified regulation, hedonic motivation, intention to use, intention to recommend, gender, and age.

### 3.1 Hypotheses

To examine whether the relationships between the variables are as we expect in our conceptual model, we derived hypotheses we will test. The purpose of our experiment is to find empirical evidence that supports rejecting the null-hypotheses. Our expectation is that the gamified mockup will increase the identified regulation in users, as well as their hedonic motivation. In turn these two will lead to higher intention to use, higher actual use and higher intention to recommend. Based on the UTAUT2 model (Venkatesh et al., 2012) we expect that the outcome variables are also affected by gender and age. Summarized, we expect that in the treatment group the identified regulation, hedonic motivation, intention to use, intention to recommend, and actual system use are significantly higher than the control group, when controlling for age and gender. Four hypotheses are derived to test this expectation. These hypotheses are described below, and also shown in Figure 3.1.

- H1: Users of the gamified mockup will show significantly higher identified regulation than users in the control group, when controlling for age and gender.
  - H1<sub>0</sub>:  $\mu_1 = \mu_2$  (adjusted for age and gender)
  - H1<sub>1</sub>:  $\mu_1 \neq \mu_2$
  
- H2: Users of the gamified mockup will show significantly higher hedonic motivation than users in the control group, when controlling for age and gender.
  - H2<sub>0</sub>:  $\mu_1 = \mu_2$  (adjusted for age and gender)
  - H2<sub>1</sub>:  $\mu_1 \neq \mu_2$
  
- H3: Users of the gamified mockup will show significantly higher intention to use than users in the control group, when controlling for age and gender.
  - H3<sub>0</sub>:  $\mu_1 = \mu_2$  (adjusted for age and gender)
  - H3<sub>1</sub>:  $\mu_1 \neq \mu_2$
  
- H4: Users of the gamified mockup will show significantly higher intention to recommend than users in the control group, when controlling for age and gender.
  - H4<sub>0</sub>:  $\mu_1 = \mu_2$  (adjusted for age and gender)
  - H4<sub>1</sub>:  $\mu_1 \neq \mu_2$

## 4. Research methods

The objective of this thesis is to gain a deeper understanding of the underlying motivational principles that influence the use of a gamified software application. This knowledge can be used to enrich our understanding of user adoption, and to be able to gamify applications in a way that causes the desired outcome. As described in Section 1.1 not much is known about the underlying principles that play a role in gamification, therefore we will collect our own empirical data. To test the conceptual model and corresponding hypotheses we proposed in the previous chapter, we will create a gamified mockup application and test if and how this mockup influences the user adoption. This chapter describes our overall research strategy, as well as our methods for collecting and analyzing data.

### 4.1 The design science method

Because our research includes the creation of a new artifact, our main research strategy is derived from the domain of design science (Simon, 1996). The design science method is a cyclic five-step method, during which a new artifact is created to solve a real world problem (Wieringa, 2014). Figure 4.1 shows a visualization of the design science method as described by Wieringa (2014).

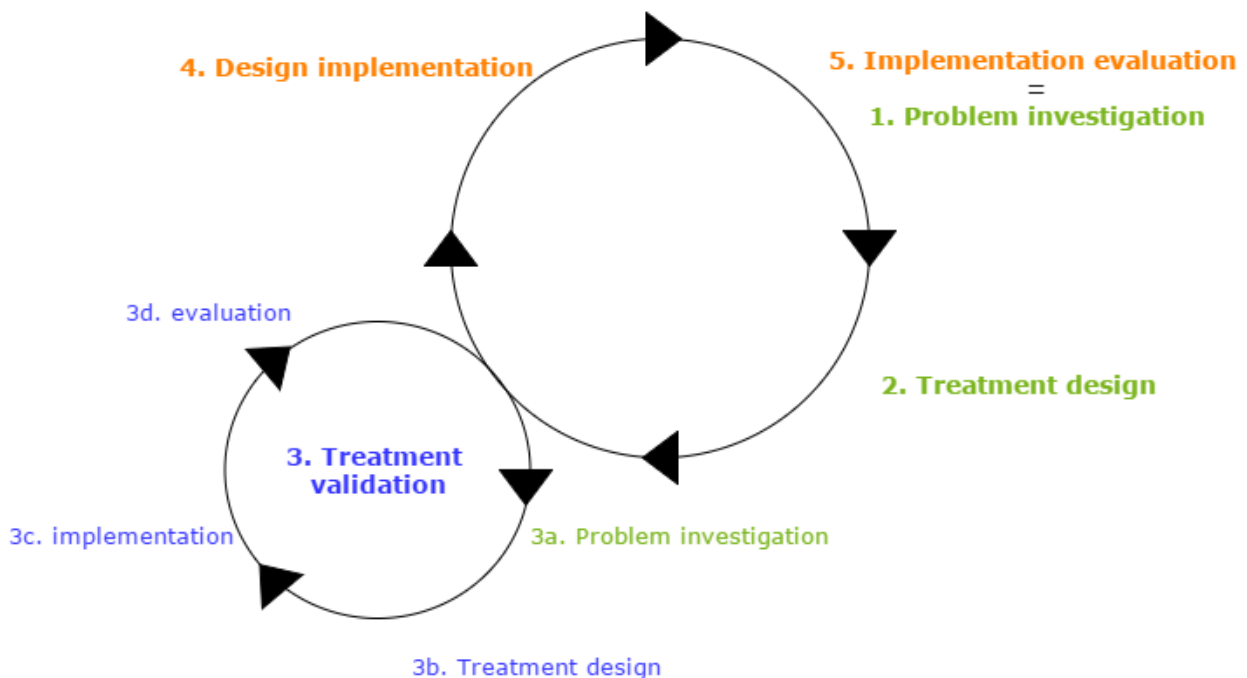


Figure 4.1. The design science method. Adapted from *Design science methodology for information systems and software engineering*, by R. J. Wieringa, 2014, Dordrecht: Springer.

The method consists of five steps, where the fifth step could be the first step of a new cycle. The third step is also a special step, since it is subdivided in four smaller steps, which constitute a smaller research cycle on their own. Wieringa (2014) names this ‘nesting of cycles’, and the smaller cycle that is step



three is named ‘the empirical cycle’. The different colors of the steps in Figure 4.1 indicate how many times a step is carried out in this project. The green colored steps are carried out once, the blue colored steps are carried out twice, and the orange colored steps are omitted in this research. Underneath is an overview of the five steps and the corresponding actions.

1. The first step in the cycle is the **problem investigation**. In this step the researcher should analyze the context of the problem, e.g. the stakeholders, goals, and phenomena that play a role. A conceptual model should also be created. For this research the first step is described in the previous chapters. The problem we are trying to solve is to improve user adoption by using a gamified mockup ODB that introduces the functionality of the ODB in a fun way, in order for the application to be adopted.
2. The next step is **treatment design**, namely designing the artifact that should solve the described problem. To do this we formulate requirements that contribute to solving the problem, and create a gamified mockup ODB. This process is described in Chapter 5.
3. The third step is **treatment validation**. In this step the designed artifact is examined to check if it causes the desired effects in the specific context at hand. As described this step is subdivided in four steps that form the empirical cycle. The research methods we will use to complete this empirical cycle are described in Section 4.2.
4. The fourth step is **design implementation**, meaning implementing the created artifact in the field. In our research this step will not be performed, since we will only evaluate a prototype in the sub cycle in step three.
5. The fifth and last step is the **implementation evaluation**, which could also be the first step of another design cycle. The same as step four this step will not be performed in this research.

## 4.2 The empirical cycle

As described in the previous section, step three consists of four sub steps that form a cycle nested in the whole research process. The main difference with the main research cycle is that the artifact that is created is a prototype, and is tested in an experiment instead of a real-world situation (Wieringa, 2014). The four steps of this cycle are named the same as in the main cycle, but their content differs:

- a. The first sub step is the **problem investigation**. In this step the researcher analyzes how his design could be tested.
- b. The second step is **treatment design**, in which the researcher designs the intended experiment.
- c. The third step is **implementation**. This step holds the actual development of the experiment and conducting it.
- d. The fourth and last step is the **evaluation**. This includes analyzing the data that is collected with the experiment and drawing conclusions upon it.

The problem investigation (step A) is conducted once, and the results are described in the next section. Based on these results we decided to run through the rest of the cycle twice, since we want to test our design with two separate experiments. Section 4.3 and Section 4.4 each describe the setup of one experiment. Step d, the evaluation of the collected data, is described in Chapter 6.



## Problem investigation

As described in Section 1.3 our research includes designing a gamified version of the ODB. The goal of this artifact design is both to create an improved version of the ODB, as well as empirically testing which underlying mechanisms play a role in motivating users and increasing user adoption. In Chapter 2 we examined the existing knowledge on the subject, and based on those findings we designed and developed a gamified version of the ODB, that we expect to improve user adoption. Chapter 5 describes this design. Next to developing an application based on the findings, these findings are also the basis on which we built our conceptual model. This model was presented in Chapter 3 and depicts the causal relationships we expect to find between the treatment, different variables and the intended outcome. Based on our conceptual model we derived hypotheses we want to test with experiments. The fact that we already had hypotheses about which variables play a role and the relations between them, made the nature of this research explanatory instead of exploratory. To analyze if we implemented our findings in theory reliably into our gamified design, we conducted expert-interviews. Next to this we tested our hypotheses about our design with a controlled experiment.

### 4.3 Expert interview setup

The goal of the expert interviews ( $N = 3$ ) was to compare the difference between the gamified mockup and the non-gamified situation. Our hypotheses were derived from different scientific disciplines and therefore we interviewed experts in those fields:

- user experience (UX) for the variable effort expectancy;
- social psychology and communication for the variables identified regulation and rationale awareness;
- game design for the variable hedonic motivation.

To select experts we used convenience sampling, by asking researchers in our network to participate or to recommend an expert. We did not want to evaluate the actual ODB itself. Since we have specific hypotheses about our design we conducted semi-structured interviews guided by an interview protocol. The interview protocol we created is attached as Appendix A. The protocol we used for the interviews is in Dutch, but we also included an English translation in the Appendix. The structure of the protocol in short is as follows.

We first explained the interview conditions, and had the interviewee sign an informed consent. The signed informed consents are attached, as Appendix B. Next we introduced the ODB and its purpose. We emphasized we wanted to discuss the difference between the gamified and non-gamified situation, instead of the ODB itself. We then discussed slightly different questions with each of the experts. These questions focused on their perception of the gamified dashboard and if they believe, based on their knowledge of their field, that the gamified mockup evokes our intended effect. We also asked for advice on possible improvements of the gamified mockup. Our evaluation of the interview is a summary of each interview, and a list of main takeaway points, described in Chapter 6.





## 4.4 Controlled experiment setup

We performed a between-subjects experiment ( $N = 58$ ), where the treatment group was exposed to a gamified mockup ODB and the control group was not. To be able to compare only the effect of gamification it was important to keep the other experiment conditions as constant as possible. To accomplish that, we created a non-gamified mockup ODB next to the gamified version. Thus the participants that did not use the gamified mockup, were exposed to a mockup version of the ODB that is as similar to the gamified mockup as possible.

The population we wanted to test is all intended users of the ODB. The ODB has the potential to be used by any municipality in the Netherlands, therefore the population of intended users is Dutch women and men, of any age, and any level education. We selected a sample of participants living in the municipality Moerdijk, since that is the first municipality where the ODB is deployed. Considering that we had no access to a comprehensive list of all inhabitants of the municipality Moerdijk, we used convenience sampling, which is a non-probability sampling technique. We sent out e-mail invitations for our experiment to employees of the municipality, and a panel of inhabitants that signed up to help evaluate the ODB.

### Data collection

Our data collection method was an online questionnaire. We chose this method because it is a fast way to collect data from many people in a limited amount of time. Another advantage of using a questionnaire is the anonymity of the participants, which will decrease the chance they will fill in socially acceptable answers. This method was also convenient for the participants since they could participate in the experiment at any time that suited them. They just had to follow the link in their e-mail invitation, and within the questionnaire they were redirected to one of the mockups, which they could also access online. After using the mockup they had to close it and return to the questionnaire to fill out questions about their beliefs and attitudes. The questionnaire was created on SurveyMonkey.

As described in Chapter 3, we only measured the variables: identified regulation, hedonic motivation, intention to use, and intention to recommend. These variables were operationalized as found in the following researches:

- Identified regulation, derived from the self-determination theory website (Questionnaires.n.d., 2016);
- Hedonic motivation, as found in Venkatesh, Thong, and Xu (2012);
- Intention to use, as found in Venkatesh and Davis (2000);
- Intention to recommend, as found in Reichheld (2003);

For the operationalization of these variables we chose to use the same questions that were used in the papers we derived them from. Since we based our conceptual model on the results of experiments that used this operationalization, we expected the best results when changing as little as possible. The only operationalization we did not derive from the original article, is that of identified regulation. We chose to change it because the operationalization of identified regulation used by Jang (2008) was not easily applicable for our experiment. The questions are specified for a situation where the participant is



learning a lesson about statistic correlations by solving different exercises. Questions included: “learning about correlations will be valuable to me” and “I believe it was my own choice as to which puzzle to solve”. These questions should have been largely adjusted to fit our experiment, especially since those questions were also to be presented to the users in the non-gamified group. Therefore we searched for another identified regulation scale, and found one more applicable to our experiment on the self-determination theory website (Questionnaires.n.d., 2016). This questionnaire originally focused on people’s motivation to exercise, hence we slightly adjusted the questions for our activity. All questions were also translated to Dutch, since our participants and our prototype were in Dutch as well. Appendix C shows an overview of the questionnaire. We decided to include all four motivation scales in our questionnaire (instead of only the identified regulation scale), since the scales can be combined into a ‘Relative Autonomy Index’ (RAI). This index is an indication of how ‘self-determined’ a participant is (Connell & Ryan, 1985). The level of self-determination is an indication of the kind of motivation (external regulation, introjected regulation, identified regulation, or intrinsic motivation) participants are reporting. As described in Section 2.3, we assume that participants with a higher relative autonomy index will be more sustainably motivated to use the application.

While designing our questionnaire in SurveyMonkey, we used the guidebook for surveying of Baarda, de Goede, and Kalmijn (2007) to write and position our questions. For example we split the list of sixteen questions in half and positioned both halves on different pages, so that participants would not be overwhelmed by the amount of questions. We used so-called ‘transition sentences’ (Baarda et al., 2007) at the top of a new page to explain to the participant what the purpose of the next questions was. To check the intelligibility of the questionnaire, we conducted a pilot-test with eight participants. Based on their comments we made minor adjustments to the questions (e.g. changing word order). We also changed the order of the questions, so that participants could start a new page with a relatively simple question (“because other people would find me stupid...”). On the first page of our questionnaire we included an informed consent. On top of the questions we included to test our hypotheses, we added three open questions. Those questions are intended to give the participants the opportunity to explain why they would use the dashboard and what functionality they would like to see added. We summarized the answers and used them to provide perspective for our statistical findings.

### Data analysis framework

After collecting our data we statistically analyzed it using IBM SPSS Statistics, version 22. The data obtained with the questions derived from the self-determination questionnaire (Q1 and Q3 in Appendix C) were processed first. The data was transformed into five variables: external regulation score, introjected regulation score, identified regulation score, intrinsic motivation score, and the RAI. These variables were calculated as described in Table 4.1. These calculations are derived from the appendix of the self-determination questionnaire we used (Questionnaires.n.d., 2016). For our analysis we used the identified regulation score, and the relative autonomy index; the other variables are only calculated to be used in the calculation of the RAI.

Table 4.1. Calculations per variable.

Variable name	Formula for calculation
External regulation score	Take the average of the scores for sub questions 3, 7, 11, and 14 from Q1 and Q3 as described in Appendix C.
Introjected regulation score	Take the average of the scores for sub questions 1, 6, 9, and 13 from Q1 and Q3 as described in Appendix C.
Identified regulation score	Take the average of the scores for sub questions 4, 5, 12, and 16 from Q1 and Q3 as described in Appendix C.
Intrinsic motivation score	Take the average of the scores for sub questions 2, 8, 10 and 15 from Q1 and Q3 as described in Appendix C.
Relative Autonomy Index	$2 * \text{Intrinsic motivation score} + \text{Identified regulation score} - \text{Introjected regulation score} - 2 * \text{External regulation score}$

The other variables (hedonic motivation, intention to use, and intention to recommend) were measured with one question, and thus those data did not have to be transformed. To test our hypotheses we used a Multivariate Analysis of Covariance (MANCOVA;  $\alpha = .05$ ), that allowed us to include all our variables in one model. MANCOVA supports testing the effect of one independent variable, on two or more dependent variables, while controlling for one or more covariates.

#### 4.5 Validity and reliability

An important aspect of a research is the assessment of the validity and reliability of it. This section describes our analysis of possible threats to the reliability and validity of our research. We also describe the actions we undertook to counteract these threats. Since our research consists of two main experiments, we separately assess their validity and reliability.

##### Expert interviews

In order to increase the reliability of our interviews, we decided to have semi-structured interviews, with comparable questions for each different expert. We composed an interview protocol that was used as guidance during the interview. To be able to precisely recall the statements of the experts we recorded the interviews of the experts who agreed on that. During the other interview we took detailed notes. We selected the experts based on academic or job experience, and reported on that in our results. A minor threat to the reliability of our interviews is the possibility of receiving socially acceptable answers. However, since we interview experts, we expect that we can rely on their integrity when giving an interview about their knowledge domain. To ensure the validity of our interviews we explained our intentions, theoretical findings and design decisions thoroughly to the experts. We also asked them to support their statements with scientific evidence.



## Controlled experiment

To ensure the validity and reliability of our controlled experiment we took several measures. The first aspect we considered was our sampling method, convenience sampling and inviting participant via e-mail. Since this method does not randomly select participants the results are not representative for the whole population. We will take this into account when analyzing our results. Another problem with this way of selecting participants, is that it evokes a self-selection bias in the sample. This bias is neutralized by the experiment set-up, because the participants were randomly assigned to either the treatment group or control group, and we are comparing the differences between these two groups.

