MASTER THESIS

# Testing the Effectiveness of Game-Based Learning for Adults by Designing an Educational Game

A design and research study to investigate the effectiveness of educational games for adults to learn basic skills of Microsoft Excel

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**Abstract**

Game-based learning (GBL) has become more popular in education. Research shows that it yields higher learning gains and provokes more motivation than traditional education. However, most of this research is focused on students or children. With adult education becoming more common, proper research into and development of GBL for adults is desired. In this study an educational game about Microsoft Excel was developed using the ADDIE-model, supported by an extensive literature study. This game was compared to the control condition using traditional education. Participants (n=62) were adults and they had to complete a pretest about Microsoft Excel skills and a prequestionnaire about motivation to learn, followed by one of the two types of education and finally complete a posttest about Microsoft Excel skills and a postquestionnaire about motivation to learn. The findings in this research indicate that playing an educational game leads to learning and yields higher learning gains than traditional education. Against expectations, playing an educational game does not lead to an increase in motivation to learn. However, the perspective of (young) adults on learning with an educational game regarding their motivation to learn is positive. Limitations of the study are discussed as well as practical and scientific implications. Recommendations for further research include advice regarding the design of the game and the target group. The final conclusion is that GBL is effective to use with adults.

# Introduction

## Problem statement

Game-based learning (GBL) is an emerging hot topic in education. In the last decade, there has been a rising interest in both the opportunities GBL offers as a learning and teaching tool as well as in research into its use (Backlund & Hendrix, 2013; Whitton, 2007a).

Although extensive research shows that GBL yields higher learning gains than traditional education, most studies had students or children as participants (e.g., Backlund & Hendrix, 2013; Sabourin & Lester, 2014; Wouters et al., 2013). Adult education is becoming more common in our life-long learning society (Field, 2005), consequently educational methods for adults need to be developed. The (online) educational environment is increasingly being used by adults (Cercone, 2008), but not much research has been done for them. Therefore, the scientific relevance of this study is to solve this lack of research into GBL for adults by developing and testing an educative game for adults to learn Microsoft Excel skills.

GBL has potential to help learners improve their learning performance and increase their learning motivation (Huang et al., 2010; Wang & Chen, 2010). It enables experiential, immersive and engaging problem-based learning experiences that can appropriately cover the learning goals (Whitton, 2007b). Big rationales for educational games are thus that using games can transform the way in which students learn and they have the potential to motivate and engage students in a way that traditional education cannot.

However, the fact that games are intrinsically motivating (Becker, 2001; Grice & Strianese, 2000) is debatable for adults. Because learners' preferences might differ it is possible that games might not be motivational for all age categories. This is often not considered in the mentioned studies, little research has been done with adults themselves. Most studies are carried out with children, who are more likely to be motivated to play with games, and those results are often generalised to adults (Whitton, 2007a).

To solve the lack of research into adult GBL, an educational Microsoft Excel game is designed in this study. The game has as subject Microsoft Excel because this is a programme that offers a lot of opportunities for employed adults, making it relevant to learn about. The ADDIE-model (Morrison et al., 2019) is used to design the game. First, an analysis is done in the form of a literature study. Second, the game is designed based on the design guidelines from the literature study. Third, the game is developed and tested and reviewed by adults.

Fourth, the game is implemented during the data collection of this study. And finally, the game is evaluated by analysing the results and comparing these to the results of the traditional education condition.

This study's research into GBL could be beneficial for teachers, designers, and publishers of educational material. Thus, the practical relevance of this study is that the outcomes can support them with making decisions on whether to use adult GBL or not. Because the development of educational games is time-consuming (Nadolski et al., 2008) and expensive (Prensky, 2001), it is important to know if these games are effective in order to decide whether they are worth investing time and money in. Therefore, the goal of the current study is to examine whether GBL offers an added value for adults regarding learning gains and motivation gains. This results in the following research question: Does game-based education for adults yield higher learning and motivation gains than traditional education for adults?

## Theoretical framework

### Analysis

The first step of the ADDIE-model is to perform an analysis. For this study the analysis is done on GBL and its characteristics, the target group by focusing on andragogy and on the type of instructional support.

#### Game-based learning

GBL is an instructional method based on educational games. In scientific literature different terms are used to address GBL, such as serious games, instructional games, educational games and digital GBL (De Freitas, 2006). What they all have in common is that their primary goal is education, rather than entertainment (Michael & Chen, 2006). The terms used in this study are GBL and educational games. These can be defined as "applications using the characteristics of video and computer games to create engaging and immersive learning experiences for delivering specified learning goals, outcomes and experiences" (De Freitas, 2006, p.10). GBL can be specified in several characteristics which are discussed next.

##### *Characteristics*

A systematic examination of game characteristics should help in refining theoretical formulations of effective education (Lepper, 1985) and will be performed to establish game guidelines. It is hard to find a consensus on the essential characteristics. However, Garris et al. (2002) have concluded that different researchers are using different approaches to describe similar game dimensions. They concluded that game characteristics can be defined using six

broad categories: fantasy, rules/goals, sensory stimuli, challenge, mystery, and control. These characteristics will be used. They will be defined here and their practical application will be explained.

1) Fantasy. Fantasy includes imaginary or fantasy context, themes, or characters. Some research indicates that instructional content that is immersed in fantasy contexts increases student learning and interest (Cordova & Lepper, 1996; Parker & Lepper, 1992).

A distinction can be made between exogenous and endogenous fantasy contexts. In contrast to exogenous fantasies, endogenous fantasies are related to the learning content. For example, learning about physics by piloting a spaceship on reentry to earth's orbit. Because endogenous fantasies are more closely tied to the learning content, the learning content becomes interesting if the fantasy is interesting. Endogenous fantasies are therefore more effective motivational tools than exogeneous fantasies (Rieber, 1996).

Implicating fantasy in games can be done by allowing users to experience interactions in situations without having to face consequences in the real world (Thomas & Macredie, 1994) and by creating a fantasy context that is related to the learning content.

2) Rules/goals. Clear and specific rules, goals, and feedback on progress toward goals enhance user's performance (Locke & Latham, 1990). Goals allow the user to make note of goal-feedback discrepancies which is crucial in triggering greater attention and motivation. The feedback leads to an increase in effort and performance because learners will try to reduce the discrepancy if feedback indicates that goals are not being met (Kernan & Lord, 1990).

However, the rules and goals must still allow flexibility in gameplay, and game activity should be able to evolve based on player styles, strategies, previous experiences and other factors (Crookall & Arai, 1995).

Implicating rules and goals in games can be done by creating a game context that is meaningful and that provides clear goal structures but still allows for a wide range of permissible actions within the game.

3) Sensory stimuli. Sensory stimuli consist of dramatic or novel visual and auditory stimuli. The imaginary world of a game allows the user to experience a distortion of perception. Stimuli such as sights and sounds can stimulate and arouse the senses causing a type of euphoria (Caillois, 1961). For example, sound effects and dynamic graphics that are strange or unfamiliar can be attention grabbing and intrigue the desire for sensations that are different from normal experiences (Malone & Lepper, 1987). By including animated graphics

the motivational appeal of instructional activities increases and students choose to return to practice activities that include dynamic graphics (Rieber, 1991).

Implicating sensory stimuli in games can thus be done by including sound effects and animated graphics.

4) Challenge. Challenge means that the game has to have the optimal level of challenge and uncertain goal attainment. The activities should neither be too easy nor too difficult. Besides, the game should make use of progressive difficulty levels, multiple goals, and an amount of informational vagueness to provide an uncertain outcome. Finally, the game must contain meaningful goals and performance feedback and score to allow the user to track progress (Malone & Lepper, 1987).

Implicating challenge can be done by making goals meaningful to the user by linking activities to valued personal competencies and ensuring an optimal level of challenge using progressive difficulty levels, multiple goals, informational vagueness and progressive feedback.

5) Mystery. Mystery means the game should include an optimal level of informational complexity. Curiosity is seen as one of the key components that encourages learning (Malone & Lepper, 1987). It is provoked by an information gap; a product of perceived discrepancies or inconsistencies in our knowledge (Loewenstein, 1994). However, this information gap should not be too simple nor should it be too complex. Mystery is an external feature of the game itself, it stimulates curiosity.

Implicating mystery can be done by involving a search for information and embedding activities in fantasy contexts allowing the user to encounter imaginary situations that differ from their knowledge of how things work in the real world, stimulating curiosity (Garris et al., 2002).