The next aspect we considered is our data-collection method. Using an online questionnaire was the most feasible method, and an advantage of a standardized questionnaire is that the obtained data is uniform, and not influenced by the researcher. However, there are also few disadvantages. The first disadvantage is that the researcher is not on site to explain any questions a participant has about the questionnaire. To minimize this possibility we pilot-tested our questionnaire with eight participants, and adjusted questions that were hard to understand. Another disadvantage of questionnaires is that the data is self-reported, which could lead to three problems. The first problem is that participants could be inclined to fill in answers that are more socially acceptable. To lower this risk we have participants fill in the questionnaire anonymously and explicitly explain that their data is confidential. The second problem is that participants could (accidentally) skip questions. To exclude this risk we set all questions as required fields, to enforce participants to fill in all questions before proceeding to the next page. The third problem is that there could be a difference between what participants think they do (and report upon), and their actual behavior. To decrease this possibility researchers often use measurement scales.

This leads to the third aspect we considered; the scales we use to measure the variables. We used validated scales that were found in literature, or derived from the scientific community. However, those scales were in English and we had to translate them to Dutch, in this process some of the nuances could be lost. In order to test if the translated questions were still understandable for participants, we pilot-tested the questionnaire with eight participants. Based on their comments we adjusted some questions. To test the reliability of the used motivation scale we calculated Cronbach's alpha. Based on the results of these calculations, that are presented in Section 6.2, we concluded that the reliability of the scale was sufficient.



## 5. Artifact design

This chapter describes the design process of the gamified and non-gamified mockup ODBs. We designed both mockups in the wire framing tool Axure RP Pro 7.0. Since the basis of our mockups was a rebuild of the actual ODB developed by Centric, we did not create a comprehensive list of user stories. Instead we formulated more abstract requirements for our gamified mockup based on the findings in literature, described in Chapter 2. We first created the gamified mockup, and the probable user journey for that mockup. Based on that user journey we decided which instructions were included in the non-gamified mockup. The remainder of this chapter describes both designs.

### 5.1 Requirements gamified

Based on the literature discussed in Chapter 2 we formulate focus areas for our gamified mockup. We intend to influence the user via two variables: *Hedonic motivation* and *identified regulation*. Hedonic motivation is the fun or pleasure derived from using a technology. We want to increase this by adding game elements to the ODB. Next to increasing hedonic motivation we want to increase the identified regulation of users, which is, as described in Section 2.3, a form of motivation. Based on the findings of Cerasoli et al. (2014) and Lombriser et al. (2016), we decided that we will exclude from our design external incentives that are salient and controlling. With respect to game elements this translates to excluding points, badges, and leaderboards from our design.

To increase the identified regulation of users we apply the recommendations of Jang (2008). This means focusing on conveying the importance of the activity (preparing for emergencies), in a non-controlling way, such that the user feels autonomous in his decision to carry out the activity. To convey the importance of preparing we want to show the user examples of incidents that can happen in his environment. To have the user relate to this, we introduce an avatar that lives in their municipality and that they are asked to help prepare for emergencies. To increase the perceived autonomy of users Deci, Eghrari, Patrick, and Leone (1994) state these two complementing options:

- Acknowledge the perspective of the users (possibility of negative feelings);
- Use non-controlling language that offers choice instead of pressure.

Their research shows that when the importance of the activity is conveyed, but in controlling language, the identified regulation will still be low (Deci et al., 1994). Therefore we will incorporate both these strategies in our gamified mockup. We assigned an ID to each strategy to be able to easily refer to the strategies when explaining our design decisions in the next sections. Table 5.1 shows an overview of the strategies we will use in our gamified mockup to increase user adoption.

Table 5.1. Overview of strategies to increase user adoption.

Variable to be influenced	Sub-variable to be influenced	Strategy	Strategy-ID
Hedonic motivation	Fun	Use game elements	F1
Identified regulation	Perceived importance	Provide rationale	PI1
		Show future benefit for user	PI2
	Perceived autonomy	Use non-controlling language	PA1
		Give choices	PA2
		Acknowledge possible negative feelings	PA3
		Use non-controlling game elements	PA4

## 5.2 Design decisions

Within the requirements framework described in the previous section, we created the gamified mockup. We first recreated the pages and functions that are included in the actual ODB. A screenshot of the homepage is shown in Figure 5.1.

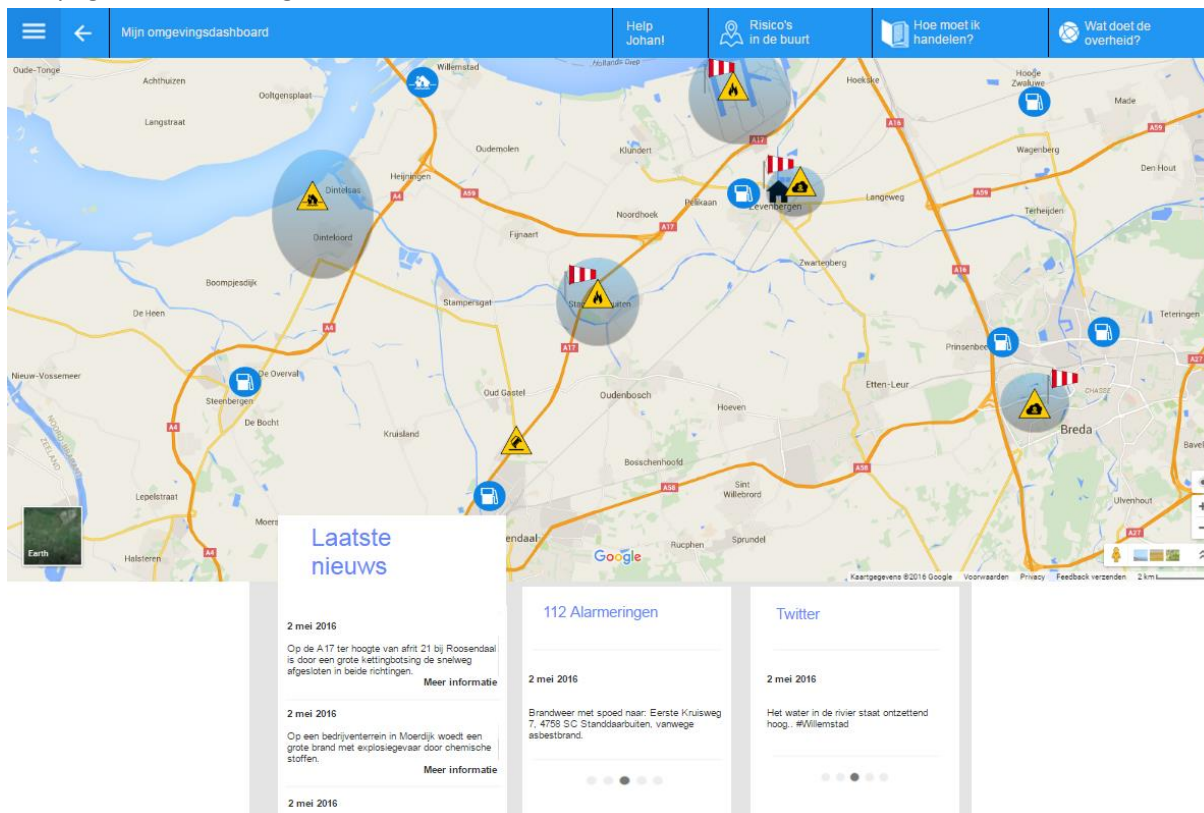


Figure 5.1. The homepage of the gamified mockup.



The main component of the homepage is the map, on which different icons are located. Just as in the actual ODB, blue icons show risks, and yellow icons show incidents. The homepage in Figure 5.1 shows fictional risks and incidents devised for this mockup. The top of the page shows a blue bar with menu buttons. This blue bar is included on all pages throughout the (mockup) ODB. Underneath the map are three columns, “Laatste nieuws” (latest news), “112 Alarmeringen” (notifications of the emergency number), and “Twitter”. In the mockup those columns are filled with static fictional content that relates to the incidents shown on the map. After rebuilding the functions of the actual dashboard we worked on incorporating the strategies listed in Table 5.1. The next two subsections explain how we incorporated the different strategies.

### Identified regulation strategies

To provide users with a rationale (strategy P11) and show them the future benefit of preparing for emergencies (strategy P12), we decided to visualize possible situations that users can easily relate to. Inspired by an ODB explanation video created by Centric, we used the avatar Johan who lives in Zevenbergen. Zevenbergen is a town in the municipality Moerdijk that encapsulates a railroad, via which chemicals are transported towards the industrial area in Moerdijk. The ODB project was initiated by an internal project group that focuses on safety around that railroad. Therefore it is a logical choice to have Johan live near this railroad in Zevenbergen. In the first screen, shown in Figure 5.2, Johan invites the user to help him prepare for possible emergencies in his living environment. Throughout the user journey, Johan asks the user to help him prepare for possible emergencies in his municipality, which is also the municipality the intended users live in. By asking for help in example situations Johan explains what risks there are in the environment, and during the missions the users come in contact with fictional -though realistic- incidents, that show them the rationale of preparing (strategy P11). Since the incidents are located in their own municipality, and are happening to Johan who could be their neighbor, the probability increases that they relate the importance of preparing to their own lives (strategy P12).





Figure 5.2. Johan invites the user to help him.

To support the perceived autonomy of users we used non-controlling language (strategy PA1), by minimizing the use of imperatives and presenting next steps as optional instead of mandatory steps (strategy PA2). As can be seen in Figure 5.2, Johan also proposes to the user to show where he lives on the map, but also gives the option to decline. Allowing the users to choose his next actions to some extent (strategy PA2), is incorporated in more pages. For example there are three missions the user can complete, as seen in Figure 5.3. To show the different decision points for users we created the flowchart that can be seen in Figure 5.4. Another strategy we used to support the user's autonomy is acknowledging possible negative feelings of the user (strategy PA3). After each of the three missions there is a wrap-up page for that mission. On that page there is feedback about the mission, in which possible negative feelings are acknowledged. On the wrap-up pages for the flooding and toxic cloud, there is also a question to complete the mission, to check whether the user found the right information. A screenshot of the wrap-up page of the toxic cloud is included in Figure 5.5.



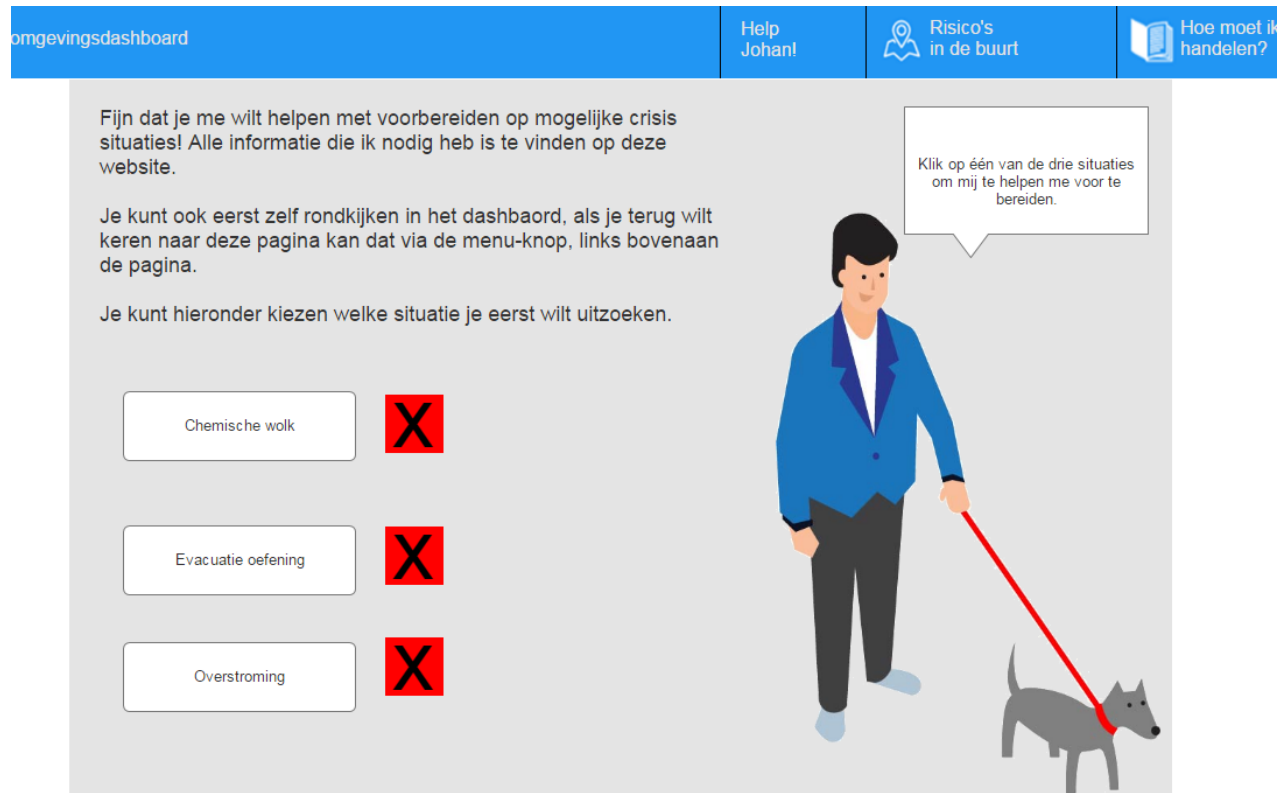


Figure 5.3. The screen showing the game missions.

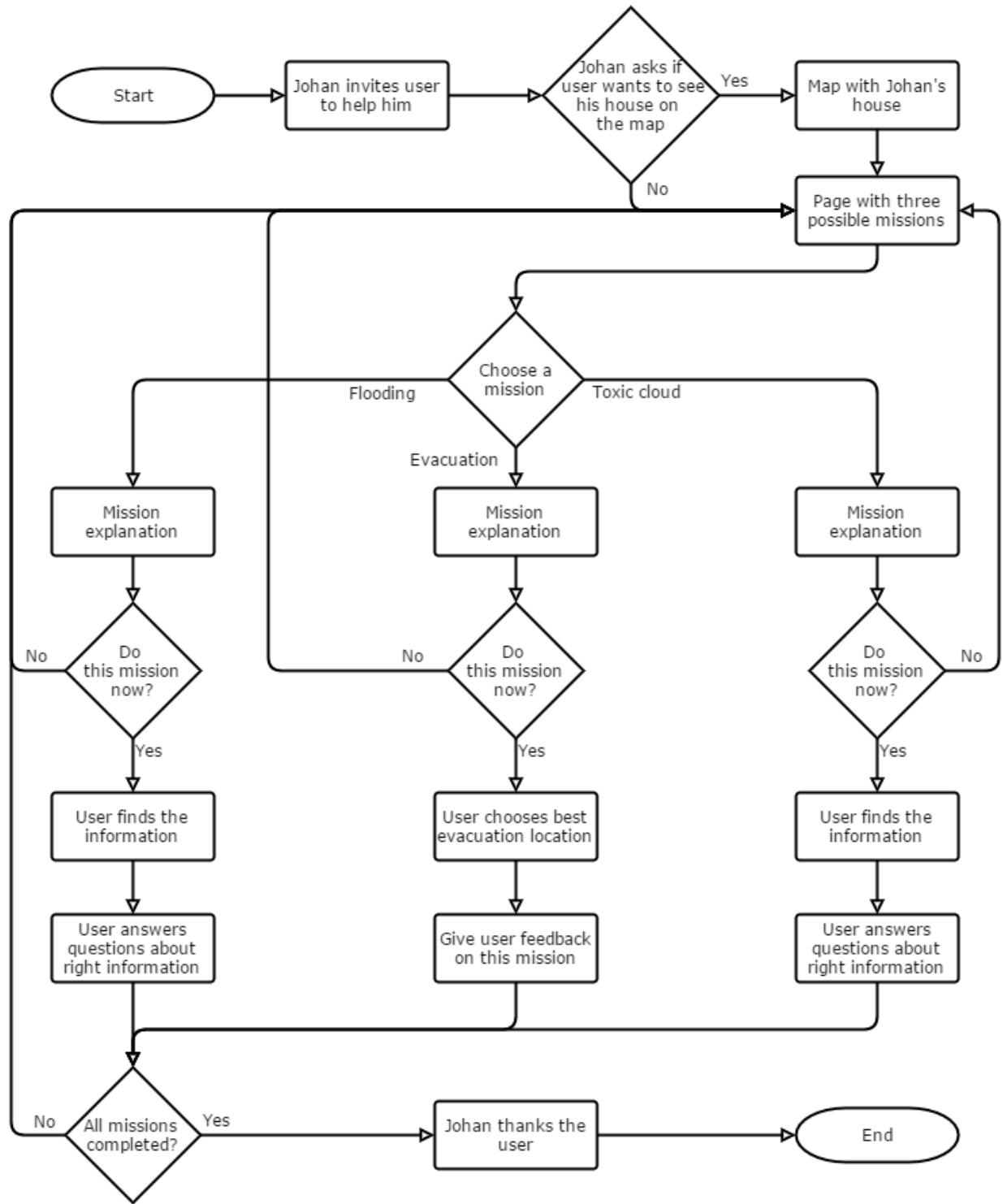


Figure 5.4. Flowchart of the gamified mockup.

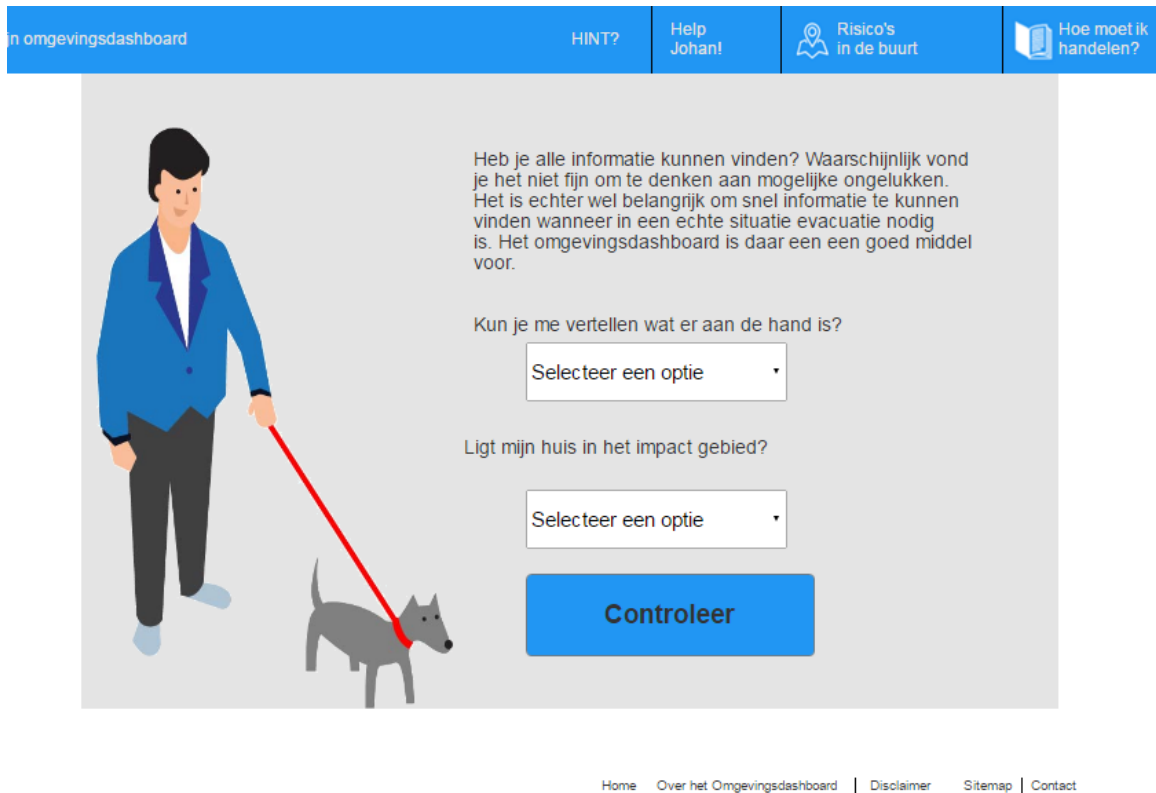


Figure 5.5. The wrap-up page for the toxic cloud mission.

### Hedonic motivation strategy

The final strategy we used to increase user adoption was to influence the users' hedonic motivation by including game elements (strategy F1). The game mechanics and game components that were included were restricted by strategy PA4, which demands the exclusion of salient and controlling game elements. In practice this led to excluding points, badges, and leaderboards. From the remaining lists of game elements (as listed in Table 2.6 and Table 2.7) we used several game dynamics, mechanics and components.

In our design we used constraints, narrative, emotions, and progression as game dynamics. The narrative is about Johan, who lives in Zevenbergen and needs to prepare for emergency situations. We expect this evokes emotions in the user, since they live in the same municipality, and the risks are realistic. The constraint, or problem the user needs to solve, is the possible unsafety of Johan, since he does not know what emergencies can happen in his living environment and is not prepared to react adequately would an emergency occur. The progression the user makes is finding information for Johan so he is able to prepare himself for the risks in his environment. The game mechanics we included challenges, feedback, rewards, and win states. Completing the missions is challenging for the user, and when he completes a mission he gets feedback in the form of a reward. The rewards the user receives; one balloon, several balloons, and confetti, are all shown in Figure 5.6. The win state of the game is when the user completed all three missions and Johan thanks the user for his help.

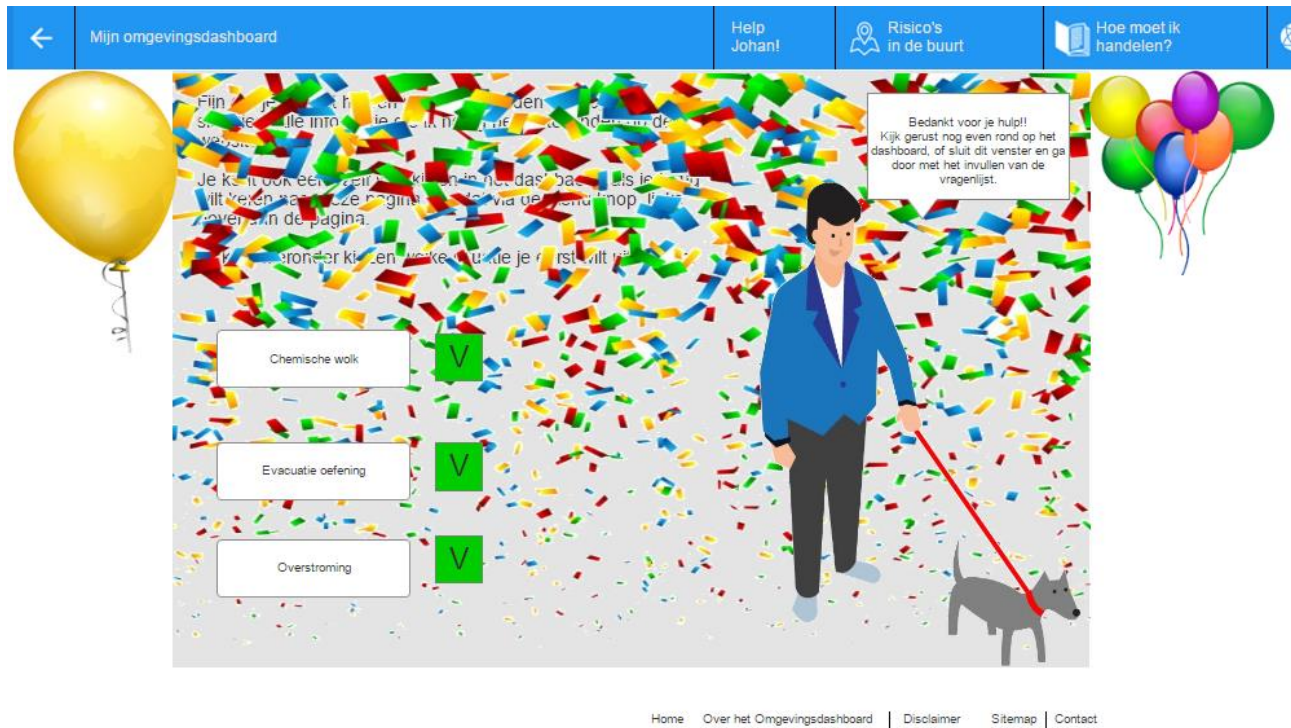


Figure 5.6. The rewards for completing the missions.

The game components we used to implement the above described mechanics are: quests, achievements, and avatars. Johan is the avatar, a visualization of a character the user helps to prepare. The situations Johan asks the user to prepare for are the quests, and completing a quest is an achievement for the user. By implementing these game dynamics, mechanics, and components into our mockup application, we hope to increase the hedonic motivation of the user.

### 5.3 Non-gamified design

For our non-gamified design we wanted to keep the ODB as constant as possible. Therefore we kept all information in the dashboard the same, including the fictional incidents. Next to this we decided to implement elements that direct the user towards the pages that the users of the gamified mockup are likely to also visit. This in order to keep all aspects of the experiment constant, while manipulating only the independent variable. By subtly steering all users to the same pages we can be more confident they all come in contact with approximately the same content. This decreases the difference in variables other than gamification that influence users' feelings toward the ODB. The pages that are most likely to be visited by the users of the gamified mockup are: the homepage, and the page about emergency kits (noodpakketten). On the home page there are different elements that are convenient to use when looking for the information that is needed to complete the missions in the gamified mockup. Therefore we included directions to those elements on the home page as well as to the page about emergency kits. Figure 5.7 shows a screenshot of the homepage.

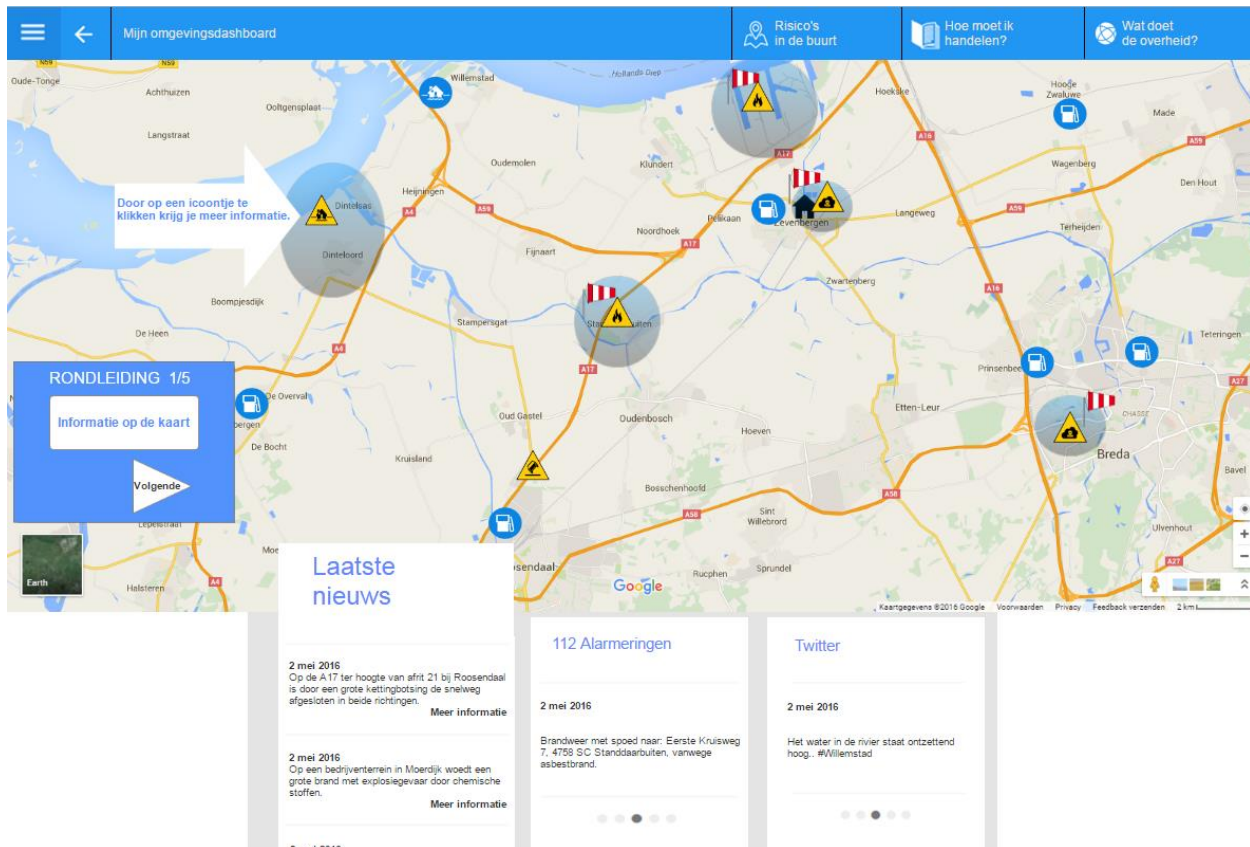


Figure 5.7. Screenshot of the homepage of the non-gamified mockup.

On the left side of the screen we included a box that provides a guide tour of the ODB. In the box there is a description of a function, and the big white arrow gives directions on where to find and how to use that function. The box in Figure 5.7 explains that users can click icons on the map to find more information. The user can use the arrow in the tour-box to switch between explanations about different functions. The other elements we direct the user to are: the three columns below the map, the menu buttons on the left in the blue bar, the buttons on the right side of the blue bar, and the way to reach the page about emergency kits. The arrows we implemented to direct the user towards the page concerning emergency kits are shown in Figure 5.8 and Figure 5.9.



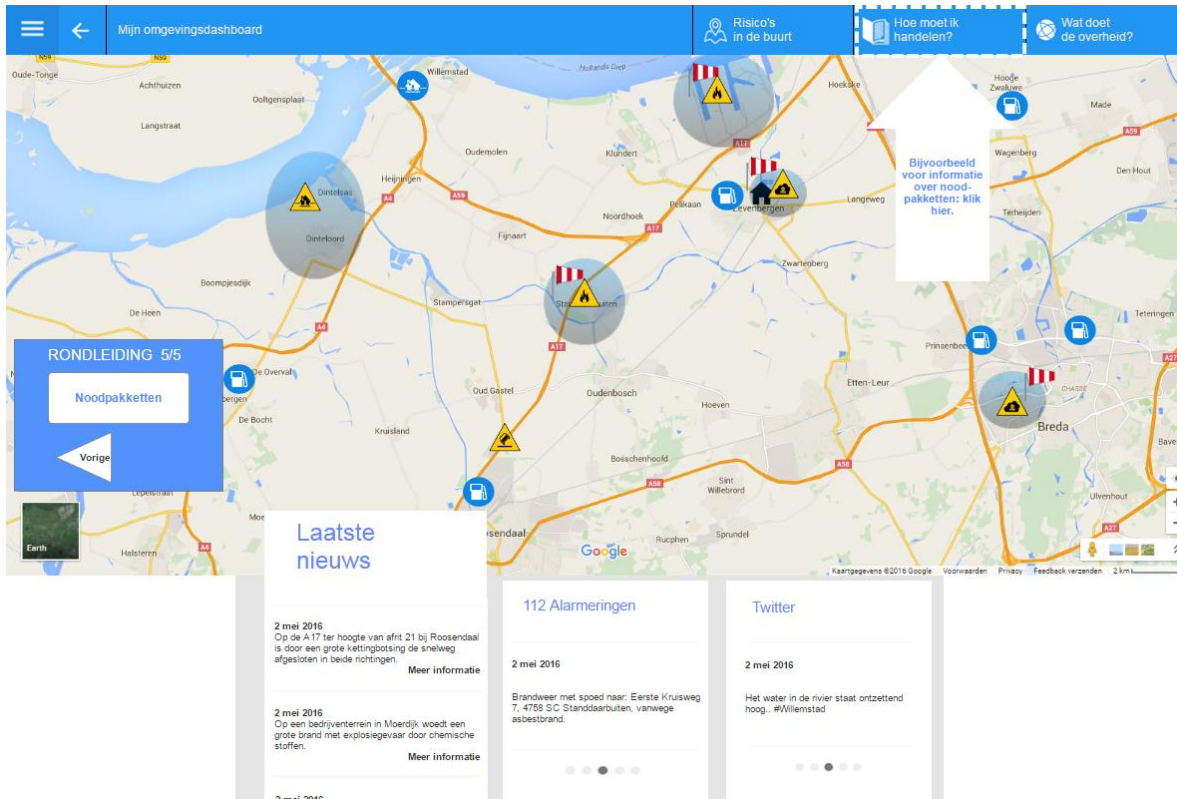


Figure 5.8. The homepage explanation arrow for the emergency kits.

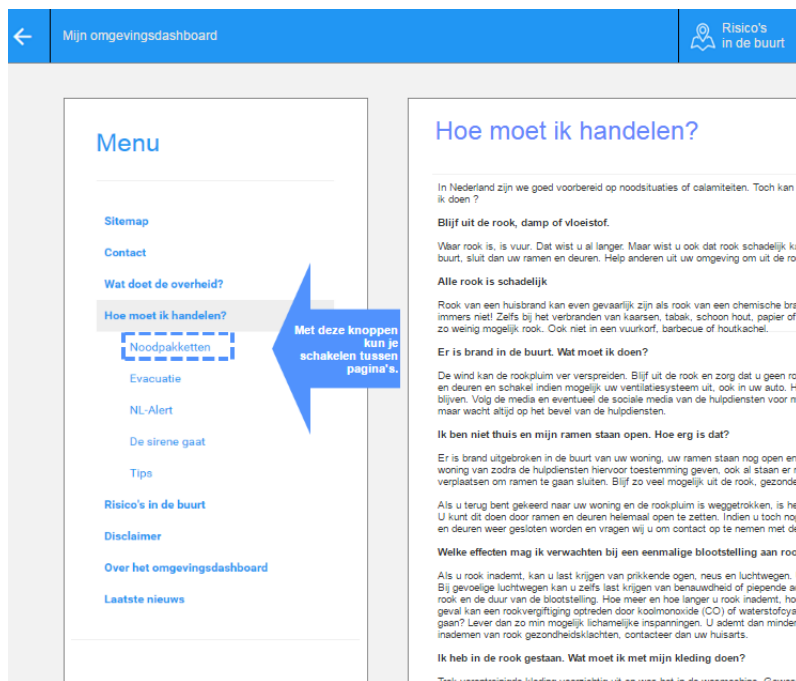


Figure 5.9. The second step in directing the user to the actual emergency kits page.



## 5.4 Pilot testing

After designing both mockups, we pilot-tested the designs with eight participants. Those participants only participated in the pilot-test and were excluded from participation in the actual experiment. Next to some trivial mistakes, (e.g. typos, use of a non-corresponding incident-icon), we made few changes to the designs. Table 5.2 lists a summary of the comments of the pilot-participants, and the subsequent changes we made to our designs.

Table 5.2. Overview of changes to our designs after pilot testing.

Which design	Comment from the pilot-test	Change in our design to improve this
<i>Gamified design</i>	It would be more fun if I receive a reward when completing a mission.	We introduced balloons and confetti after the users completes a mission.
	Change the comment that Johan gives on the mission page.	We made the text more general, and introduced more feedback on the page where the user completes the mission.
	I do not know where to find the information about emergency packages.	We added an extra hint, explaining the last step to get to this page.
<i>Non-gamified design</i>	When you have scrolled down and change the tutorial to the next arrow, some arrows are out of sight.	The page automatically scrolls back to the place where the next arrow pops up.
	The tutorial arrows are confusing; partly because the tutorial is circular (you can skip from arrow 5 back to arrow 1).	We made the tutorial non-circular, and added information on which arrow the users is looking at (1/5, 2/5, etc.).
<i>Both designs</i>	The page is too wide for a smaller screen.	We created a smaller version of the design that loads when a smaller screen size is detected.
	After a while I forget I have to go back to the questionnaire.	We made this more explicit in the introduction text. We also instruct the user to go back to the questionnaire in the feedback of Johan when all three missions are complete.



## 5.5 Limitations

The design scope of our gamified mockup was limited to a certain amount. Therefore we see a number of aspects that could be improved upon. One limitation of our current design is the use of only one avatar. To improve the extent to which users can relate to the avatar, more avatars could be introduced into the design. Users could be given the option to choose which avatar they want to help prepare for emergencies. For example there could be a mother included who wants to learn about risks in the vicinity of her children's school, or a caregiver that wants to find out what risks there are around the health institution he works.

Another aspect of our design that could be a limitation, is the low amount of social opportunities. Our gamified design is relatively static and users cannot add any (social) content to it. For example our design does not support users to form teams, and socially interact on the dashboard. In terms of game element we excluded the following: competition, cooperation, transactions, turns, gifting, social graphs, and teams. Including these game elements in a gamified design might increase the user adoption an application, however, social motivators are beyond the scope of our conceptual model and hypotheses.





## 6. Results

To evaluate our designs we conducted two experiments, the first experiment to assess the *expected effectiveness* of our designs based on scientific knowledge, the second experiment to assess the *actual effectiveness* in a controlled experiment with a sample of the intended users as participants. As described in section 4.3, the interviews were conducted with experts from three domains: user experience (UX), social psychology and communication, and game design. Section 6.1 describes the results of these interviews. In the controlled experiment, as described in section 4.4, we measured the attitudes and beliefs of participants about the design after using the gamified mockup. Section 6.2 presents the results of the controlled experiment.