6) Control. Control refers to the ability to regulate or lead something.
Active learner control, when the learner has control over parts of the instruction, has a positive effect on user reactions and motivation (Garris et al., 2002). Games can stimulate a sense of personal control when the user can pick strategies, control the direction of activity, and make decisions that directly influence outcomes, even if actions are not instructionally relevant (Cordova & Lepper, 1996).

Implicating control can be done by allowing the user to choose the amount and the context of practice problems and by giving them control over instructionally irrelevant parts of a learning activity.

These characteristics cause, among others, advantages of GBL of which some will be discussed next.

### *Advantages*

GBL offers several advantages opposed to traditional education. It is assumed that repetition leads to proficiency. However, most learners do not enjoy working on the same topic dozens of times. GBL can make the learning process more enjoyable. Through the challenge of the game, learners can receive benefits of repetition without the sense of work that they might feel otherwise (Philpot et al., 2003).

Furthermore, a game allows the learner to become proficient in their skills at their own pace in an environment that is non-judgmental but competitive and amusing (Philpot et al., 2003). It should allow learners to explore the game at their own pace (Petri & von Wangenheim, 2016).

Another reason for using GBL is that games are engaging and immersive in a way that traditional education is not (Garris et al., 2002). Because of the aforementioned game characteristics in games, learners are actively engaged in the learning process.

Another big advantage of GBL is that it can provide immediate feedback. When feedback is provided just-in-time learners are enabled to test hypotheses and learn from their actions (Yue & Jing, 2015). It therefore improves learning and reduces uncertainty (Oblinger, 2004). Besides, providing immediate feedback can help to reduce extraneous cognitive load for novices (Johnson et al., 2017), which is helpful because the target audience of this study is fairly new to Microsoft Excel.

**Motivation.** A third rationale for using GBL is that games seem to be effective in enhancing motivation and increasing student interest in subject matter (Druckman, 1995). The motivational goal of GBL is to develop learners who are self-directed and self-motivated, both because the activity is interesting in itself and because achieving the outcome is important (Garris et al., 2002). Learners are often motivated to learn material when it is required for successful game play. Games can provoke players to search for data and information in order to be successful instead of beginning with facts and figures and then figuring out how they can be applicable (Oblinger, 2004). When compared to more traditional education, GBL evokes higher motivation by offering learning materials in an interactive, rule-based and competitive way (Boeker et al., 2013). The characteristics that make games engaging and motivating will be discussed in more detail later.

**Initial motivation.** However, the motivational benefit of educational games needs to be looked at with a critical eye. Although educational games are proven to have a motivating

effect on children, this cannot just be generalised to adults. Adults' initial perceptions on games are more negative than those of younger people. Where children perceive learning a new game as a challenge or just a natural thing to do, adults sometimes shy away from learning games. This is probably due to the fact that playing games demands practice and effort. Besides, adults are often embarrassed to be bad at something (Prensky, 2001). Some adults also have a negative perception of games because they are known to be more trivial and sillier than traditional media such as books or movies. Games are harder to study than traditional media because they are more difficult to comprehend and take more time to experience (Wolf, 2001).

Whitton (2011) argues that educational games may be motivational for some learners but they may demotivate others. Undergraduate computing students were asked for their perceptions on learning with a game. Surprisingly, even in a group of mostly male, mostly computing students, who you might expect to be more motivated than other groups to learn with computer games, only fewer than two-thirds of the students actually think that using a game to learn would be positively motivating (Whitton, 2011).

Adults might be more motivated to learn through playing educational games if they have had a positive experience with one. They are willing to try game-based learning if it was perceived to be an efficient way to learn (Whitton, 2011). Thus, the motivational benefit of educational games for adults is very dependent on the design of the game. Therefore, in the design of the game of this study extra attention will be paid to the characteristics of adults and the way they learn.

***Disadvantages.***

However, there are some disadvantages of using GBL that need to be taken into account as well. First, regarding the development of the games. For example, there is an interdisciplinary-expert dependency while developing educational games. Domain experts and game experts need to collaborate (Boeker et al., 2013). Besides, the development of educational games is time-consuming (Nadolski et al., 2008) and expensive (Prensky, 2001). In addition, there is a lack of widely accepted guidelines on how to teach effectively with games (Boeker et al., 2013).

Second, regarding the teaching and learning processes. Learners' preferred learning styles differ from each other. Some learners prefer taking a passive role and may not view gaming as worthwhile (Richardson, 2005), while other learners may find the competitive nature of games threatening or intimidating (Royse & Newton, 2007).

A third disadvantage that is very relevant to the design of the game in this study is that players of an educational game often lack the capabilities to focus on the relevant information due to the complex nature of educational games (Wouters & van Oostendorp, 2013). To overcome this limitation instructional support can be implemented in the game. Instructional support includes several techniques such as reflection, feedback, modelling or personalisation. Its goal is to help learners engage in relevant cognitive activities (Wouters & van Oostendorp, 2013).

***Guidelines.***

For the educational game to be successful and to benefit from the aforementioned advantages its design must be effective. Therefore, guidelines need to be followed in the design of this study's game. The aforementioned characteristics of GBL will be implemented. Additionally, elements that make games engaging will be used as well as criteria to enable learning. Finally, some design criteria to make the game challenging and interesting as well as educational will be incorporated if possible.

**Engagement.** Prensky (2001) described six key elements that make games engaging: rules, goals and objectives, outcomes and feedback, challenge, interaction, and representation. Some of these overlap with the aforementioned characteristics of games, but their goals differ.

1) Rules. As mentioned before, rules enhance performance, but they also make the game engaging. They establish limits, forcing all players to take specific paths to reach goals. By informing players what is accepted and what is not, they are enclosed in the game world (Prensky, 2001).

2) Goals and objectives. A key element of what motivates people in a game is achieving their goals and objectives. People are goal-oriented from nature, being able to envision a future state and to come up with strategies to achieve it. They often enjoy the process. Goals encourage people to win and to achieve objectives (Prensky, 2001).

3) Outcomes and feedback. It is important for the players to measure their progress towards reaching the goals, this can be done through feedback. Winning and losing have a big influence on our emotions and ego-gratification, which plays a factor in how engaging games are. Feedback informs the player whether what they have done moves them closer to the goal or further away. In games, it almost always involves immediate feedback. It can be given in many different forms, for example: as a numerical score, graphically or orally from characters in the game. The goal of feedback is to improve the experience and to help you progress in the game (Prensky, 2001).

4) Challenge. The game has to have problems that the player needs to try to solve. Challenge in a game gives players adrenaline and makes them excited about playing. The challenge needs to be balanced, not too simple or too complex, to keep each player engaged (Prensky, 2001).

5) Interaction. A game can include two types of interaction; between the player and the computer, or between different players. The interaction between the player and the computer occurs through the aforementioned feedback. The other type of interaction is the social aspect of most games, as you can often play with or against other people (Prensky, 2001). Although it is mostly more fun to play with others, it can be more practical to play a solo game as you are not dependent on others.

6) Representation. A game should be about something, which is meant by the representation. It includes any narrative or story elements in the game. It also includes the aforementioned element of fantasy. Representation can be abstract or concrete, direct or indirect (Prensky, 2001).

**Learning principles.** Gee (2007) listed some learning principles that good games incorporate. A few of these will be used as guidelines as well.

1) Risk taking. The game should allow for risk taking, which can be achieved by having low to no consequences of failure. For example by being able to try as many times as needed, the players should be stimulated to try new things and explore (Gee, 2007).

2) Well-ordered problems. The challenges and problems in the game should be ordered from easier to harder. This way learners can use the learned information from earlier problems when solving the later, more difficult, ones (Gee, 2007).

3) Challenge and consolidation. The game should offer the player several challenging problems and then let them solve these problems until their solutions are virtually automatic. When they have accomplished that, they should be given a set of new problems, enabling them to learn something new. Thus, the game should consist of repetition and constant new challenge (Gee, 2007).

4) Agency. Players of the game need to feel a sense of ownership over what they are doing. For example, by playing the game at their own speed (Gee, 2007).

5) Just-in-time and on demand. An advantage of games is that they are able to give information just-in-time, thus, when the player needs or wants it. Making the game more efficient than textbooks (Gee, 2007).

**Design criteria.** A well-designed game is challenging and interesting for the learner while, at the same time, it requires the application of particular knowledge or skills. To meet

this requirement five design criteria are important, these are summarized in Table 1 (Gredler, 2004).

**Table 1**

*Gredler's Design Criteria of Well-Designed Games*

| Criterion | Rationale |
|---|---|
| 1. Winning should be based on knowledge or skills, not random factors. | When chance factors contribute to winning, the knowledge and, effort of other players are devalued. |
| 2. The game should address important content, not trivia. | The game sends messages about what is important in the class. |
| 3. The dynamics of the game should be easy to understand and interesting for the players but not obstruct or distort learning. | The goal is to provide a practical, yet challenging exercise; added "bells and whistles" should be minimal and fulfill an important purpose. |
| 4. Students should not lose points for wrong answers. | Punishing players for errors also punishes their effort and generates frustration. |
| 5. Games should not be zero-sum exercises. | In zero-sum games, players periodically receive rewards for game-sanctioned actions, but only one player achieves an ultimate win. The educational problem is that several students may demonstrate substantial learning but are not recognized as winners. |

**Instructional support.** Finally, the instructional support needs to be implemented in the game to yield higher learning gains. In GBL instructional support that supports learners in selecting relevant information seems to be most effective. Feedback is one of the techniques to achieve this, it is information on whether and/or why an answer is correct. It appears to be one of the most effective techniques and is therefore used in the game of this study (Wouters & van Oostendorp, 2013). There are a few guidelines on how to implement instructional support most effectively.

1) Basic/schematic designs rather than cartoonlike and (photo)realistic designs (Wouters & van Oostendorp, 2013).

2) Use instructional support for skills and knowledge rather than in-game performance (Wouters & van Oostendorp, 2013).

3) Use process-based feedback rather than outcome-based feedback. Giving an explanation that guides learners to the correct answer enhances essential processing as it reduces extraneous processing (Johnson et al., 2017).

4) Take into account the design of the game and the amount of cognitive load while playing it and adjust the way the feedback is presented to this (Johnson et al., 2017).

5) Offer the feedback immediate (just-in-time) (Johnson et al., 2017).

6) Adjust feedback to the prior knowledge level. Learners with a lower prior knowledge may need more detailed feedback (Johnson et al., 2017).

These are the guidelines that will be used to make the educational game effective. The next part will discuss the needs of the target audience that must also be taken into account.

## Adult learning

Because the target group of this study consists of adults it is important to pay attention to the way adults learn and how to apply this in the design guidelines as it is different from the way children learn. However, there is not one adult learning theory. Many different theories exist that explain how adults learn and aim to help create effective learning experiences for adults (Taylor & Hamdy, 2013). The base of this study is andragogy, which will be discussed first. Another theory that will be used is the experiential learning theory (Kolb, 2014).

### *Andragogy*

Andragogy can be defined as the science of the lifelong and lifewide learning of adults (Reischmann, 2003). The subject of this discipline is the study of education and learning of adults in all its forms of expression (Savicevic, 1999). This means it also applies to distance- and E-learning, which occur in this study.

**Characteristics.** Knowles (1984) made six assumptions about the characteristics of adult learners, which are different from child learners. First, a more recently added one, the need to know: adults need to know why they need to learn something before learning it (Knowles et al., 1998). Second, self-concept: the self-concept of an adult changes towards one of being a self-directed human being. Third, adult learner experience: an adult gains experience over time providing an increasing resource for learning. Fourth, the readiness to learn: the readiness of adults to learn becomes oriented towards their present life. Adults are most interested in learning subjects that they can apply immediately, relevant to their life. Fifth, orientation to learning: adult learning is problem-centred rather than content-oriented, adults see education as a process of developing increased competency levels to achieve their full potential. And sixth, motivation to learn: the motivation of adults to learn is internal rather than external (Knowles, 1984).

**Guidelines andragogy.** The aforementioned characteristics can be used as a foundation to establish design guidelines for adult education. Combining these with the findings of a literature review results in the following guidelines which will be used in the design of the game for this study.

1) Give adults a hand in the design and development of their learning experience. Receiving feedback from adults during the design process of the game can help in designing materials and activities based upon the needs and wants of the adult learners. This can support in making the game relevant for the learners, strengthening their motivation and readiness to learn (Knowles, 1984; Pappas, 2014).

2) Involve learners in diagnosing their learning needs. This helps trigger their internal motivation to learn. (Kaufman, 2003; Knowles, 1984). This can be done by showing them their pretest results and letting them interpret these. When they are given an overview of the knowledge and skills they are lacking they might be more motivated to learn and focus on these subjects during the learning activity.

3) Offer a valid reason behind every course, module or educational activity. This can increase the motivation to learn. This makes adults often feel more involved in the process of learning. When they do not know the reason for the need of learning certain subjects or skills they might question the validity of the course. To execute this the game should explain why the learners need education on the subject and why they need to participate in the learning activities (Knowles, 1984; Pappas, 2014).

4) Create learning experiences that offer minimum instruction and maximum autonomy. Offering maximum autonomy encourages the learners' self-concept. Because adults believe they are responsible for their own learning, they need to be treated as self-directed. This can be done by allowing them to play the game without giving any information beforehand. The learners will have to explore the activity on their own, maximizing autonomy (Knowles, 1984; Pappas, 2014).

5) Emphasize how the subject matter is going to solve problems that an adult learner regularly encounters. This applies to the orientation to learning of adults being problem-centred rather than content-oriented and it has a positive effect on their readiness to learn. Most adults want to know whether they can apply the learned information in the immediate future. They prefer to engage in learning activities that help them with solving problems and doing tasks they face regularly (Knowles, 1984; Pappas, 2014). This can be achieved by offering real world examples and scenarios.

6) Make instruction task-oriented instead of promoting memorization. Most adults learn best in a task-oriented context, they learn by doing (Knowles, 1984). This can be achieved by letting the learners do exercises in the game rather than just explaining what to do. This will show them immediately how they can apply the learned information in the real world. And it enables them to learn through repetition and experience.

7) Take into account the wide range of different backgrounds of learners. All learners have different previous experiences and therefore the learning material should be adjusted to allow for different levels of experience. For example, their experience with computers should be taken into account.

8) Utilize assessment to measure the learners' progress and ensure that they fully

comprehend the concepts. Most adults learn best when there is feedback to assess progress towards their goals (Ozuah, 2016). Because adults often prefer to learn self-directed they need to be able to see their own results and progress, and they need to find out what areas they need to focus on (Knowles, 1984).

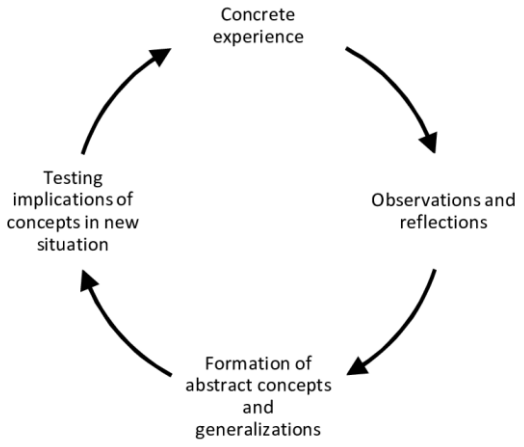
9) Allow active learning: let learners control their own learning, as well as submit and answer their own questions.

***Experiential learning theory***

A theory that shares several characteristics with andragogy is the experiential learning theory (ELT). This theory is based on the idea that people learn through the transformation of experience (Kolb, 1984). According to this, the emphasis should be on learning instead of teaching. Instead of conveying information to the learner, gaining experience should be reinforced. In doing this the characteristics of adult learning should be taken into account (Dernova, 2015). The most widely recognised and used concept in the ELT is Kolb's experiential learning cycle. This model consists of four stages (Figure 1). During the first stage, concrete experience (CE), the learner will complete a concrete experience by doing an activity. The second stage, reflective observation (RO), focuses on reflecting and observing this experience. The third stage, abstract conceptualisation (AC), consists of forming abstract concepts by thinking about the experience. And in the fourth stage, active experimentation (AE), the learner is confident with the learned concept and they will be able to use the learning experience in future tasks (Kolb, 1984).

**Figure 1**

*Kolb's Experiential Learning Cycle.*




**Guidelines ELT.** To apply the ELT to the game in this study the four stages need to be completed by the learners and the game needs to facilitate this. Feedback from the experience is key in the improvement of the performance and the ability of the learner to

apply the learned concept in new situations. Therefore, a reflective step will be added in the game consisting of direct feedback on answers and a reflective question about why they made certain decisions. The practical implications of the ELT in the game will be discussed next.