### 6.1 Interview results

The three experts we interviewed all have a considerable amount of experience in their field. They all completed an educational program in their field, and have relevant job experience. After his education, the UX expert has been working as a UX designer for six years, and since two years also as Business Consultant. The social psychology and communication expert co-founded the innovative consultancy agency 'Tabula Rasa' 19 years ago. Tabula Rasa focuses on implementing psychological insights into daily practice. Next to her work for Tabula Rasa, she is writing her dissertation at the Radboud University Nijmegen, on the development of interventions to help people with (a higher risk of) cancer adjust to a healthier lifestyle. In addition to her research she also teaches courses on communication at the Radboud University. The game design expert has been teaching courses in game design, and since one year he is conducting Ph.D. research on human motivation to play games.

For brevity we will use the following abbreviations for the different experts throughout the rest of this section: UX (user experience expert), SPC (social psychology and communication expert), and GD (game design expert). The rest of this section is divided into subsections that summarize and analyze the statements of the experts on different themes. These themes are overarching themes that follow from the structure of the interview protocol.

#### Gameplay

In general the GD and SPC agree that the game in itself is enjoyable, and the GD adds that the game feels natural and runs smoothly. However, the UX finds the game childish and a bit outdated, because of the style and name of the avatar, and the level of difficulty of the missions. Both the GD and SPC find it positive that after a mission the user has to answer a question about the mission on a new page. The GD states that not being able to look up the correct answer quickly on the same page effectively emphasizes that the user did not know the correct answer. The SPC experienced this when she saw the questions: "I now see that I actually did not look at the information very well". Both the GD and SPC are pleasantly surprised by the balloons that pop up when a mission is finished.

The GD also analyzes the game on a more abstract level. He states that the start of the game could be changed to support the user in changing his mindset. He explains that for the user the transition from the mindset for looking at a new safety application, to the mindset for playing a game



feels a bit sudden. He connects this to the concept 'magic circle'. This concept is described by Castranova (2008) as a membrane that protects a synthetic world (the game world) from the real world. Before using the gamified design, the user's mindset is focused on the real world, and when he starts using the gamified design he suddenly finds himself inside the magic circle. To support the user in this transition, the GD suggests to implement a surprise at the start of the game. An example of this idea is to show an animation of an explosion on the starting screen, followed by the statement "This explosion is not real, but can you help me to be prepared for actual emergencies?". This surprise effect helps the user to let go of his expectations and supports the transition to the game mindset, or in other terms: into the magic circle.

### Perceived autonomy

There are two factors that affect identified regulation in the gamified design: perceived autonomy (see this section) and perceived importance (see the next section). To support autonomy, we designed the gamified dashboard without the use of controlling game elements and controlling language, and we provided the user with choices. What was clear from the interviews was that the possibility to choose (whether or not to see where Johan lives, or to start a mission) is intriguing. Both the GD and SPC comment about it two times. They both suggest that it could be made clearer what happens when the user chooses 'no'. Whether the saliency of the possibility to choose, does actually indicate that they perceive autonomy cannot be concluded from their statements. However, the GD did make other statements that suggests he feels autonomous: "It's nice Johan says I can look around first before I have to start helping him", and "The game felt natural, not like a tutorial that demands 'click here, now click here'". To be able to draw more conclusions about the autonomy of the users, an analysis of the controlled experiment's results is essential.

### Perceived importance

The second factor that plays a role in identified regulation is the perceived importance of the task. To increase the perceived importance we provided the users with a rationale, and showed them the future benefit of using the ODB. The main comment of the GD and SPC about the perceived importance was about the high amount of risks and incidents that was shown in the mockup dashboards. The GD stated it was "confusing there immediately are so many icons on the map", and the SPC commented that "showing so many incidents can unwantedly concern users".

She adds that many people do not want to think about risks they cannot influence in any way, and that the communication on the (gamified) dashboard could be more effective if it focuses on increasing the perceived self-efficacy of users. Self-efficacy is "concerned with people's beliefs in their ability to influence events that affect their lives", according to Bandura (1994). The SPC suggests the ODB would be more helpful if it focuses on communicating to users that the ODB is the best place to quickly get information on your action perspective in case of emergencies. Communicating that message could help users gain confidence that in case of an emergency they will be able to stay safe, by going to the ODB and following the instructions. Following this suggestion would mean shifting the goal of the



gamified dashboard. Namely a shift from increasing the users' perceived importance of using the ODB to prepare for emergencies, to making users familiar with the ODB and increasing their self-efficacy.

### Comparison of the designs

When asked to compare the gamified design with the non-gamified design on effectiveness to increase user adoption, the UX favors the non-gamified design, where the GD and SPC both favor the gamified version. The UX states that he thinks the game elements are implemented in a way that is too obtrusive and distracting. In his opinion it is better to just show the functionality, he clarifies: "the non-gamified version immediately shows the concept and its functionality, while in the gamified version you have to click many times before you see the functionality".

Though they disagree on which version would be most effective to increase user adoption, the GD and SPC use approximately the same explanation as the UX. The GD states the difference between the two versions resembles the difference between 'knowledge and ability'. The non-gamified version shows the user the functionality, while the gamified version causes the user to experience the functionality. He comments that: "the gamified version really uses the power of games: providing users with the *experience* of using the ODB". He adds that this makes the application more approachable for new users, and invites them to look around longer. The SPC says the gamified version is an improvement over the non-gamified version, because: "the application really guides the user through the application". She explains that in the non-gamified version she did not know what she had to do, or what the goal of using the application was. She concludes that having such a guide through the application could also be helpful in the case of an actual emergency (in jargon: during the 'hot phase').

An explanation for the experts holding different opinions, though supported by comparable arguments, could be that they are based on different assumptions. We suppose that the UX draws his conclusion based on the assumption that users start using an application when they have a clear goal they want to accomplish. In contrast, the GD and SPC base their conclusion on the assumption that the user first needs to get familiar with the application, its functionality, and its importance. This last assumption is the closest to the goal of our research, and therefore we adhere to the opinions of the GD and SPC, and expect that the gamified version will be more effective than the non-gamified version to increase user adoption of the ODB. However, we do take the comments of the UX in account, and believe that for a next version of the gamified design the game should be less childish and outdated.

### Content of the actual dashboard

Based on comments of the SPC, we discuss some remarks on the theme 'content of the actual dashboard'. The SPC gave a few suggestions on how the communication in the actual ODB could be improved. Some of these improvements have already been implemented in the ODB, since the development of the actual ODB continued after the mockup versions were devised. The SPC states that not all of the icons and the used terms are easy to understand, and that the fact that she needed to use the 'hint' button indicates that not all information is located in a logical place. She also suggests that when a user selects an incident icon, it would be helpful if the information about the action perspective is shown immediately. Last but not least, she wondered why the button to 'report an unsafe situation' is



tucked away at the bottom of the page. She indicates that reporting a situation is something users are not likely to think of themselves, but will only be inclined to do when they see that it is a possibility. For our research this is out of scope, since the current version of the ODB does not support this functionality. The focus of the current ODB, and thus our research, is only on the communication from municipality to inhabitants, and not vice-versa.

## Usability

All three experts made several comments about the usability of the designs:

- There is much text, maybe it is possible to include animations of some instructions;
- Some buttons are not working (mainly the 'close' buttons on incident information popups);
- Johan is sometimes only fully visible when the users scrolls down;
- On the mission explanation pages it is unclear that Johan is 'speaking' to the user. When the text refers to 'I' the user could get confused who 'I' is.

These are all minor usability issues that can easily be improved in a next version of the designs.

## 6.2 Controlled experiment results

This section presents the results of the controlled experiment with participants, which we conducted with the goal of testing our hypotheses as presented in Chapter 3. Appendix D includes various SPSS output tables that show the results we report on in this section. In the tables the exact results we used are marked green, for results that show that assumptions are satisfied, red, for results that show assumptions are violated, and blue, for results that were used to evaluate our hypotheses. Our group of participants largely consists of employees of the municipalities Moerdijk, Halderberge and Roosendaal, and a few inhabitants. The inhabitants were recruited via a panel of inhabitants that gives feedback about the ODB, for which they applied earlier during the ODB project. A total of 88 participants started the survey, of which 30 participants did not fill out the entire questionnaire, therefore  $N = 58$ . Two participants skipped one (different) sub question of the identified regulation scale. Since the scale measures each construct with four questions, we calculated the average of the three questions, and used that score for filling in the missing question. Three participants did not fill in their intention to recommend, gender, and age. Another two participants only skipped the question about their age. All those values were labeled in SPSS as missing, and were in some cases left out of the calculations. As can be seen in Figure 6.1 and Figure 6.2, the random assignment of participants to one of the groups resulted in evenly distributed groups, considering age and gender. The age of the participants in the gamified group ranged from 21 to 58 years ( $M = 43.8$ ,  $SD = 10.62$ ), and the age of the participants in the non-gamified group ranged from 27 to 63 years ( $M = 43.5$ ,  $SD = 10.61$ ).

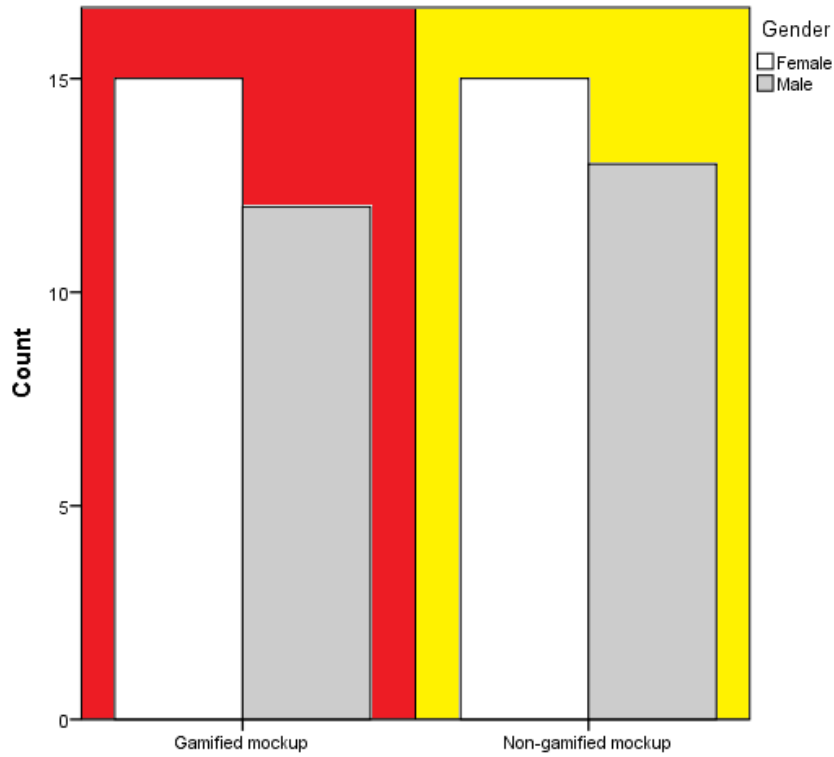


Figure 6.1. The gender distribution of the participants within and between the groups.

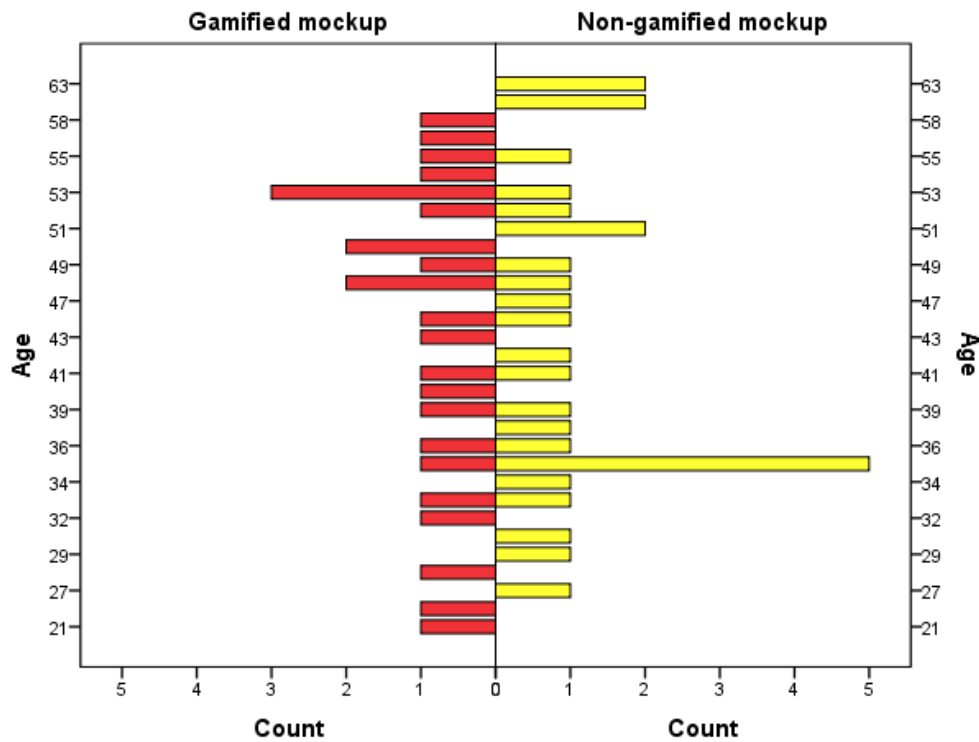


Figure 6.2. The age distribution of the participants within and between the groups.



### Reliability of the motivation scale

To assess the reliability of the scale used to measure the different motivation constructs, we calculated Cronbach's alpha for each of the four kinds of motivation: External regulation ( $\alpha = .791$ ), introjected regulation ( $\alpha = .733$ ), identified regulation ( $\alpha = .798$ ), and intrinsic motivation ( $\alpha = .803$ ). These are all considered reliable scales, especially since the scales consist of four factors each (Field, 2009). However, we also calculated how Cronbach's alpha would change for each scale if any of the items would be deleted. This led to the conclusion that the reliability of our scale for identified regulation would improve ( $\alpha = .867$ ) if sub question 4 ("Omdat ik het gevoel zou hebben dat ik tekort schiet als ik het niet doe."/ "Because I would feel like a failure if I did not.") was removed. Therefore we decided to remove this question from our scale, which led to this new calculation for identified regulation:

Take the average of the scores for sub questions 5, 12, and 16 from  
Q1 and Q3 as described in Appendix C.

**Identified regulation score** =

### Assumptions for Multivariate Analysis of Covariance

When using a statistical test to analyze data, it is important to first check whether the data satisfies the assumptions of that test (Field, 2009). When using MANCOVA the data has to satisfy several assumptions (Multivariate analysis of covariance (MANCOVA).n.d., 2016), which are listed in Table 6.1.

The first and second assumptions are both satisfied. This can be deduced from our experiment and questionnaire design. Firstly, all participants were randomly assigned to one of the treatment groups (gamified or non-gamified design) within the online questionnaire. Secondly the measurement levels of the data are sufficient:

- The independent variable, the intervention, is categorical (gamified or non-gamified);
- The dependent variables, identified regulation, hedonic motivation, intention to use, and intention to recommend, are all Likert scales, and those are assumed to be continuous by many academics (Field, 2009);
- The covariate age is continuous;
- The covariate gender is dichotomous.

Table 6.1. The assumptions for MANCOVA.

#	Assumption	Explanation	Assumption satisfied?
1	Independent random sampling	The groups that are compared should be independent; i.e. the participants should be randomly assigned to one of the groups.	Yes.
2	Level and measurement of the variables	The independent variables should be categorical, and the dependent variables should be continuous or scale variables. The covariates should be continuous, ordinal or dichotomous.	Yes.
3	Absence of multicollinearity	The correlations between the dependent variables should not be 'too high'.	Not entirely.
4	Normality	The variables should be normally distributed.	Not for all variables.
5	Homogeneity of variance/covariance	The variance for the dependent variables and covariates should be homogeneous for both groups.	Yes.
6	Homogeneity of regression slopes	There should be no interaction between the independent variable and the covariates.	Yes.
7	Relationship between covariate(s) and dependent variables	There should be a correlation between the covariates and the dependent variables.	Yes.

To check whether our data satisfies the assumption of multicollinearity, we calculated the correlations between the dependent variables. According to Tabachnick and Fidell (2012) a correlation is too high when Pearson's  $r > .90$ . The dependent variables and the correlations between them are listed in Table 6.2. As can be seen in the table, the correlation between intention to use and intention to recommend in the gamified group is above .90. Considering that this correlation is not as high for the non-gamified group, we expect this is due to the sample size, since that is a known cause of multicollinearity (Paczkowski, n.d.). Since the multicollinearity assumption is only partly violated we proceeded with our analysis.

Table 6.2. The correlations between the dependent variables.

Variables	Correlation in the gamified group	Correlation in the non-gamified group
Identified regulation and intention to use	$r(29) = .76, p < .01$	$r(29) = .46, p < .05$
Identified regulation and hedonic motivation	$r(29) = .78, p < .01$	$r(29) = .37, p < .05$
Identified regulation and intention to recommend	$r(27) = .83, p < .01$	$r(28) = .70, p < .01$
Hedonic motivation and intention to use	$r(29) = .77, p < .01$	$r(29) = .62, p < .01$
Hedonic motivation and intention to recommend	$r(27) = .76, p < .01$	$r(28) = .65, p < .01$
<i>Intention to use and Intention to recommend</i>	$r(27) = .92, p < .01$	$r(28) = .52, p < .01$

Table 6.3. Results of the Shapiro-Wilk test for each of the variables for each of the groups.