In the first stage, CE, the learner will play the game. In the second stage, RO, the learner will reflect on their actions in the game by reviewing their actions and by answering a reflective question. What went right and what can be improved? In the third stage, AC, an explanation will be given on the concepts. The learner can decide what to do differently next time. And finally the fourth stage, AE, the learner will continue in the game and practice the learned concepts in new situations.

## Design

The second step of the ADDIE-model is to design the game. Design guidelines have been written based on the performed analysis and the development of the game is planned.

### Design guidelines GBL - Andragogy

Table 2 shows how the aforementioned guidelines regarding adult learning and GBL is aimed to be applied in the design of this study's educational Microsoft Excel game. Because the preferred learning styles still might differ, the final design is not only based on the theoretical guidelines but also on the results of testing and reviewing.

**Table 2**

*Overview of Design Guidelines and their Application*

| Guideline | Practical application |
|---|---|
| Include rules.<br><br>Include goals and objectives. | • The game context is meaningful and provides clear goal structures but still allows for a wide range of permissible actions within the game.<br>• The game includes goals and objectives the player has to achieve. |
| Include challenge.<br><br>The dynamics of the game should be easy to understand and interesting for the players | • The player has to solve problems in the game which are based on their pre-knowledge.<br>• The game uses progressive difficulty levels, multiple goals, informational vagueness and progressive feedback. |

| | |
|---|---|
| but not obstruct or distort learning. | • The game consists of repetition and constant new challenge by offering new problems after completion of one set. |
| Include fantasy.<br>Include representation. | • The game includes narrative elements.<br>• The game context is an endogenous fantasy.<br>• The game allows players to experience interactions in situations without facing consequences in the real world. |
| Include sensory stimuli. | • The game includes animated graphics and sound effects. |
| Include mystery. | • The players encounter an information gap, they do not have enough knowledge to easily perform the activities. |
| Include active learner control.<br>Include agency. | • Players are allowed to choose the amount of the activities they perform in the game. |
| Allow for risk taking.<br>Students should not lose points for wrong answers. | • Players will never face high consequences of failure during the activities.<br>• Players are allowed to try as many times as needed to solve a problem.<br>• Players do not lose points for wrong answers. |
| Address important content, not trivia. | • The game content is based on a traditional form of an Microsoft Excel training and only addresses relevant and useful content. |
| The game should not consist of zero-sum exercises. | • Players are not dependent on or interacting with other players in the game. There is no ultimate win or comparisons with other players' achievements. |
| Winning should be based on knowledge or skills, not random factors. | • Players receive points for doing exercises correctly. These exercises are related to the learning content. |

| | |
|---|---|
| Give adults a hand in the design and development of their learning experience. | • Get feedback from adult learners to design materials based upon the needs and wants of adult learners. |
| Involve learners in diagnosing their learning needs. | • Offer results of the pretest to the learner before starting the instruction. |
| Offer a valid reason behind every course, module or educational activity. | • Offer reasons why certain learning activities need to be completed before the start of an activity. |
| Create learning experiences that offer minimum instruction and maximum autonomy.<br>Allow active learning. | • Let the learner explore a problem on their own.<br>• Let learners control their own learning, as well as submitting and answering their own questions. |
| Emphasize how the subject matter is going to solve problems that an adult learner regularly encounters. | • Offer real world examples and scenarios. |
| Make instruction task-oriented instead of promoting memorization. | • The game consists of exercises instead of just explanations with examples. The game is interactive. |
| Take into account the wide range of different backgrounds of learners.<br>Use well-ordered problems. | • Allow learning activities for different levels of precious experience with Microsoft Excel, building up the level of difficulty, making the problems well-ordered. |
| Let the player complete the four stages of ELT. | • CE: the player plays the game.<br>• RO: the player reflects on their actions in the game by reviewing their actions and by answering a reflective question. |

| | |
|---|---|
| | • AC: an explanation is given on the concepts.<br>• AE: the player continues playing the game and practices the learned concepts in new situations. |
| Utilize assessment.<br>Include interaction.<br>Include just-in-time and on demand information. | • Offer information at the exact time it is needed and players are able to access information if they want to. |
| Offer outcomes and feedback. | • Offer outcomes and feedback during the game.<br>• Use basic/schematic designs.<br>• Use feedback for skills and knowledge.<br>• Use process-based feedback.<br>• Adjust presenting of feedback to level of cognitive load in the game.<br>• Offer the feedback just-in-time.<br>• Offer detailed feedback adjusted to learners with a low prior knowledge level. |

## Development

The third step of the ADDIE-model is the development of the game. In this section it is described how the game is build and what the final product was.

### Summary

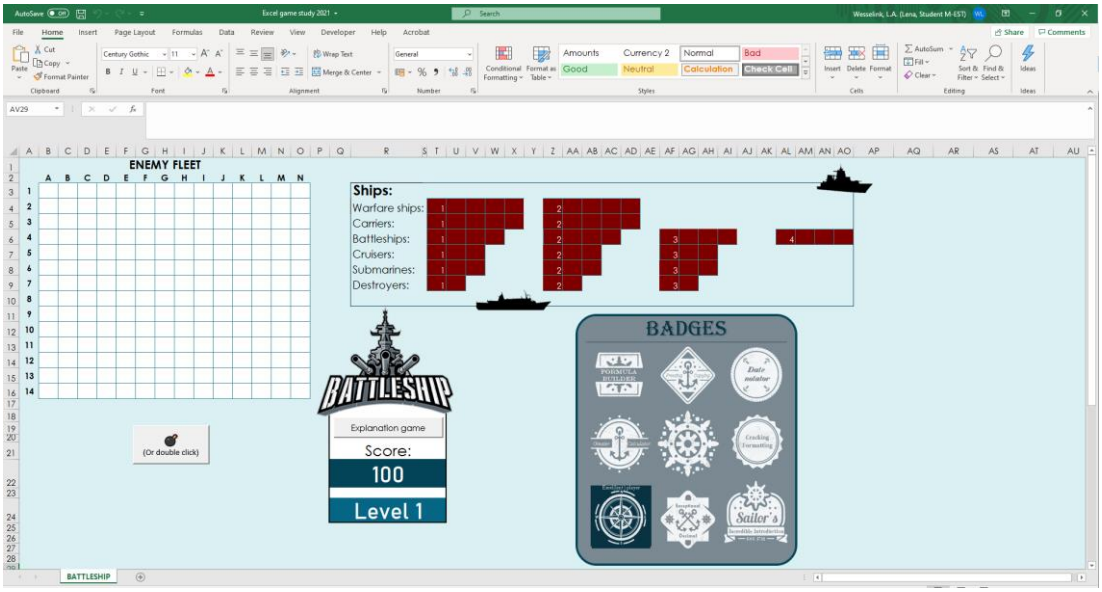
An educational game was created based on the guidelines from the literature study. The game was developed using Visual Basic for Applications and completely playable in the program Microsoft Excel. The idea of the game was similar to the game “Battleship”, in which ships had to be found and captured (Figure 2). The ‘gaming’ goals of the game were to find all seventeen ships, capture them and gain as many points and badges as possible. The educational goal of the game was to learn basic functions of Microsoft Excel. The exact content of the game was based on an existing module of an e-learning program of the company GoodHabitz. The game consisted of three elements: 1) the playing part where players had to find a ship in the enemy fleet by attacking cells. 2) The practice part where the player had to perform an educational activity in the form of a short task in a level after they found a part of a ship. 3) The repetition part in the bonus level where they had to complete a

repetitive part successfully in one try when they found the last part of a ship to capture the found ship.

In the game the players took on different roles in different contexts, the game consisted of five practice levels and a repetition bonus level, each level had a different context. The levels had in common that the main theme was analysing or formatting data. In the game the players had to find ships by attacking cells. Every time the players found a ship they were directed to a level where they had to complete a task. When they completed the task successfully they were directed back to the home screen to continue attacking cells, when they failed the task they got informed they did something wrong and they received a reflective question to help them do the task correctly. The players were able to try as many times as they needed until they succeeded. Every time they found the last part of a ship they were directed to a bonus level where they were given one chance to perform a task successfully to capture the ship. If they failed, they were shown the correct answer and the ship sunk in the home screen. The game ended automatically when they finished all levels and completed all bonus tasks.

**Figure 2**

*Homepage Microsoft Excel Game*




**Design process.**

The designing process of the game is described next. It started out with just the base of the game, which was very basic and visually unappealing. Throughout the process the game was improved on several aspects: the game context, the tasks and levels, and the instructional support. Each aspect is discussed separately here. The design process finished with the usability testing, which led to more improvements.

**Base of game.** First, the base of the game was created (see Figure 3). The game was inspired by the game “Battleship”, which is a strategy type guessing game for two players. This game was chosen because the rules of the game are simple, so that players can focus on the learning content instead of getting distracted by a complicated or difficult game. However, for this study it was important that players could play at their own pace so the game had to be made single-player. To be able to do this the player did not have their own fleet with ships, they only had to attack the enemy, which was the computer, and find their ships. Every time the player found a part of a ship they were redirected to a level where they had to perform a task (Figure 4).

**Figure 3**

*First Version of Microsoft Excel Game*

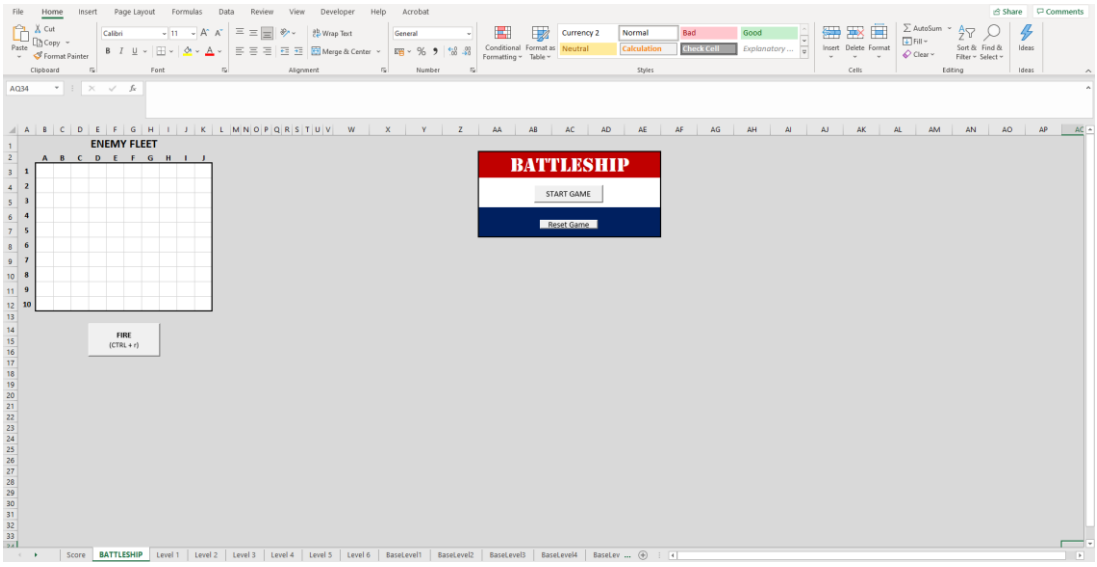
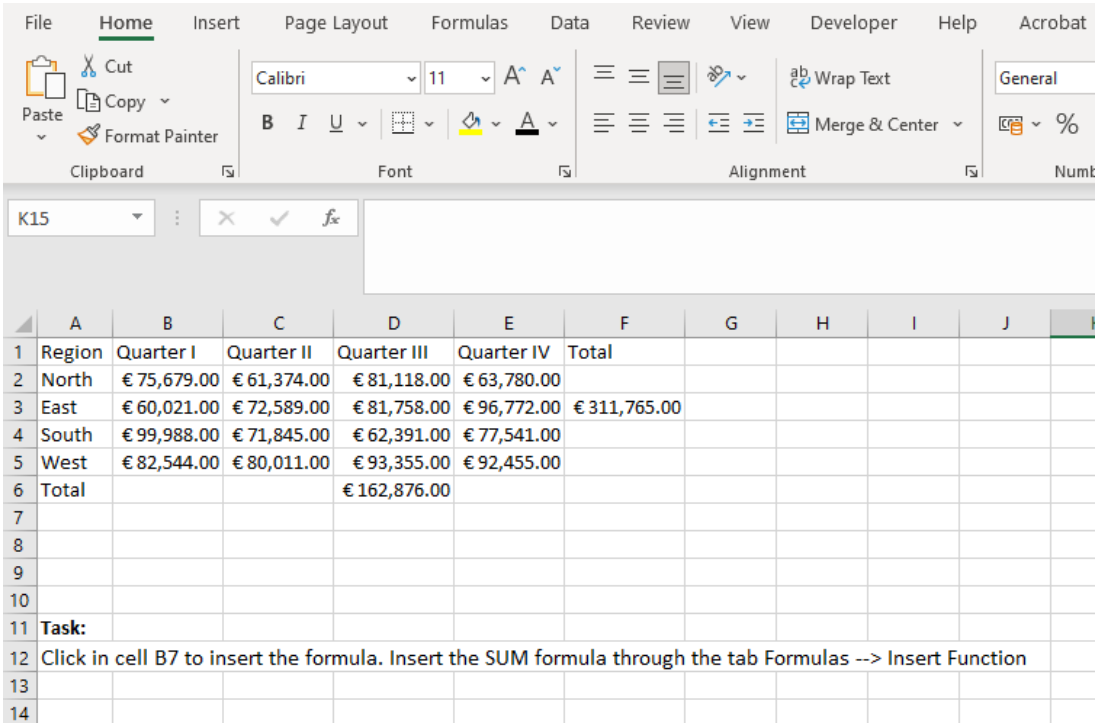



**Figure 4**

*Example Task in Base Version of Microsoft Excel Game*

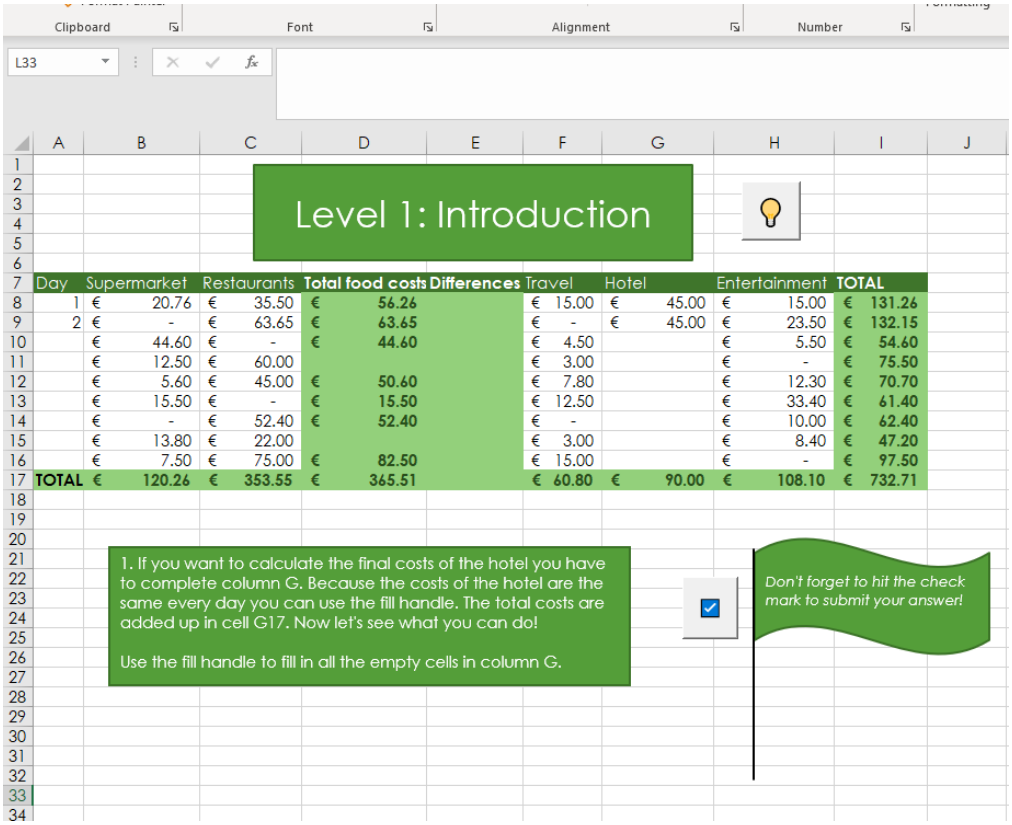



| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Region | Quarter I | Quarter II | Quarter III | Quarter IV | Total | | | | |
| 2 | North | € 75,679.00 | € 61,374.00 | € 81,118.00 | € 63,780.00 | | | | | |
| 3 | East | € 60,021.00 | € 72,589.00 | € 81,758.00 | € 96,772.00 | € 311,765.00 | | | | |
| 4 | South | € 99,988.00 | € 71,845.00 | € 62,391.00 | € 77,541.00 | | | | | |
| 5 | West | € 82,544.00 | € 80,011.00 | € 93,355.00 | € 92,455.00 | | | | | |
| 6 | Total | | | € 162,876.00 | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |
| 11 | **Task:** | | | | | | | | | |
| 12 | Click in cell B7 to insert the formula. Insert the SUM formula through the tab Formulas --> Insert Function | | | | | | | | | |
| 13 | | | | | | | | | | |
| 14 | | | | | | | | | | |