Variable	Significance of Shapiro-Wilk for in the gamified group	Significance of Shapiro-Wilk for in the non-gamified group
Identified regulation	$p = .17$	$p = .02$
Hedonic motivation	$p = .01$	$p = .00$
Intention to use	$p = .00$	$p = .00$
Intention to recommend	$p = .06$	$p = .00$
Age	$p = .08$	$p = .09$

To verify if our variables are all normally distributed (the fourth assumption) we used the Shapiro-Wilk test, which compares the scores in the sample to a normally distributed set of scores (Field, 2009). If the outcome of the test is significant, we can conclude that the tested distribution differs significantly from a normal distribution. Table 6.3 shows the calculated results of the Shapiro-Wilk test for each of the variables for each of the groups. As can be seen in the table, there are many variables that have a significant Shapiro-Wilk value, indicating they are not normally distributed. The variables that are normally distributed are, for the gamified group: identified regulation, intention to recommend, and age. In the non-gamified group the only normally distributed variable is age. Since the Shapiro-Wilk test is biased towards larger samples (Field, 2009), we expect these results are due to our small sample sizes. Another method to assess if variables are normally distributed is looking at Q-Q plots. A Q-Q plot shows the data mapped to a line that represents a normal distribution. The closer to the line the data points lie, the more the distribution resembles a normal distribution. Based on the Q-Q plots for our variables (included in Appendix D), and considering that the assumption is only partly violated, we continued our





analysis. This decision is supported by the findings of Olson (1976), who argues that all four test statistics that are used in SPSS to calculate the MANCOVA are relatively robust to violations of normality.

To assess the fifth assumption, the homogeneity of the variance and covariance, we used Box's test of equality of covariance matrices, and Levene's test of equality of error variances. With these tests we evaluate the hypothesis that the variances of variables between the two groups is significantly different. If Box's M is not significant we can assume there is homogeneity of variance and covariance. As p-value we used the .001 level, since the test is highly sensitive (Tabachnick, Fidell, & Osterlind, 2001). Equivalent to Box's M, Levene's test should not be significant (Hollenbaugh, 2016). For our data the Box's M value of 28.08 is not significant ( $p = .004$ ), and none of the variables has a significant value for Levene's test:

- Hedonic motivation,  $F(1,51) = .02, p = .89$ ;
- Intention to use,  $F(1,51) = .265, p = .11$ ;
- Intention to recommend  $F(1,51) = .13, p = .72$ ;
- Identified regulation  $F(1,51) = .44, p = .51$ ;

Based on these results we conclude that the assumption of homogeneity of variance and covariance is met.

To evaluate whether the sixth assumption, homogeneity of regression slopes, is satisfied, we need to verify there is no interaction between the covariates and the independent variable. To assess this we ran a multivariate general linear model analysis in SPSS, where we included the interaction terms: group\*age and group\*gender. When these statistics are not significant the assumption is satisfied (Hollenbaugh, 2016). For our data both statistics for the interactions are not significant (group\*age:  $p = .90$ , group\*gender:  $p = .56$ ), therefore we assume homogeneity of regression slopes.

The final assumption is that there are correlations between the covariates (gender and age) and the dependent variables. As depicted in our conceptual model in Chapter 3, we assume these variables are correlated based on our findings in literature.

### Multivariate analysis of covariance

After verifying that the assumptions are sufficiently met, we continued with running the multivariate analysis of covariance including all our variables in SPSS. We found no significant effect of group (gamified/non-gamified) on identified regulation, hedonic motivation, intention to use, nor intention to recommend, after controlling for age and gender. Because we found no effect while looking at the entire model including all variables, we did a follow-up analysis to evaluate the between-subjects effects. While looking at between-subject effects, the issue of multi comparison arises: with each separate test we evaluate, the error chance increases (Field, 2009). To counteract this increase we apply a Bonferroni correction (Harris, 1975): dividing the  $\alpha$ -value for significance by two, so our new  $\alpha = .025$  ( $.05 / 2 = .025$ ). This led to the conclusions presented in the next section.

## Evaluation of separate hypotheses

This section presents the results of the analysis per hypothesis, as presented in Chapter 3.

- H1: Users of the gamified mockup will show significantly higher identified regulation than users in the control group, when controlling for age and gender.
  - H1<sub>0</sub>:  $\mu_1 = \mu_2$  (adjusted for age and gender)
  - H1<sub>1</sub>:  $\mu_1 \neq \mu_2$

When comparing both groups on identified regulation, we found no significant effect of group on identified regulation after controlling for age,  $F(1, 51) = 4.37, p = .04$ . There neither was an effect when controlling for gender,  $F(1, 51) = .10, p = .75$ . Figure 6.3 shows the boxplot that visualizes the difference in identified regulation for both groups. The figure shows that there is close to no difference between the two groups.

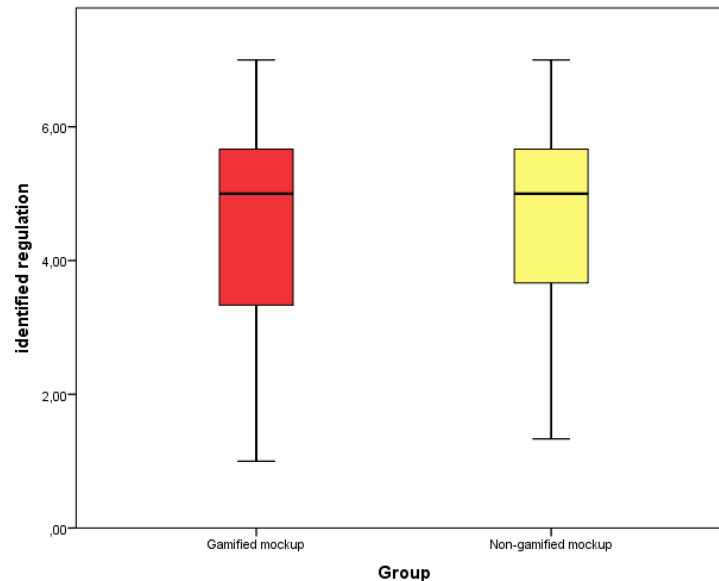


Figure 6.3. Boxplot of identified regulation for both groups.

- H2: Users of the gamified mockup will show significantly higher hedonic motivation than users in the control group, when controlling for age and gender.
  - H2<sub>0</sub>:  $\mu_1 = \mu_2$  (adjusted for age and gender)
  - H2<sub>1</sub>:  $\mu_1 \neq \mu_2$

When comparing the hedonic motivation of users, we found no significant effect of group on hedonic motivation after controlling for age,  $F(1, 51) = .57, p = .46$ . We neither found an effect after controlling for gender,  $F(1, 51) = 1.27, p = .27$ . A visualization of the difference in hedonic motivation between the two groups is shown in the boxplot in Figure 6.4. As expected based on the non-significant findings, there is no difference worth mentioning.

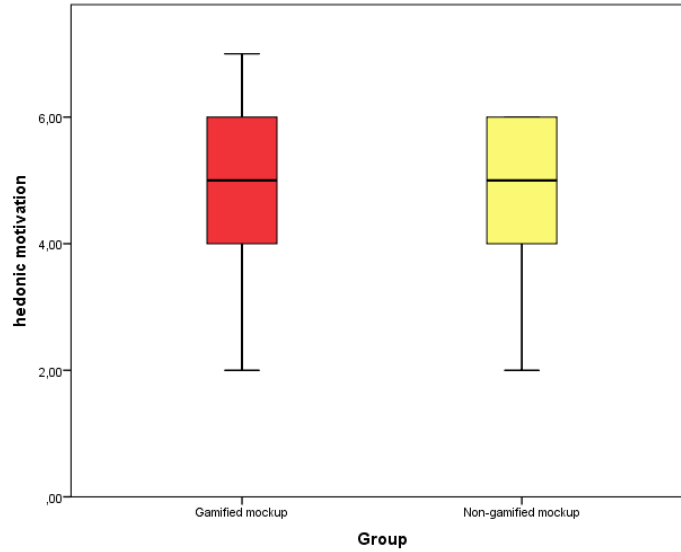


Figure 6.4. Boxplot of hedonic motivation for both groups.

- H3: Users of the gamified mockup will show significantly higher intention to use than users in the control group, when controlling for age and gender.
  - H3<sub>0</sub>:  $\mu_1 = \mu_2$  (adjusted for age and gender)
  - H3<sub>1</sub>:  $\mu_1 \neq \mu_2$

While evaluating the intention to use, we found no significant effect of group on intention to use after controlling for age,  $F(1, 51) = 1.12, p = .30$ , and we neither found an effect while controlling for gender,  $F(1, 51) = .04, p = .84$ . Figure 6.5 again shows a boxplot showing the intention to use for both groups. The boxplot shows that the non-gamified group is, except for two participants, somewhat more united in their intention to use.

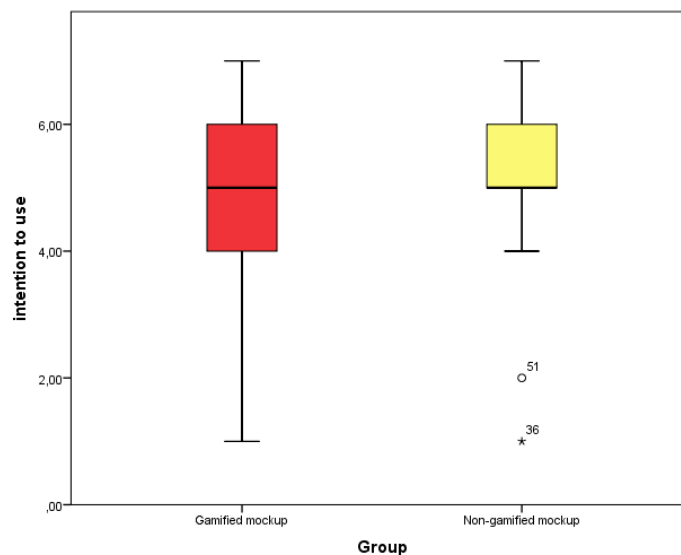


Figure 6.5. Boxplot of intention to use for both groups.

- H4: Users of the gamified mockup will show significantly higher intention to recommend than users in the control group, when controlling for age and gender.
  - H4<sub>0</sub>:  $\mu_1 = \mu_2$  (adjusted for age and gender)
  - H4<sub>1</sub>:  $\mu_1 \neq \mu_2$

Calculating the statistic for intention to recommend, we found no significant effect of group on intention to recommend, while controlling for age,  $F(1,51) = .33, p = .57$ , nor while controlling for gender,  $F(1, 51) = .25, p = .62$ . The boxplot in Figure 6.6 shows that similar to intention to use, the non-gamified group is somewhat more united in their intention to recommend.

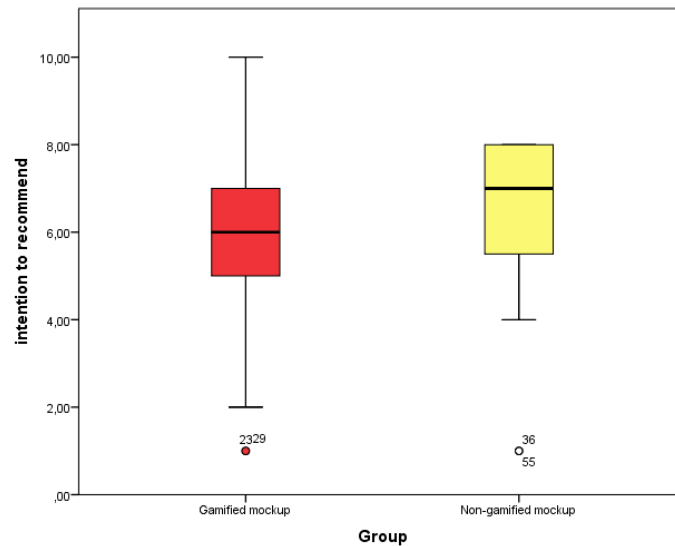


Figure 6.6. Boxplot of intention to recommend for both groups.

### Another relationship

While we did not find any significant result that supports any of our hypotheses, we also investigated an expectation that is implicitly present in our conceptual model. As described in Section 4.4, the scale we used to measure identified regulation provides us with the opportunity to calculate the relative autonomy index for each participant. We expect that the higher the relative autonomy is, the higher the intention to use is. To assess whether there is a relation between these variables we calculated Pearson's  $r$  (Field, 2009). We found that there is a strong positive correlation between the two variables,  $r(56) = .642, p < .000$ , indicating that increases of relative autonomy index are indeed correlated with increases in intention to use. The scatterplot in Figure 6.7 summarizes this result. To assess the amount of variability in relative autonomy index that is shared by intention to use, we calculated  $R^2: 0.642^2 = 0.412$ . By multiplying this by 100, we get the percentage of variance in intention to use that is accounted for by relative autonomy index: 41.2%. Note that this is no causal relationship. Figure 6.8 shows the difference in relative autonomy index between the two groups. Similar to the variables intention to use and intention to recommend, the non-gamified group seems to be somewhat more consistent in their relative autonomy. A possible explanation for the larger variance in the gamified group could be that users either hate or love the gamified dashboard, while the users in the non-gamified group are more

homogeneous in their opinion. This expectation could be verified by looking at the distributions of the different variables for each group. When the participants in the gamified group are indeed either enthusiastic or sceptic about the dashboard, the distribution would be bimodal instead of normally distributed. The histograms of the distributions of both groups are included in Appendix D. The histograms suggest that the distributions of the gamified group could be bimodal, but a bigger sample size is necessary to draw a conclusion.

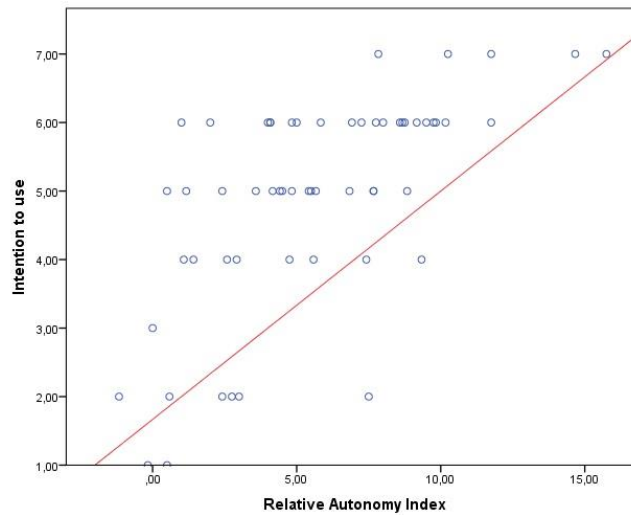


Figure 6.7. Scatterplot of Relative autonomy index and intention to use.

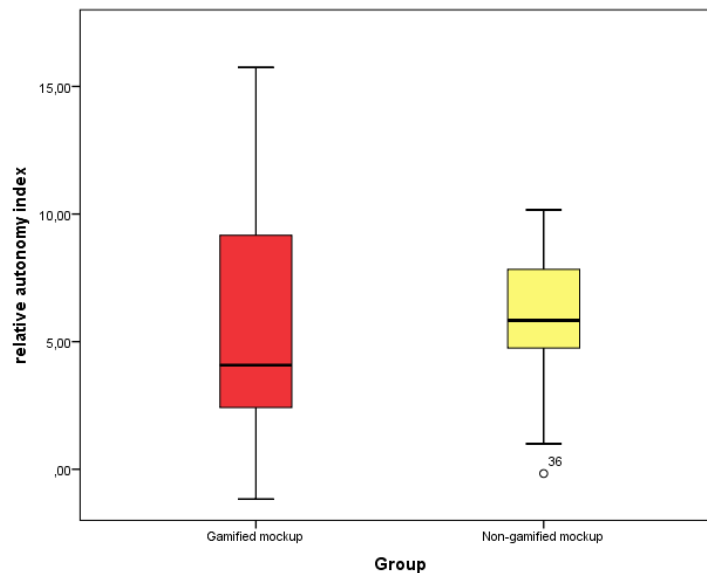


Figure 6.8. Boxplot of relative autonomy index for both groups.



## 7. Discussion

The aim of this research was to explore if, and how gamification could be applied to increase the user adoption of a software application: 'het omgevingsdashboard'. To explore this we conducted a literature review on user adoption, motivation, and gamification. Based on the findings we constructed a conceptual model, and proposed corresponding hypotheses. To test these hypotheses, we created a gamified mockup version of the ODB, as well as a non-gamified control version, which we evaluated with experts and end-users. We analyzed the results of both evaluations, and this chapter will summarize our findings and present our conclusions. We also describe implications and recommendations, and assess the limitations of our research. The next sections will answer our research question: **“How to determine the effect of gamification on user adoption of a software application?”**, by summarizing our answers and conclusions per sub question.

### 7.1 Influencing user adoption

Our first sub question was: *“What variables play a role in user adoption of a software application?”* To answer this question we did a thorough review of literature on user adoption models. We analyzed six models on user acceptance and user adoption, and found out acceptance and adoption refer to slightly different concepts. Where acceptance refers to ‘an attitude towards a technology’, adoption refers to the whole process of becoming aware of a new technology to incorporating the technology into daily life. For our analysis we evaluated variables from both adoption and acceptance models. The operationalization we used for user adoption is intention to use, and we also included the variable intention to recommend, since it is suggested to be a good predictor of system success.

Many of the variables we found in existing user adoption and user acceptance model were discarded, because they are (semi-)constant, and cannot be influenced by a system. Examples of variables we omitted are: personality traits (e.g., personal innovativeness), or external factors (e.g., cost of the system). After evaluating all variables from the different models, three variables related to user adoption remained, that we expected could be influenced by a gamified system: effort expectancy (EE), performance expectancy (PE), and hedonic motivation.

Hedonic motivation can directly be influenced by implementing game elements into the application, but effort expectancy and performance expectancy have to be influenced via intermediate variables. Therefore we continued our literature review, to discover variables that can be influenced by gamification, and in turn can influence EE and PE. Via back and forth navigation between papers, we found the variable identified regulation (which is a form of motivation). One paper provided interesting insights on how to increase identified regulation (Jang, 2008), with methods we could translate to the domain of gamification. Combining all findings into a conceptual model led to the following relations: The independent variable (IV) is the gamified application, the application influences the dependent variable (DV) hedonic motivation as well as the DV identified regulation. Hedonic motivation influences the DV's EE and PE directly, and identified regulation affects EE and PP via the DV cognitive absorption. EE and PE affect the DV intention to use, which in turn has an influence on the DV intention to recommend. We expect gender and age to have a moderating effect on the relations, and included them



as covariates in our model. In our study we only directly measured the group a participant is in, identified regulation, hedonic motivation, intention to use, intention to recommend, age, and gender.

## 7.2 Implementing gamification

The next phase of our research was focused on answering the sub question: *“How could gamification be implemented to increase user adoption?”*. We firstly continued our literature review by gaining an overview of game elements, which resulted in lists of game dynamics, mechanics, and components. Based on the findings on our first sub question, we devised a strategy to increase the hedonic motivation of users (use game elements), and a strategy to increase the identified regulation of users. The strategy to increase identified regulation focused on providing the users with a rationale, in a non-controlling way. This strategy put restrictions on which game elements we could use, and caused the omission of salient and controlling game elements (e.g., points, badges, leaderboard). Because the development of the actual ODB had to proceed unimpeded, we created a mockup version of the ODB in the wire framing tool Axure RP, in which we implemented the game elements.

## 7.3 Designing experiments

To answer the third sub question: *“What experiment could be used to measure the effect of the devised gamification implementation on user adoption?”*, we considered different evaluation methods. We concluded that to assess the effectiveness of our gamification implementation we needed a non-gamified version of the ODB to compare to our gamified version. To keep the non-gamified version as similar to the gamified mockup as possible, except for the game elements, we created another mockup in Axure instead of using the actual ODB. We implemented tutorial elements in the non-gamified mockup, which direct users towards the same pages that users of the gamified mockup are likely to visit. To evaluate the differences between the non-gamified and the gamified mockup, we determined two experiment forms were suitable.

Firstly we held interviews with experts in three fields from which our literature findings were derived: user experience, game design, and psychology and communication. The goal of these semi-structured interviews was to get an informed opinion on the difference in effectiveness between the two mockups to increase user adoption. Secondly we tested our design in a controlled experiment with participants, with the goal of testing our hypotheses. To do this we set up an online questionnaire that redirected half of the participants to the gamified mockup, and half of them to the non-gamified mockup. After using the mockup application, participants had to fill out a questionnaire about their attitudes and beliefs about the application they just used. Both experiments generated data that we analyzed in the next step of our research.



## 7.4 Analyzing the results

Our next sub question was: “*What effect has the devised gamification implementation on user adoption of a certain software application?*”. To answer this question we analyzed the data we obtained from the expert interviews and the data from the questionnaire.

### Conclusion from the expert interviews

The expert interviews (N = 3) provided us with different insights. Firstly, two of three experts were positive about the gamified dashboard and believe that it will have an advantage over the non-gamified version. They also made suggestions on how to improve the gamified mockup: by creating an experience that feels less outdated, and by surprising the user at the start to support the user to engage in a ‘game mindset’.

Secondly, the elements we implemented to increase perceived autonomy (e.g., the possibility to choose whether to start a mission or pick another one) were noted by the experts, but from the interviews we could not draw a conclusion whether this would increase the perceived autonomy of users. Thirdly, considering perceived importance, two experts stated they were overwhelmed by the amount of incidents, and this could unwantedly concern users. The social psychology and communication expert suggested that shifting the focus of the gamified dashboard towards increasing self-efficacy of users could help. She argued that many people do not like to think about risks they cannot influence. However, focusing on the self-efficacy of users and making them aware that the dashboard will inform them about the action to undertake during emergencies, is more likely to cause an effect in users.

Fourthly, when comparing the two designs, all three experts made similar comments. The game expert defined it as the difference between knowledge and ability; the non-gamified version only shows the functionality, while the gamified version provides the user with the *experience* of using the ODB. However, based on these comparable arguments, the user experience expert favors the non-gamified design, while the other experts favor the gamified design. We hypothesize this is brought about by different assumptions. We suppose the user experience expert assumed that users who start using an application have a clear goal they want to accomplish. By contrast, the other experts assume (the same as we did in this research) that first-time users of the ODB are not yet aware of why they should use the application.

Last but not least, the experts pointed out several minor usability issues, e.g., skewed buttons, or the avatar not being entirely visible. The social psychology and communication expert also advised to reconsider the information structure of the actual ODB. For example placing the action perspective of an incident more prominently on the same page as the information about the incident.





## Conclusions from the controlled experiment

Testing our hypotheses by analyzing the participant data (N = 58) from our controlled experiment produced unexpected results. When statistically testing our data in SPSS we found no significant effect of group (gamified/non-gamified) on identified regulation, hedonic motivation, intention to use, nor intention to recommend, after controlling for age and gender. When verifying the follow-up analysis of our data, we neither found significant relations between any of the tested variables. Next to the four explicit hypotheses, our conceptual model contains an implicit hypothesis; we expect that the higher the relative autonomy index of a user is, the higher the intention to use will be. Exploring this hypothesis with a correlation analysis revealed that 41.2% of the variance in intention to use is accounted for by relative autonomy index. This indicates that there is a strong relation between the two variables; however, this is no causal relationship. For our research we conclude that our way of implementing gamification in the ODB, caused no effect on hedonic motivation, identified regulation, intention to use, nor intention to recommend. Although this indicates that there is no positive effect of our gamification implementation on user adoption, there neither was a negative effect. In addition, we found that there is a correlation between relative autonomy index and intention to use, and thus we conclude that the kind of motivation users are reporting is related to intention to use. A possible explanation for the absence of a significant difference between the two groups is that the distributions of the variables in the gamified group are bimodal. Looking at the distributions does not exclude this possibility, but a larger sample, in combination with qualitative reactions of participants would be needed to draw conclusions.

## 7.5 Generalizing the results

Finally, we answer our fifth sub question: *“How and to what extent can the outcomes of such an experiment be generalized to other software applications?”*. Despite that we did not find an effect of our gamification implementation, we did learn something. As Thomas Edison said after a series of failed scientific experiments: *“We had learned for a certainty that the thing couldn’t be done that way, and that we would have to try some other way.”* (Terry, 1948). Looking at our results, we conclude that we found one way how to *not* implement gamification to increase identified regulation, hedonic motivation, intention to use, or intention to recommend, in first-time users of the ODB, and that we have to try some other way to increase user adoption with gamification.

We conclude that our implementation strategy (showing the future benefit for the user, using non-controlling language, giving choices, acknowledging negative feelings, and using non-controlling game elements) failed to cause the intended effect. However, we found one promising effect in our data, the relation between RAI and intention to use. This finding provides some support for our implicit hypothesis on motivation (the higher the relative autonomy index is, the more intention to use the application there will be). Although this finding does not imply a causal relationship, it neither falsifies the hypothesis that a high RAI leads to a high intention to use. It follows, from the finding that our strategy had no effect, and the finding that RAI is correlated with intention to use, that although *this*



strategy was not effective in increasing identified regulation, an implementation with game elements that does increase identified regulation would probably lead to a higher user adoption.

In addition to this, evaluating our design with the three experts provided interesting insights to consider while implementing gamification in software applications. Firstly, two experts agreed that for onboarding new users to the application, the gamified version is an improvement over the non-gamified version. As stated before, the third expert came to a different conclusion, while using a similar argument. This seems to point out that the way we implemented gamification does make a difference, in providing users with an experience, instead of only showing the functionality (depending on the expert if this difference is for the better or worse). Generalizing this statement, we can say that gamification could improve tutorials of software applications by providing a goal for users (completing the game's missions), instead of only having users click on functionality with no purpose other than showing.

Secondly the suggestion to surprise the user at the start of the 'game', to support the shift of the user's mindset to a 'game mindset'. This can be generalized to any software application that is to be gamified, because gamification is always used in non-game contexts. Therefore any user that starts using a gamified application could experience difficulty in shifting to a 'game mindset'. When implementing gamification, it should be taken into account that it is important to implement one or more elements that support the user's shift into a game mindset.

The third insight is induced from the suggestion to shift the focus of our design (and possibly the focus of the actual ODB) towards evoking self-efficacy in users. The focus of this research was mainly on intention to use, i.e., user adoption, from a system perspective. However, that viewpoint seemingly failed to capture the goal of the application. In more general terms we can state that it is important to thoroughly evaluate what effect should be evoked by an application, and how gamifying that design could support that effect.

## 7.6 Recommendations and future research

Based on the generalizations of our findings described in the previous section, we draw several recommendations. Figure 7.1 gives an overview of our recommendations on steps to be taken when developing gamified applications. Note that the diagram is not a comprehensive overview of the entire process of developing a gamified application. As can be seen in the diagram, we recommend to analyze the goal of the application. This process of analysis can be supported by researching the context of the application. After the goal of the application is clear, it should be decided whether that goal is suitable to be supported with gamification. This can be accomplished by researching literature related to the application goal, and evaluating whether strategies to support that goal can be translated to the gamification domain. If the answer is no, there are no further recommendations derived from this research. If the application is suitable to be gamified, the next step we recommend to take is defining a gamification implementation strategy. We recommend to support this strategy with findings from literature. Our final recommendation is to implement one or more elements to support the user in the shift to a game mindset. To devise such elements, we advise to draw on creativity.

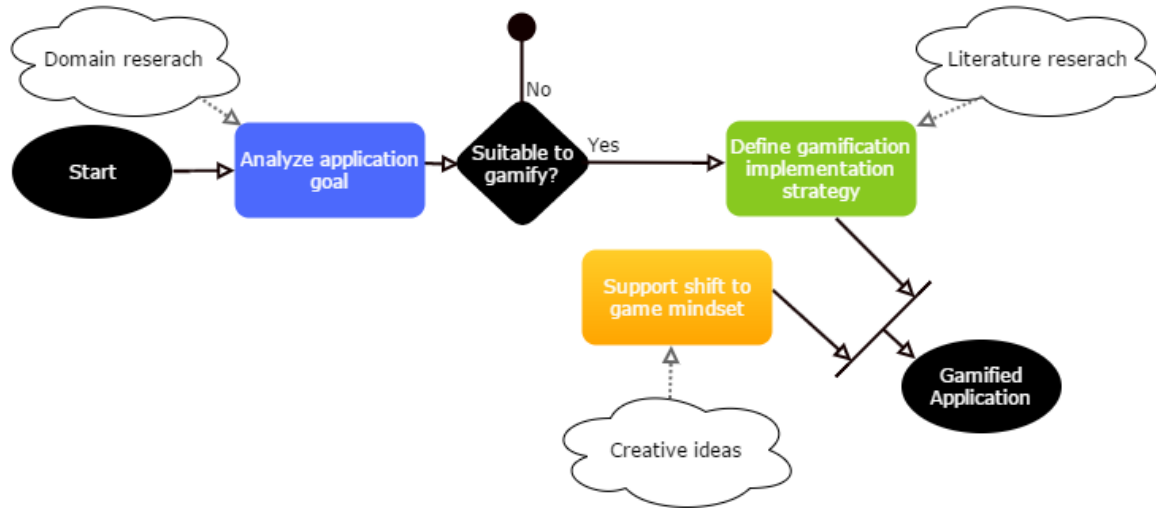


Figure 7.1. Diagram with recommendations.

Overviewing our modest results, we see opportunities for further research. Regarding our failure to find a difference between the non-gamified and gamified design, it would be interesting to compare our design to designs that implemented gamification in a different way. When developing such a new way of implementing gamification, we recommend to at least consider the steps in Figure 7.1. Based on the comments of the social psychology and communication expert, focusing the design on increasing self-efficacy of users is an interesting solution direction to investigate. Another aspect worth investigating, is the possibility that the distributions of the variables for the gamified group are bimodal. To verify this, an experiment with a larger participants sample is needed. Finally, regardless of gamification, researching the relationship between user adoption and relative autonomy index could be a next step in user acceptance and user adoption models.

## 7.7 Limitations

As with any research, there are several limitations that could have had an impact on our results. To start with, our conceptual model is based on literature from several disciplines, which could have led to minor integration errors since we are not scientifically literate in all fields. Next, we could have implemented more iterations of pilot-testing the mockup applications; during the expert interviews and controlled experiment, several minor usability issues emerged, that could have been resolved relatively easily. These minor errors have possibly distracted the participants from the essence of the experiment. Thirdly, the size of our participant sample could be improved, since the sizes of the groups in the current sample are too small to reliably establish whether the variables are normally distributed. In the fourth place, the scale we used for identified regulation could be improved (e.g., by pretesting), since our data revealed that the scale was internally more consistent after removing one of the questions. Last but not least, although we had reasons to continue our analysis despite the partly violated assumptions, this could have impacted our results.



## 7.8 Conclusion

This research evaluated many user adoption and user acceptance models to identify variables that could be affected by gamification to increase user adoption. Based on our literature findings, we devised a strategy to implement gamification in a software application, to increase the hedonic motivation and identified regulation of users. Our strategy explicitly omitted points, badges, leaderboard, and other salient and controlling game elements. To assess the (expected) effectiveness of our gamification implementation we evaluated the design with expert interviews and a controlled experiment. The controlled experiment led to no significant results. However, the expert interviews led to different insights that should be considered when developing a gamified software application. Our recommendations for aspects to consider when implementing gamification are to:

- Evaluate thoroughly what the goal of the application is, and if, and how gamification could support this goal;
- Develop a strategy to implement gamification in a way that supports this goal;
- Incorporate elements that support the user in shifting to a game mindset.



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## 9. Appendix

### 9.1 Appendix A: The interview protocol

#### Praktische informatie

*Fijn dat u mee wilt werken aan dit interview. Om uw antwoorden beter te kunnen uitwerken wil ik het interview graag opnemen. Wilt u eerst de 'informed consent' tekenen. Deze houdt in dat:*

- *U vrijwillig deelneemt en op ieder moment kunt stoppen zonder consequenties;*
- *Uw antwoorden vertrouwelijk worden behandeld;*
- *Het onderwerp van onderzoek zijn de prototypes, niet uw gedrag of mening;*
- *Het interview wordt opgenomen.*

*Als u niet wilt dat ik het interview opneem kunt u die zin doorstrepen. Ik verwacht dat het interview maximaal een half uur duurt.*

#### Introductie

Ik heb u gevraagd mee te werken aan dit interview omdat u bent aangemerkt als expert op het gebied van – usability / gedrag en communicatie / game design -. Zoals u ook kon lezen in de informed consent, wil ik uw kennis van uw vakgebied aanspreken om te beoordelen welke van de twee prototypes die ik heb gemaakt beter geschikt is om de gebruikersadoptie te verhogen. (Uitleg wat gebruikeradoptie is).

Ik zal u eerst uitleggen wat het Omgevingsdashboard is. Het ODB is een applicatie die ontwikkeld is door Centric (mijn stage bedrijf) in opdracht van drie gemeenten. Het ODB is bedoeld om burgers te informeren over veiligheidsrisico's in hun woon- of werkomgeving. Dit gaat om zowel de zogenaamde 'koude fase' als de 'warme fase'. De koude fase is de periode waarin er geen crisis situatie is. Dan dient het dashboard om risico's aan te merken, (denk aan: opslag LPG, opslag andere chemische stoffen). De warme fase ontstaat wanneer er daadwerkelijk een incident gebeurd is. Het doel van het omgevingsdashboard is dat om daar op één plaats eenduidige informatie te communiceren richting de burger.

#### Achtergrond van interviewee

- Wat is je opleiding / werkervaring etc?
- Hoe lang bent u al UX specialist / gedrag en communicatie specialist / game designer?
- Kun je beschrijven op welke manier (game design, usability, gedrag en communicatie) terug komt in je dagelijks werk.

#### Vergelijken van de prototypes

Laten we kijken naar de verschillen tussen de beide prototypes. De vergelijking die ik wil onderzoeken gaat over het verschil tussen de twee prototypes, niet over het systeem op zichzelf.

*[Kies vanaf hier de vragen bij de bijbehorende expert.]*

#### Game design expert

- Wat vindt u van dit gamified ontwerp?



- Welke game elementen ziet u dat er in verwerkt zijn?
- Wat vindt u van het niet-gamified ontwerp?
- Is op basis van onderzoek / uw kennis te verwachten dat de gebruikers van de gamified versie deze leuker vinden dan de andere versie?
- Hoe zou dit gamified ontwerp verbeterd kunnen worden?

#### Psychologie / communicatie expert

- Wat vindt u van het gamified ontwerp?
- Ziet u toepassingen van theorieën die kunnen leiden tot verhoogde motivatie om de applicatie te gebruiken?
- Wat vindt u van het niet-gamified ontwerp?

Ik heb in mijn ontwerp bewust geen 'opvallende' game elementen gebruikt, zoals punten, badges, en leaderboards. Literatuur lijkt er namelijk op te wijzen dat is sommige gevallen deze vorm van expliciete motivators de lange termijn motivatie kan ondermijnen. Om dit te mijden heb ik gekeken naar andere mogelijkheden om gebruikers te motiveren. Literatuur wees mij hierbij in de richting van identified regulation. Dit is een meer 'duurzame' vorm van motivatie, waarbij de gebruiker zich autonoom voelt in zijn keuze, evenals het belang inziet van het gedrag dat wordt 'gepromoot' door de gemeente (namelijk zich voorbereiden op mogelijke noodsituaties door het ODB te bekijken).

- o Ziet u manieren in dit gamified ontwerp terugkomen waarop het belang van voorbereiding wordt gecommuniceerd?
- o Ziet u in dit ontwerp manieren terugkomen waarin de autonomie van de gebruiker wordt gecommuniceerd/ondersteund?
- Is op basis van onderzoek/uw kennis te verwachten dat de motivatie (in de vorm van identified regulation) van mensen hoger is voor de gamified versie?
- Is het op basis van onderzoek/uw kennis te verwachten dat gebruikers van de gamified versie meer het belang voelen om zich voor te bereiden?
- Is het op basis van onderzoek/uw kennis te verwachten dat gebruikers zich meer autonoom voelen in de gamified versie?
- Hoe zou de communicatie in het gamified ontwerp verbeterd kunnen worden om de motivatie van mensen meer te verhogen?

#### Usability expert

- Wat vindt u van de usability van de *game elementen* van het gamified-ontwerp?
- Wat vindt u van de usability van het niet gamified-ontwerp?
- Is het op basis van onderzoek / uw kennis te verwachten dat de usability van het gamified ontwerp hoger is dan de usability van het niet-gamified ontwerp?
- Zijn er instrumenten voor om de usability van beide ontwerpen 'objectief' te vergelijken?
- Hoe zou de usability van het gamified ontwerp verbeterd kunnen worden?

#### *Afsluitend*

Heeft u verder nog vragen of opmerkingen?



## English translation of the interview protocol

### Operational information

Thank you for participating in this interview. To be able to analyze your answers I would like to record the interview. Could you first sign the informed consent? In short the informed consent entails:

- Your participation is voluntarily and you can stop participating at any moment without consequences;
- Your answers are confidential;
- The research focuses at the prototypes, not on your opinions or behavior;
- The interview will be recorded if you agree.

I expect the interview to last a maximum of one hour.

### Introduction

You are selected to participate in this interview because you are considered an expert in your domain (usability / behavior and communication / game design/gamification). The goal of this interview is to compare the difference in effectiveness to increase user adoption between the two prototypes we created. (Optional explanation on user adoption).