**Game context.** The game needed to include fantasy and representation. The homepage of the game was in a ‘battleship’ theme. Because players of the game all had different backgrounds the context had to be appealing to all of them. Therefore, it was decided that each level had a different context where the player took on a different character. For example, in level 1 the player had to imagine they went on a holiday to Spain and they wanted to create an overview of their expenses (see Figures 5 and 6). Whereas in level 4 they played the role of a HR employee creating work schedules for employees of the company. Furthermore, the game needed to include sensory stimuli. This was added, as far as technically possible, in the form of animated graphics. The designs of the levels and the homepage were also made more appealing (see Figures 5, 6 and 7).

**Figure 5**

*Level 1 Context*




| Day | Supermarket | Restaurants | Total food costs | Differences | Travel | Hotel | Entertainment | TOTAL |
|---|---|---|---|---|---|---|---|---|
| 1 | € 20.76 | € 35.50 | € 56.26 | | € 15.00 | € 45.00 | € 15.00 | € 131.26 |
| 2 | € - | € 63.65 | € 63.65 | | € - | € 45.00 | € 23.50 | € 132.15 |
| | € 44.60 | € - | € 44.60 | | € 4.50 | | € 5.50 | € 54.60 |
| | € 12.50 | € 60.00 | | | € 3.00 | | € - | € 75.50 |
| | € 5.60 | € 45.00 | € 50.60 | | € 7.80 | | € 12.30 | € 70.70 |
| | € 15.50 | € - | € 15.50 | | € 12.50 | | € 33.40 | € 61.40 |
| | € - | € 52.40 | € 52.40 | | € - | | € 10.00 | € 62.40 |
| | € 13.80 | € 22.00 | | | € 3.00 | | € 8.40 | € 47.20 |
| | € 7.50 | € 75.00 | € 82.50 | | € 15.00 | | € - | € 97.50 |
| TOTAL | € 120.26 | € 353.55 | € 365.51 | | € 60.80 | € 90.00 | € 108.10 | € 732.71 |

**Figure 6**

*Level 1 Introduction Context*

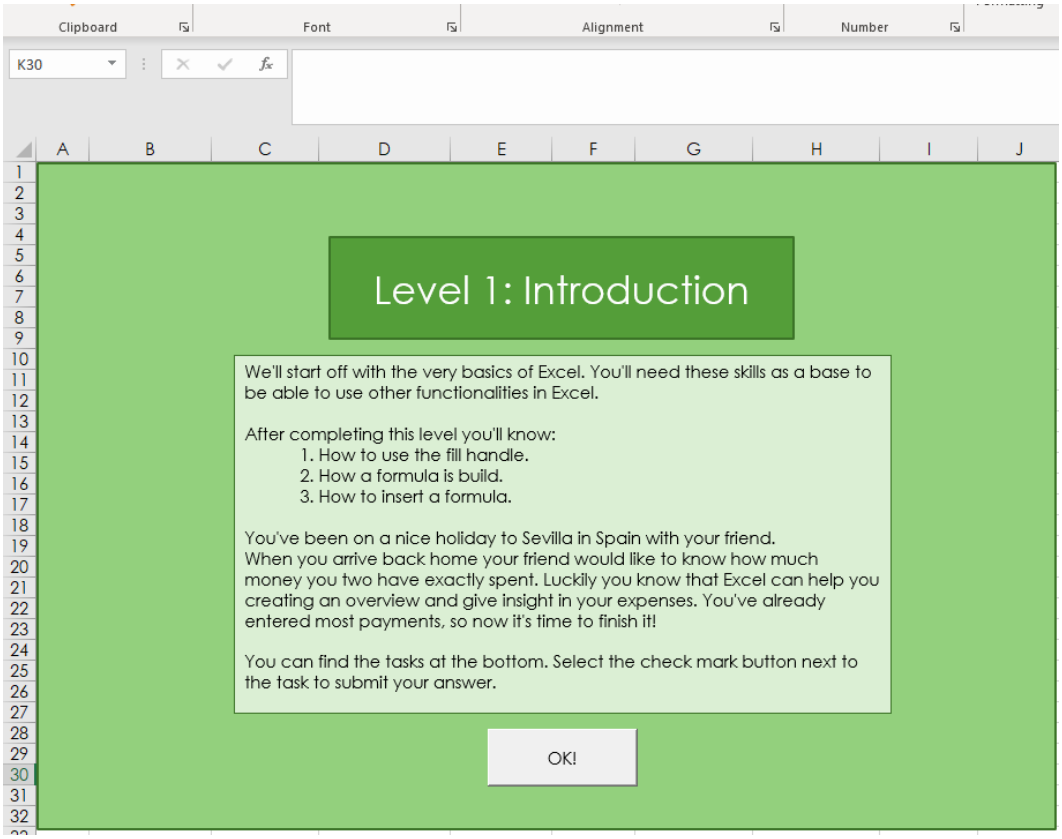
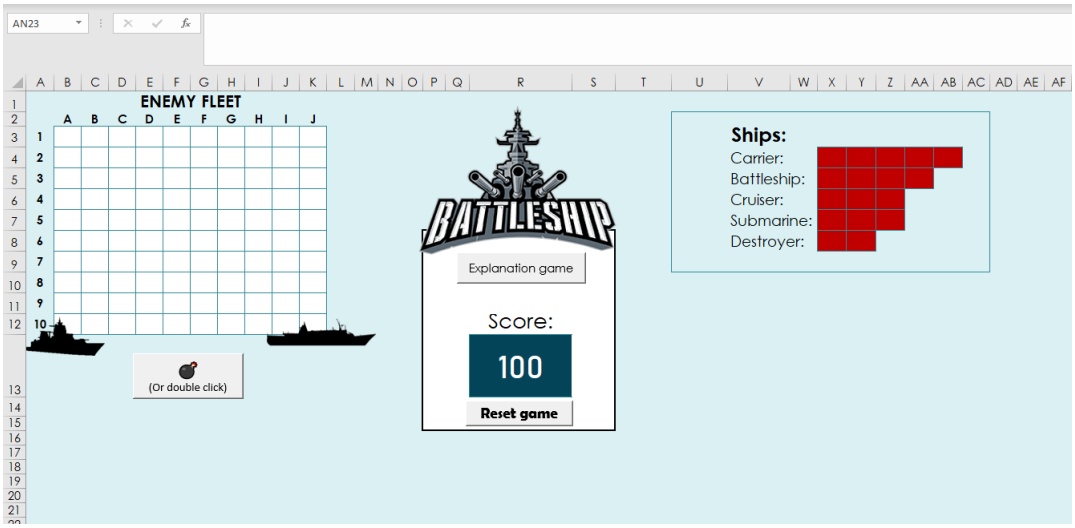



**Figure 7**

*Updated Visuals of Homepage Game*




**Tasks and levels.** The game consisted of six levels, all with a different theme and subject. The levels were: 1. Introduction, 2. Inserting formulas, 3. Freezing cells while copying & finding the highest and lowest values, 4. Calculating sums, numbers, and averages, 5. Rounding & formatting numbers, and 6. Calculations with dates. Each level started with instructions of the level including the learning objectives, their relevance and some context as explained before (see Figure 6).