I will first explain what the ODB is. It is an application that is developed by Centric for three municipalities. The purpose of the application is to inform and communicate to inhabitants about safety risks in their environment. It is intended to inform both in the 'cold phase' and the 'hot phase'. The cold phase is the time when there is no crisis situation. During that time the ODB informs inhabitants about possible risks (for example storage of LPG or other chemicals). When an incident happens, the so-called hot phase, the ODB's purpose is to inform the public on one centralized website, with one centralized message about what is going on.

### Background of interviewee

- What is your education / work experience etc.?
- How long have you been working as (UX specialist, behavior and communication specialist / game researcher)?
- Can you describe in what way your expertise is a part of your daily job?

### Comparing the prototypes

We will now compare the differences between the prototypes. The focus of this comparison is on the difference between the gamified and non-gamified version, not on the ODB itself.

*[Choose the questions for the appropriate expert.]*

### Game design expert

- What do you think of the gamified design?
- Which game elements can you identify?
- What do you think about the non-gamified design?
- Do you expect, based on your experience and knowledge of your field, that users will have more fun using the gamified version?
- How could the designs be improved upon?



### Behavior /communication expert

- What do you think of the gamified design?
- Do you see application of theories in the design that could increase the motivation of users?
- What do you think of the non-gamified design?

In my design I explicitly omitted 'salient and controlling' elements, like points, badges, leaderboards. This is done because there exists literature that suggests that explicit motivators in the long term undermine intrinsic motivation. To work around this, I found literature about increasing identified regulation. This form of motivation should be more sustainable, and arises when the user feels autonomy in his choices, as well as the importance of the activity (preparing for emergencies).

- Do you see any methods used in the gamified design that communicate the importance of preparing?
- Do you see any methods used in the gamified design that promote/ support the autonomy of the user?
- Do you expect, based on your knowledge and experience, that the identified regulation of users would be higher for the gamified design?
- Do you expect, based on your knowledge and experience, that the users of the gamified design feel more perceived importance?
- Do you expect, based on your knowledge and experience, that the perceived autonomy of users of the gamified design is higher?
- How could the gamified design be improved to increase the motivation of the users (even more)?

### Usability expert

- What do you think of the gamified design?
- What do you think of the non-gamified design?
- What do you think of the difference in usability of both designs?
- Which design do you expect, based on your knowledge and experience, to have higher usability?
- What instruments/tools do you use to assess the usability of designs you create?
- How could the usability of the designs be improved upon?

### *Closing comments*

Do you have any other comments or questions?



## 9.2 Appendix B: The informed consents of the interviewed experts



Universiteit Utrecht

### Informed consent voor een expert interview Thesis project Kelly van den Dool

Dit interview wordt gehouden in het kader van een onderzoek naar gamification en het Omgevingsdashboard. Het Omgevingsdashboard is een webapplicatie, ontwikkeld door Centric voor de gemeenten Moerdijk, Halderberge, en Roosendaal. Voor dit onderzoek hebben we twee prototypes ontwikkeld van het Omgevingsdabsboard. Aan één versie zijn game-elementen toegevoegd om de gebruiker het systeem leren kennen, aan de andere versie 'gewone' instructies om het systeem te leren kennen. Het doel van dit interview is het vergelijken van deze twee prototypes op basis van kennis van experts op verschillende gebieden. De onderliggende vraag die we proberen te beantwoorden met deze interviews is: welk prototype is meer geschikt om de gebruikers adoptie van de applicatie te verhogen? Om hier achter te komen evalueren we de verschillen tussen de prototypes met experts op het gebied van: usability, gedrag en communicatie, en game-design.

- ~~Het interview wordt opgenomen (alleen-audio)~~
- De resultaten van dit interview worden alleen gebruikt om de geschiktheid van de prototypes te vergelijken, niet om uw gedrag of mening te onderzoeken.
- Uw antwoorden zullen vertrouwelijk worden behandeld en alleen beschikbaar zijn voor de onderzoekers.
- Deelname aan het onderzoek is volledig vrijwillig, en u kunt op ieder moment besluiten te stoppen zonder negatieve consequenties.

Indien u na het interview nog vragen heeft kunt u contact opnemen via [p.vandendool1@students.uu.nl](mailto:p.vandendool1@students.uu.nl)

- voor publicatie uitwerkingen eerst mailen van  
afkruis

Door dit formulier te ondertekenen verklaart u bovenstaande informatie gelezen te hebben, en deel te willen nemen aan dit interview.

Naam: Tom Hoffing

Datum: 21-06-2016

Handtekening





### Informed consent voor een expert interview Thesis project Kelly van den Dool

Dit interview wordt gehouden in het kader van een onderzoek naar gamification en het Omgevingsdashboard. Het Omgevingsdashboard is een webapplicatie, ontwikkeld door Centric voor de gemeenten Moerdijk, Halderberge, en Roosendaal. Voor dit onderzoek hebben we twee prototypes ontwikkeld van het Omgevingsdabsboard. Aan één versie zijn game-elementen toegevoegd om de gebruiker het systeem leren kennen, aan de andere versie 'gewone' instructies om het systeem te leren kennen. Het doel van dit interview is het vergelijken van deze twee prototypes op basis van kennis van experts op verschillende gebieden. De onderliggende vraag die we proberen te beantwoorden met deze interviews is: welk prototype is meer geschikt om de gebruikers adoptie van de applicatie te verhogen? Om hier achter te komen evalueren we de verschillen tussen de prototypes met experts op het gebied van: usability, gedrag en communicatie, en game-design.

- Het interview wordt opgenomen (alleen audio).
- De resultaten van dit interview worden alleen gebruikt om de geschiktheid van de prototypes te vergelijken, niet om uw gedrag of mening te onderzoeken.
- Uw antwoorden zullen vertrouwelijk worden behandeld en alleen beschikbaar zijn voor de onderzoekers.
- Deelname aan het onderzoek is volledig vrijwillig, en u kunt op ieder moment besluiten te stoppen zonder negatieve consequenties.

Indien u na het interview nog vragen heeft kunt u contact opnemen via [p.vandendool1@students.uu.nl](mailto:p.vandendool1@students.uu.nl)

Door dit formulier te ondertekenen verklaart u bovenstaande informatie gelezen te hebben, en deel te willen nemen aan dit interview.

Naam: Marvin van de Sloef

Datum: 05/07/2016

Handtekening

Marvin van de Sloef



### Informed consent voor een expert interview Thesis project Kelly van den Dool

Dit interview wordt gehouden in het kader van een onderzoek naar gamification en het Omgevingsdashboard. Het Omgevingsdashboard is een webapplicatie, ontwikkeld door Centric voor de gemeenten Moerdijk, Halderberge, en Roosendaal. Voor dit onderzoek hebben we twee prototypes ontwikkeld van het Omgevingsdabsboard. Aan één versie zijn game-elementen toegevoegd om de gebruiker het systeem leren kennen, aan de andere versie 'gewone' instructies om het systeem te leren kennen. Het doel van dit interview is het vergelijken van deze twee prototypes op basis van kennis van experts op verschillende gebieden. De onderliggende vraag die we proberen te beantwoorden met deze interviews is: welk prototype is meer geschikt om de gebruikers adoptie van de applicatie te verhogen? Om hier achter te komen evalueren we de verschillen tussen de prototypes met experts op het gebied van: usability, gedrag en communicatie, en game-design.

- Het interview wordt opgenomen (alleen audio).
- De resultaten van dit interview worden alleen gebruikt om de geschiktheid van de prototypes te vergelijken, niet om uw gedrag of mening te onderzoeken.
- De opname <sup>de opname</sup> ~~de opname~~ <sup>van de opname</sup> ~~van de opname~~ <sup>zou</sup> ~~zou~~ vertrouwelijk worden behandeld en alleen beschikbaar zijn voor de onderzoekers.
- Deelname aan het onderzoek is volledig vrijwillig, en u kunt op ieder moment besluiten te stoppen zonder negatieve consequenties.

Indien u na het interview nog vragen heeft kunt u contact opnemen via [p.vandendool1@students.uu.nl](mailto:p.vandendool1@students.uu.nl)

Door dit formulier te ondertekenen verklaart u bovenstaande informatie gelezen te hebben, en deel te willen nemen aan dit interview.

Naam: Christine Swankhuizen

Datum: 6-7-2016

Handtekening

### 9.3 Appendix C: Overview of the questionnaire

This questionnaire is Dutch, for the English version see below.

#### Page 1

Information about the research, and informed consent.

#### Page 2

Shows a link that redirects 50% of the participants to the gamified mockup, and 50% to the non-gamified mockup.

#### Page 3

**Q1:** Geef aan in hoeverre je het met de volgende stellingen eens bent:

Wanneer ik heb omgevingsdashboard ga gebruiken, doe ik dat om de volgende redenen:

	Geheel mee eens	Mee on-eens	Enigszins mee on-eens	Neutraal	Enigszins mee eens	Mee eens	Geheel mee eens
1. Omdat anderen me dom zouden vinden als ik me niet voorbereid.							
2. Omdat ik geniet van het gebruik van het omgevingsdashboard.							
3. Omdat anderen boos op me zouden zijn als ik het niet zou doen.							
4. Omdat ik het gevoel zou hebben dat ik tekort schiet als ik het niet doe.							
5. Omdat ik het gevoel heb dat het de beste manier is om me voor te bereiden op noodsituaties.							
6. Omdat ik me slecht zou voelen over mezelf als ik het niet zou doen.							
7. Omdat ik het gevoel heb dat ik geen keus heb; anderen willen dat ik het gebruik.							
8. Omdat het een uitdaging is om zo goed mogelijk voorbereid te zijn op noodsituaties.							



Q2:	Geheel me eens	Mee on-eens	Enigs-zins mee on-eens	Neu-traal	Enigs-zins mee eens	Mee eens	Geheel me eens
Ik vond het leuk om de onderzoeksversie van het omgevingsdashboard te gebruiken.							

**Page 4**

An indication that this question is the second part of the first question on page 3.

**Q3:** Geef aan in hoeverre je het met de volgende stellingen eens bent:

Wanneer ik heb omgevingsdashboard ga gebruiken, doe ik dat om de volgende reden:

	Geheel me eens	Mee on-eens	Enigs-zins mee on-eens	Neu-traal	Enigs-zins mee eens	Mee eens	Geheel me eens
9. Omdat ik het gevoel heb dat ik belangrijke dingen leer door het gebruik van het omgevingsdashboard.							
10. Omdat ik het leuk vind.							
11. Omdat ik bang ben dat ik problemen krijg met anderen als ik het niet doe.							
12. Omdat ik het gevoel heb dat het voor mij persoonlijk belangrijk is me voor te bereiden.							
13. Omdat ik me schuldig voel als ik me niet voorbereid op noodsituaties.							
14. Omdat ik wil dat anderen zien dat ik het advies van de gemeente opvolg (om me voor te bereiden).							
15. Omdat ik het interessant vind om te weten hoe ik me kan voorbereiden op noodsituaties.							
16. Omdat voorbereid zijn op noodsituaties een belangrijke waarde voor mij is.							



**Q4:**

	Geheel mee eens	Mee on- eens	Enigs- zins mee on- eens	Neu- traal	Enigs- zins mee eens	Mee eens	Geheel mee eens
<b>Wanneer het echte omgevingsdashboard beschikbaar is, ben ik van plan het te gebruiken.</b>							

**Page 5**

**Q5:**

**Hoe waarschijnlijk is het dat je het omgevingsdashboard zou aanbevelen aan een vriend of collega?**

1	2	3	4	5	6	7	8	9	10

**Q6: Wat is je geslacht?**

- Vrouw
- Man

**Q7: Wat is je leeftijd?**

[ ]

**The questions in English**

The original questions were:

**Q1:**

When I will use the ODB, I will do this for the following reason:

1. Because others would think I'm a weak person if I did not.
2. Because I enjoy exercising.
3. Because others would be angry at me if I did not.
4. Because I would feel like a failure if I did not.
5. Because I feel like it's the best way to help myself.
6. Because I would feel bad about myself if I did not.
7. Because people would think I'm a weak person if I did not.
8. Because I feel like I have no choice about exercising; others make me do it.
9. Because it is a challenge to accomplish my goal.

**Q2:** I enjoyed using the experimental version of the ODB.

**Q3:**

When I will use the ODB, I will do this for the following reason:

10. Because I believe exercise helps me feel better.



11. Because it's fun.
12. Because I worry that I would get in trouble with others if I did not.
13. Because it feels important to me personally to accomplish this goal.
14. Because I feel guilty if I do not exercise regularly.
15. Because I want others to acknowledge that I am doing what I have been told I should do.
16. Because it is interesting to see my own improvement.
17. Because feeling healthier is an important value for me.

Q4: When the actual ODB is available I intend to use it.

Q5: How likely is it that you will recommend the ODB to a friend or colleague?

Q6: What is your gender?

Q7: What is your age?



### 9.4 Appendix D: SPSS output

This appendix presents the output of SPSS on which we based Section 6.2.

#### Cronbach's alpha for the motivation scale

##### External regulation

**Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.791	.802	4

**Item-Total Statistics**

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Omdat anderen boos op me zouden zijn als ik het niet zou doen.	6,4828	12,359	,508	,301	.788
Omdat ik het gevoel heb dat ik geen keus heb; anderen willen dat ik het gebruik.	6,0000	8,982	,679	,609	.698
Omdat ik bang ben dat ik problemen krijg met anderen als ik het niet doe.	6,1897	9,595	,750	,636	.669
Omdat ik wil dat anderen zien dat ik het advies van de gemeente opvolg (om me voor te bereiden).	5,5862	9,194	,534	,358	.791



**Introjected regulation**

**Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.733	.734	4

**Item-Total Statistics**

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Omdat anderen me dom zouden vinden als ik me niet voorbereid.	9,0000	17,123	,422	,193	.729
Omdat ik me slecht zou voelen over mezelf als ik het niet zou doen.	8,1379	12,437	,598	,385	.627
Omdat ik me niet goed voel als ik me niet voorbereid op noodsituaties.	6,9828	13,561	,466	,231	.712
Omdat ik me schuldig voel als ik me niet voorbereid op noodsituaties.	8,1552	12,274	,642	,422	.599





**Identified regulation**

**Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.798	.804	4

**Item-Total Statistics**

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Omdat ik het gevoel heb dat het de beste manier is om me voor te bereiden op noodsituaties.	11,9828	18,684	,670	,520	.722
Omdat ik het gevoel zou hebben dat ik tekort schiet als ik het niet doe.	14,0345	20,876	,365	,139	.867
Omdat ik het gevoel heb dat het voor mij persoonlijk belangrijk is me voor te bereiden.	12,5690	16,495	,718	,582	.690
Omdat voorbereid zijn op noodsituaties een belangrijke waarde voor mij is.	12,3103	17,341	,735	,643	.686

**Intrinsic motivation**

**Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.803	.809	4



**Item-Total Statistics**

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Omdat ik geniet van het gebruik van het omgevingsdashboard.	13,0517	19,664	,595	,424	,773
Omdat het een uitdaging is om zo goed mogelijk voorbereid te zijn op noodsituaties.	11,0690	15,750	,609	,451	,762
Omdat ik het leuk vind.	12,0000	16,140	,625	,476	,751
Omdat ik het interessant vind om te weten hoe ik me kan voorbereiden op noodsituaties.	10,4310	16,355	,674	,501	,726

**Correlations between outcome variables**

**Gamified group**

**Correlations<sup>a</sup>**

		hedonmotivation	intent_t_u	intent_t_r	Identified_regulation
hedonmotivation	Pearson Correlation	1	,765**	,762**	,776**
	Sig. (2-tailed)		,000	,000	,000
	N	29	29	27	29
intent_t_u	Pearson Correlation	,765**	1	,924**	,764**
	Sig. (2-tailed)	,000		,000	,000
	N	29	29	27	29
intent_t_r	Pearson Correlation	,762**	,924**	1	,828**
	Sig. (2-tailed)	,000	,000		,000
	N	27	27	27	27
Identified_regulation	Pearson Correlation	,776**	,764**	,828**	1
	Sig. (2-tailed)	,000	,000	,000	
	N	29	29	27	29

\*\* . Correlation is significant at the 0.01 level (2-tailed).

a. Klik hier om naar het Omgevingsdashboard te gaan! = Gamified mockup



**Non-gamified group**

**Correlations<sup>a</sup>**

		hedonmotivation	intent_t_u	intent_t_r	Identified_regulation
hedonmotivation	Pearson Correlation	1	,615**	,649**	,372*
	Sig. (2-tailed)		,000	,000	,047
	N	29	29	28	29
intent_t_u	Pearson Correlation	,615**	1	,515**	,457*
	Sig. (2-tailed)	,000		,005	,013
	N	29	29	28	29
intent_t_r	Pearson Correlation	,649**	,515**	1	,697**
	Sig. (2-tailed)	,000	,005		,000
	N	28	28	28	28
Identified_regulation	Pearson Correlation	,372*	,457*	,697**	1
	Sig. (2-tailed)	,047	,013	,000	
	N	29	29	28	29

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

a. Klik hier om naar het Omgevingsdashboard te gaan! = Non-gamified mockup



## Normality of the variables

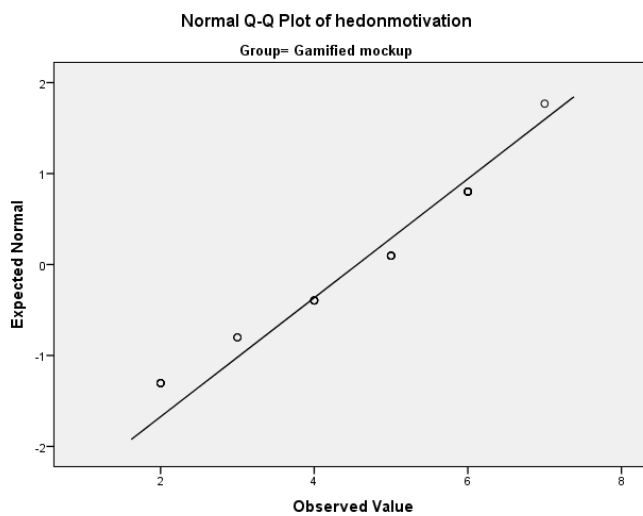
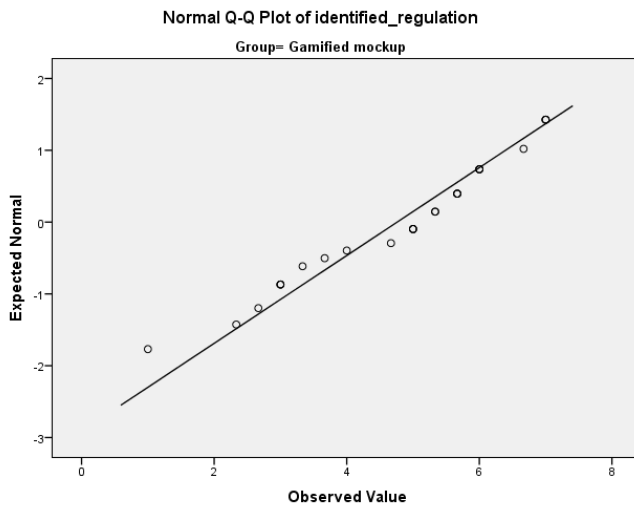
### Gamified group