The game needed to contain instructions that were task-oriented instead of promoting memorization. Therefore, the game was interactive. It consisted of tasks the players had to perform instead of just explanations with examples. This way, the players were learning by doing. All tasks were inspired by the information offered in the e-learning module of the traditional condition. Example tasks were: “Click in cell B7 to insert the formula. Insert the SUM formula through the tab Formulas → Insert Function.” or “Enter the formula for the SUM of Quarter II in cell C7 manually.”. Furthermore, for the sake of the study it was important that every player practiced the same subjects for the same amount of time. Therefore, there was a set amount of ships to be found, and thus a set amount of tasks each player had to complete in the game.

Each level had the same structure of tasks. First, the players had to explore a problem on their own. Just a task without instructions was given to see if they were able to find out the solution on their own already (see Figure 8). They were given one try and if they did not know the answer yet they automatically continued to the next task. In the second task the solution was explained and they had to practice again (see Figure 9). The tasks in each level were well-ordered, there was a build-up in the level of difficulty. The players were able to try as many times as needed until they performed the task correctly. They received bonus points

if they performed the task correctly in one try but they did not lose points for wrong answers. For every subject there was a bonus task adjusted to the knowledge level of the player. If they performed enough tasks correctly in one try they received a more difficult bonus task (Figure 10). If they had more trouble with performing the tasks they received an easier bonus task with more instructions (Figure 11).

**Figure 8**

*Explorative Task*

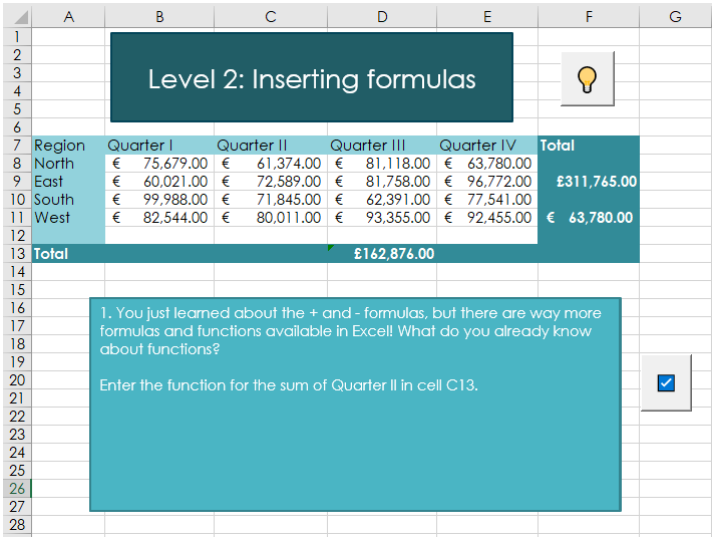



**Figure 9**

*Basic Task With Explanation*

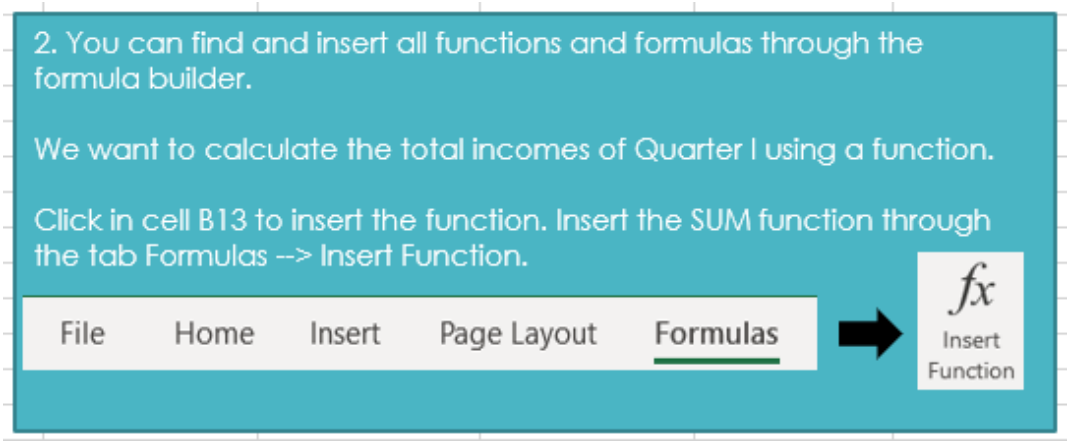



**Figure 10**

*Hard Bonus Task*

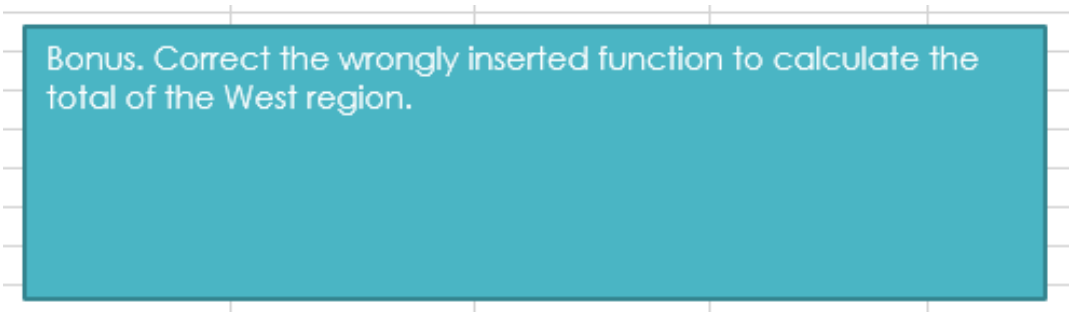
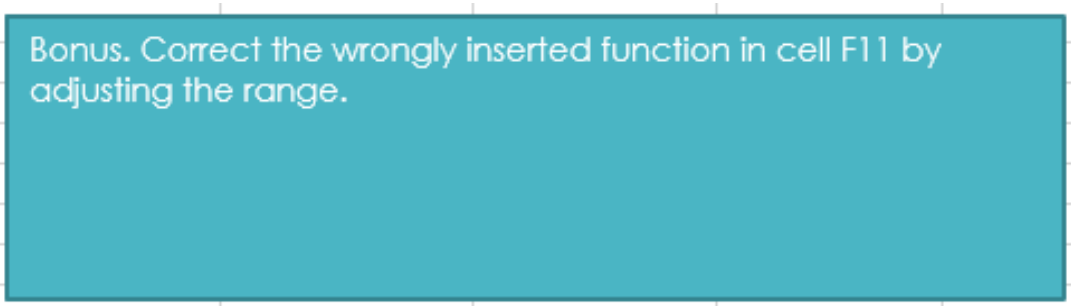



**Figure 11**

*Easy Bonus Task*




**Instructional support.** The game needed to contain instructional support. This was included in the form of on demand information and feedback. The on demand information was available through a hint button (Figure 12), whenever a player was stuck and did not know how to continue they could use the hint button. A hint popped up with information on how to continue (Figure 13). The hints were always available but players were informed that they would receive less points if they had to use the hint button. This was to prevent them of using the button all the time instead of trying to come up with the solution themselves.

**Figure 12**

*Hint Button For On Demand Information*

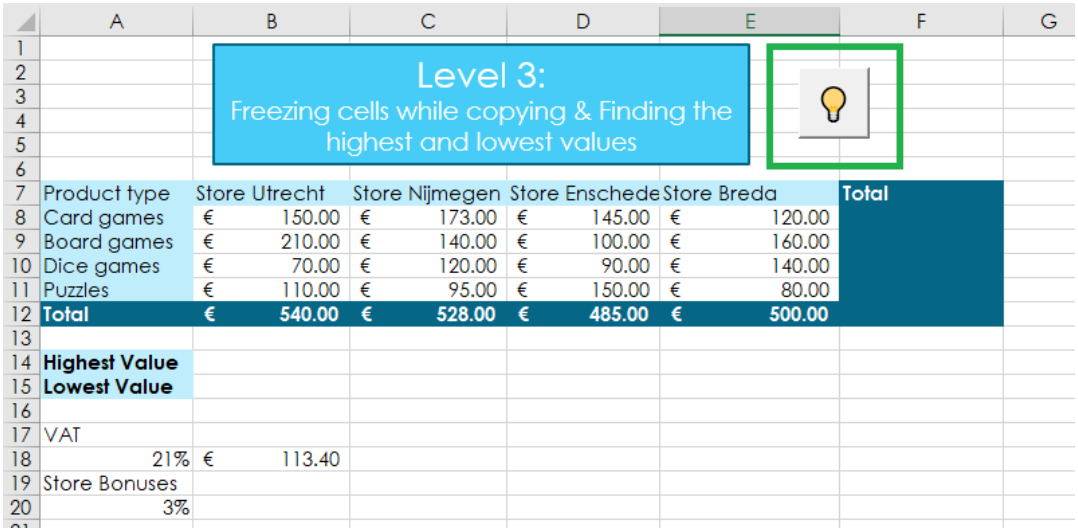
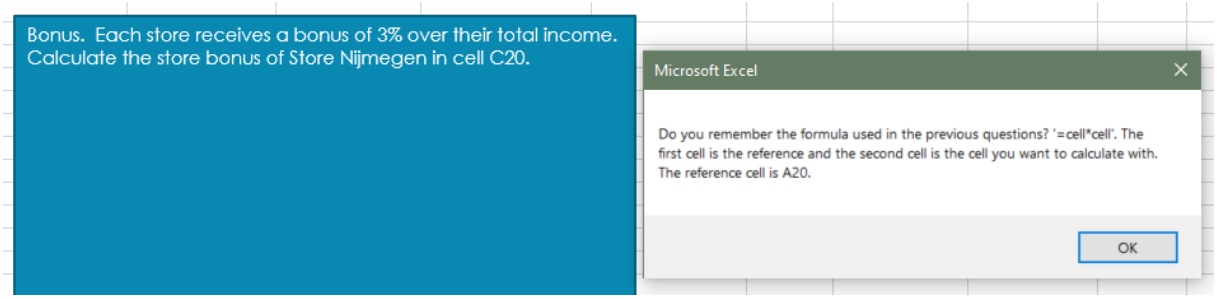