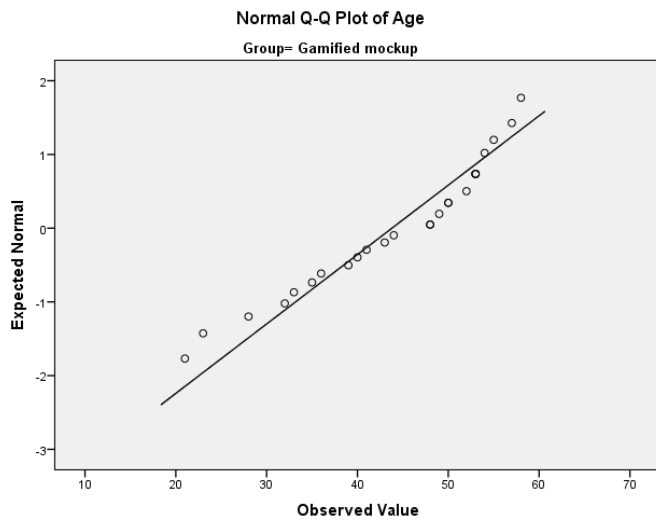
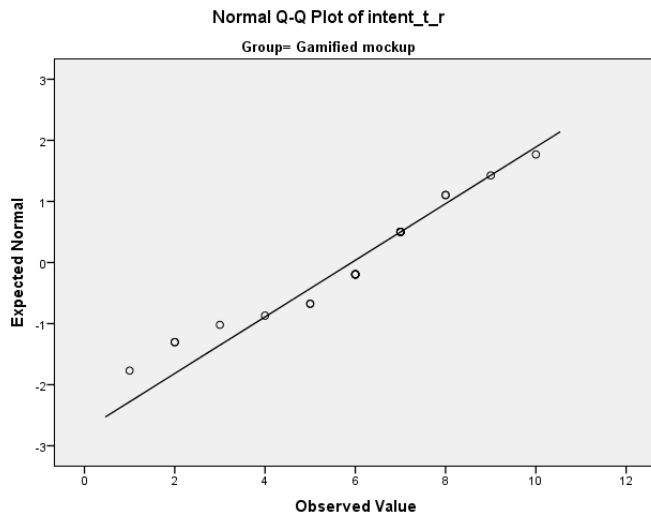
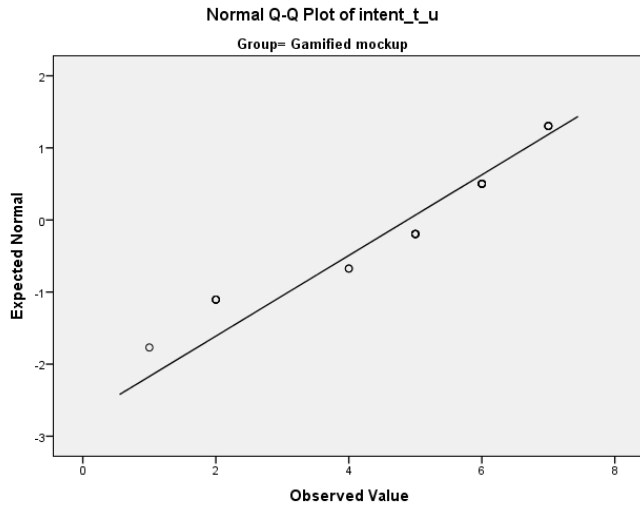
Tests of Normality<sup>a</sup>

	Kolmogorov-Smirnov <sup>b</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
identified_regulation	,158	25	,106	,943	25	,170
intent_t_r	,235	25	,001	,922	25	,058
intent_t_u	,247	25	,000	,864	25	,003
hedonmotivation	,187	25	,025	,891	25	,012
Age	,174	25	,050	,930	25	,088

a. Klik hier om naar het Omgevingsdashboard te gaan! = Gamified mockup

b. Lilliefors Significance Correction







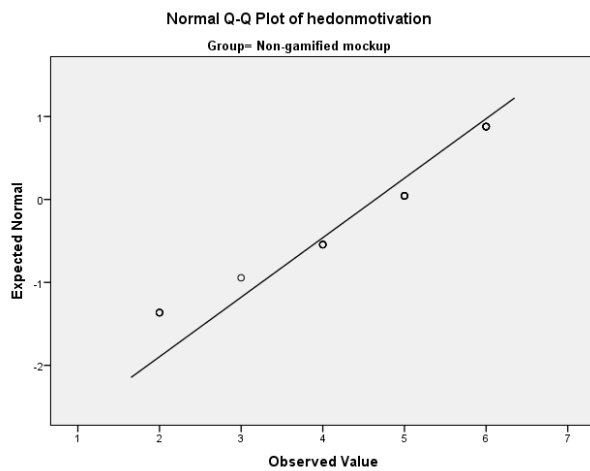
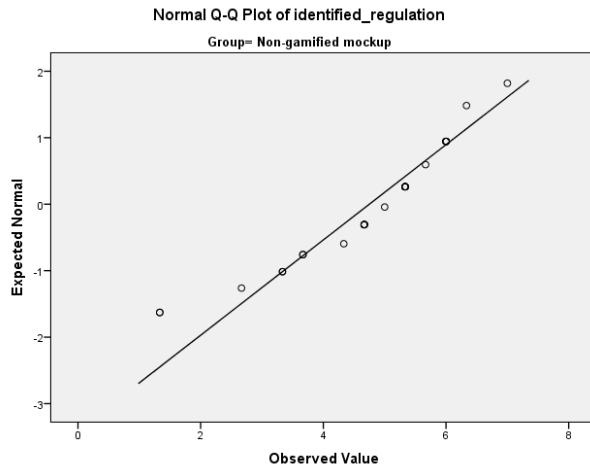
Non-gamified group

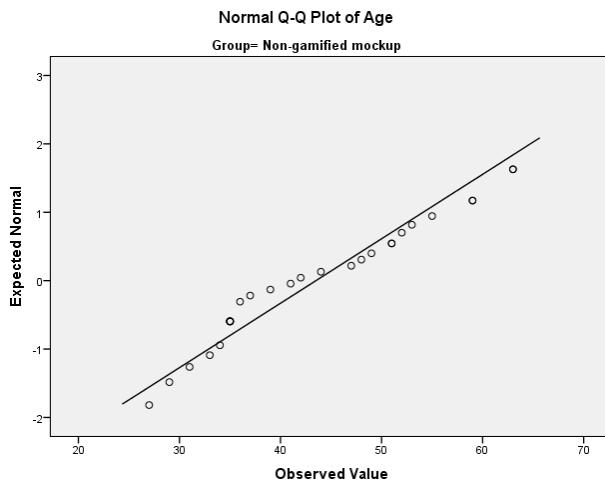
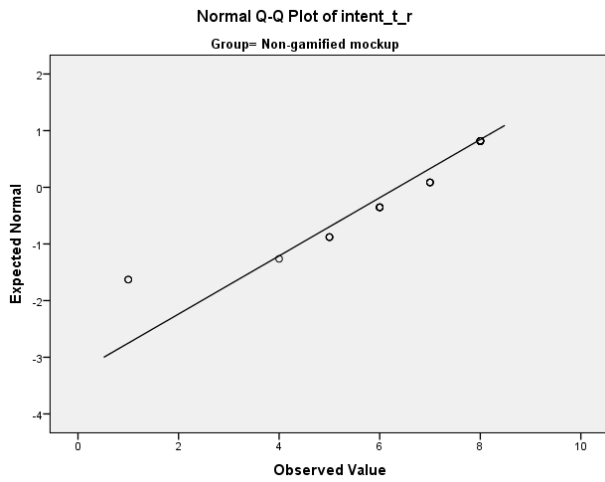
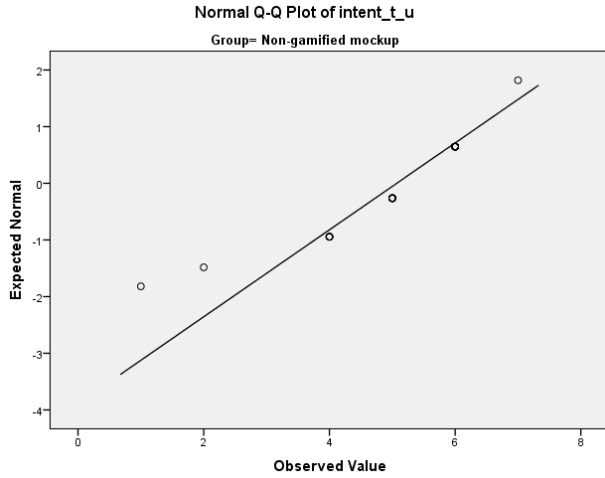
Tests of Normality<sup>a</sup>

	Kolmogorov-Smirnov <sup>b</sup>			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
identified_regulation	,190	28	,011	,909	28	,018
intent_t_r	,199	28	,006	,791	28	,000
intent_t_u	,228	28	,001	,813	28	,000
hedonmotivation	,208	28	,003	,831	28	,000
Age	,159	28	,069	,937	28	,091

a. Klik hier om naar het Omgevingsdashboard te gaan! = Non-gamified mockup

b. Lilliefors Significance Correction







**Homogeneity of variance/covariance**

**Between-Subjects Factors**

	Value Label	N
Klik hier om naar het Omgevingsdashboard te gaan!	Gamified mockup	25
	Non-gamified mockup	28

**Box's Test of Equality of Covariance Matrices<sup>a</sup>**

Box's M	28,080
F	2,568
df1	10
df2	12055,719
Sig.	,004

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + group + age + gender + group \* age + group \* gender

**Levene's Test of Equality of Error Variances<sup>a</sup>**

	F	df1	df2	Sig.
hedonmotivation	,021	1	51	,886
intent_t_u	2,651	1	51	,110
intent_t_r	,128	1	51	,722
Identified_regulation	,441	1	51	,510

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + group + age + gender + group \* age + group \* gender





Homogeneity of regression slopes

Multivariate Tests<sup>a</sup>

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	,336	5,578 <sup>b</sup>	4,000	44,000	,001
	Wilks' Lambda	,664	5,578 <sup>b</sup>	4,000	44,000	,001
	Hotelling's Trace	,507	5,578 <sup>b</sup>	4,000	44,000	,001
	Roy's Largest Root	,507	5,578 <sup>b</sup>	4,000	44,000	,001
group	Pillai's Trace	,073	,872 <sup>b</sup>	4,000	44,000	,488
	Wilks' Lambda	,927	,872 <sup>b</sup>	4,000	44,000	,488
	Hotelling's Trace	,079	,872 <sup>b</sup>	4,000	44,000	,488
	Roy's Largest Root	,079	,872 <sup>b</sup>	4,000	44,000	,488
age	Pillai's Trace	,116	1,445 <sup>b</sup>	4,000	44,000	,235
	Wilks' Lambda	,884	1,445 <sup>b</sup>	4,000	44,000	,235
	Hotelling's Trace	,131	1,445 <sup>b</sup>	4,000	44,000	,235
	Roy's Largest Root	,131	1,445 <sup>b</sup>	4,000	44,000	,235
gender	Pillai's Trace	,036	,410 <sup>b</sup>	4,000	44,000	,801
	Wilks' Lambda	,964	,410 <sup>b</sup>	4,000	44,000	,801
	Hotelling's Trace	,037	,410 <sup>b</sup>	4,000	44,000	,801
	Roy's Largest Root	,037	,410 <sup>b</sup>	4,000	44,000	,801
group * age	Pillai's Trace	,023	,263 <sup>b</sup>	4,000	44,000	,900
	Wilks' Lambda	,977	,263 <sup>b</sup>	4,000	44,000	,900
	Hotelling's Trace	,024	,263 <sup>b</sup>	4,000	44,000	,900
	Roy's Largest Root	,024	,263 <sup>b</sup>	4,000	44,000	,900
group * gender	Pillai's Trace	,064	,751 <sup>b</sup>	4,000	44,000	,563
	Wilks' Lambda	,936	,751 <sup>b</sup>	4,000	44,000	,563
	Hotelling's Trace	,068	,751 <sup>b</sup>	4,000	44,000	,563
	Roy's Largest Root	,068	,751 <sup>b</sup>	4,000	44,000	,563

a. Design: Intercept + group + age + gender + group \* age + group \* gender

b. Exact statistic



Multivariate analysis of covariance

Between-Subjects Factors

	Value Label	N
Group	1,00 Gamified mockup	25
	2,00 Non-gamified mockup	28

Multivariate Tests<sup>a</sup>

Effect	Value	F	Hypothesis df	Error df	Sig.	
Intercept	Pillai's Trace	,349	6,166 <sup>b</sup>	4,000	46,000	,000
	Wilks' Lambda	,651	6,166 <sup>b</sup>	4,000	46,000	,000
	Hotelling's Trace	,536	6,166 <sup>b</sup>	4,000	46,000	,000
	Roy's Largest Root	,536	6,166 <sup>b</sup>	4,000	46,000	,000
age	Pillai's Trace	,125	1,646 <sup>b</sup>	4,000	46,000	,179
	Wilks' Lambda	,875	1,646 <sup>b</sup>	4,000	46,000	,179
	Hotelling's Trace	,143	1,646 <sup>b</sup>	4,000	46,000	,179
	Roy's Largest Root	,143	1,646 <sup>b</sup>	4,000	46,000	,179
gender	Pillai's Trace	,038	,458 <sup>b</sup>	4,000	46,000	,766
	Wilks' Lambda	,962	,458 <sup>b</sup>	4,000	46,000	,766
	Hotelling's Trace	,040	,458 <sup>b</sup>	4,000	46,000	,766
	Roy's Largest Root	,040	,458 <sup>b</sup>	4,000	46,000	,766
group	Pillai's Trace	,030	,354 <sup>b</sup>	4,000	46,000	,840
	Wilks' Lambda	,970	,354 <sup>b</sup>	4,000	46,000	,840
	Hotelling's Trace	,031	,354 <sup>b</sup>	4,000	46,000	,840
	Roy's Largest Root	,031	,354 <sup>b</sup>	4,000	46,000	,840

a. Design: Intercept + age + gender + group

b. Exact statistic



Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	identified_regulation	9,698 <sup>a</sup>	3	3,233	1,480	,231
	hedonmotivation	3,262 <sup>b</sup>	3	1,087	,505	,680
	intent_t_u	3,240 <sup>c</sup>	3	1,080	,442	,724
	intent_t_r	4,505 <sup>d</sup>	3	1,502	,347	,792
Intercept	identified_regulation	23,203	1	23,203	10,625	,002
	hedonmotivation	51,748	1	51,748	24,054	,000
	intent_t_u	40,910	1	40,910	16,741	,000
	intent_t_r	82,708	1	82,708	19,090	,000
age	identified_regulation	9,535	1	9,535	4,366	,042
	hedonmotivation	1,219	1	1,219	,567	,455
	intent_t_u	2,737	1	2,737	1,120	,295
	intent_t_r	1,436	1	1,436	,331	,567
gender	identified_regulation	,226	1	,226	,103	,749
	hedonmotivation	2,722	1	2,722	1,265	,266
	intent_t_u	,107	1	,107	,044	,835
	intent_t_r	1,089	1	1,089	,251	,618
group	identified_regulation	4,516E-6	1	4,516E-6	,000	,999
	hedonmotivation	,084	1	,084	,039	,844
	intent_t_u	,511	1	,511	,209	,649
	intent_t_r	2,526	1	2,526	,583	,449
Error	identified_regulation	107,002	49	2,184		
	hedonmotivation	105,417	49	2,151		
	intent_t_u	119,741	49	2,444		
	intent_t_r	212,288	49	4,332		
Total	identified_regulation	1314,889	53			
	hedonmotivation	1232,000	53			
	intent_t_u	1438,000	53			
	intent_t_r	2222,000	53			



Corrected Total	identified_regulation	116,700	52			
	hedonmotivation	108,679	52			
	intent_t_u	122,981	52			
	intent_t_r	216,792	52			

- a. R Squared = ,083 (Adjusted R Squared = ,027)
- b. R Squared = ,030 (Adjusted R Squared = -,029)
- c. R Squared = ,026 (Adjusted R Squared = -,033)
- d. R Squared = ,021 (Adjusted R Squared = -,039)

		Group			
Dependent Variable	Group	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
identified_regulation	Gamified mockup	4,754 <sup>a</sup>	,296	4,160	5,348
	Non-gamified mockup	4,755 <sup>a</sup>	,279	4,194	5,316
hedonmotivation	Gamified mockup	4,562 <sup>a</sup>	,293	3,972	5,151
	Non-gamified mockup	4,641 <sup>a</sup>	,277	4,084	5,199
intent_t_u	Gamified mockup	4,877 <sup>a</sup>	,313	4,249	5,506
	Non-gamified mockup	5,074 <sup>a</sup>	,295	4,480	5,668
intent_t_r	Gamified mockup	5,920 <sup>a</sup>	,416	5,083	6,757
	Non-gamified mockup	6,357 <sup>a</sup>	,393	5,567	7,148

- a. Covariates appearing in the model are evaluated at the following values: Age = 43,64, Gender = 1,4717.



**Correlation between relative autonomy index and intention to use**

**Descriptive Statistics**

	Mean	Std. Deviation	N
intent_t_u	4,9138	1,55918	58
relative_autonomy_index	5,7040	3,75612	58

**Correlations**

		intent_t_u	relative_autonomy_index
intent_t_u	Pearson Correlation	1	,642**
	Sig. (2-tailed)		,000
	N	58	58
relative_autonomy_index	Pearson Correlation	,642**	1
	Sig. (2-tailed)	,000	
	N	58	58

\*\* . Correlation is significant at the 0.01 level (2-tailed).

**Histograms of different variables for both groups**