**Figure 13**

*Pop-Up With On Demand Information*




Feedback was offered just-in-time. When a player performed a task wrong a pop-up appeared with a reflective question for the player to think about while reviewing their actions and information on how to continue (Figure 14). When a player performed a task correct another pop-up showed up with encouragement, confirming their correct answer (Figure 15).

**Figure 14**

*Pop-Up Feedback After Wrong Answer*

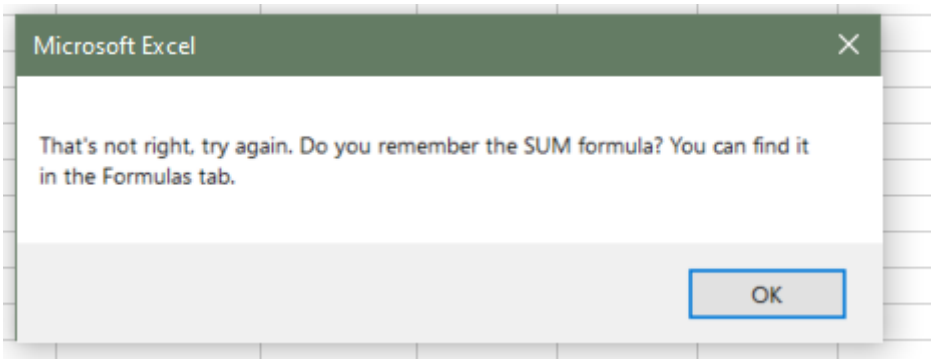
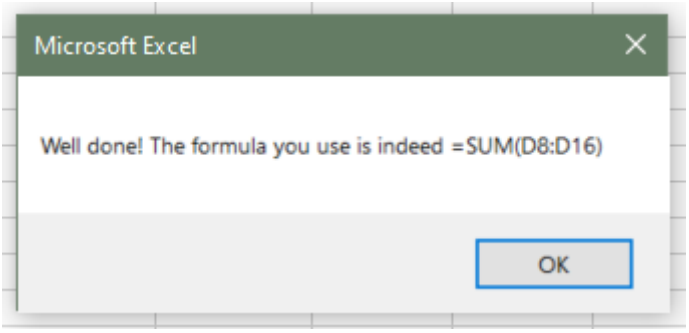


**Figure 15**

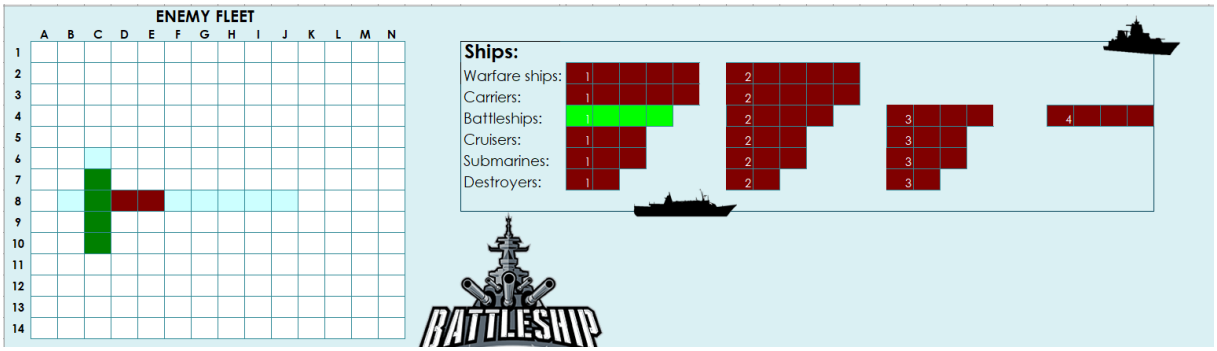
*Pop-Up Feedback After Correct Answer*




**Usability testing.** During the design of the game several adults have performed a usability test to improve the game. This resulted in the following adjustments: 1. It was experienced as demotivating that the enemy fleet was cleared and restarted after each level. In the original design, the players had to find three ships per level and then the ships were cleared and they had to start over for the next level. After the adjustments the fleet was made bigger and now contained all ships of all levels. An overview of all ships to be found was added as well so players could track their progress. Whenever they found a ship this ship was coloured green in the overview (Figure 16).

**Figure 16**

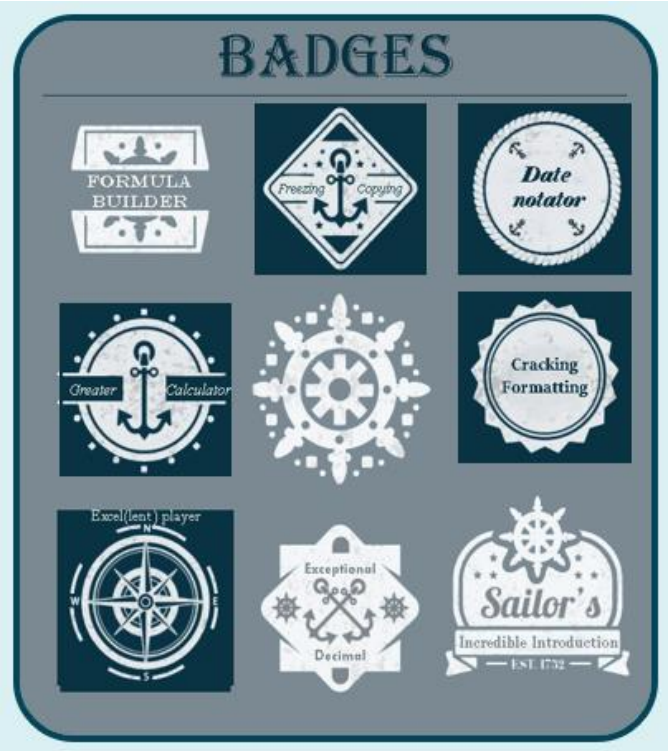
*Example of Player Finding Entire Ship*




2. A suggestion was offered to be able to earn some sort of badge as extra motivation. After adding this option players were informed that they were able to earn badges if they performed enough tasks correctly at the first try. There was a total of eight badges to be earned, of which one was given immediately at the start. Whenever the player earned a badge they received a pop-up with the notification that they earned the badge and the badge was added to the homepage (Figure 17).

**Figure 17**

*Example of Player Who Earned Five Badges*




3. Another suggestion was to make the game more challenging and rewarding, because there were too little consequences of doing everything wrong. Therefore, a bonus level was added. Every time a player found the last part of a ship they were redirected to a bonus level (Figure 18 and Figure 19). In the bonus level they had to do a task correctly in one try, these were tasks they had already learned about. When they performed the task correctly they captured the ship and only then it was coloured green in the fleet and in the overview. When they made a mistake they received feedback on why their answer was marked as incorrect and the ship escaped (Figure 20), colouring the ship grey in the fleet and in the overview.

**Figure 18**

*Introduction Bonus Level*

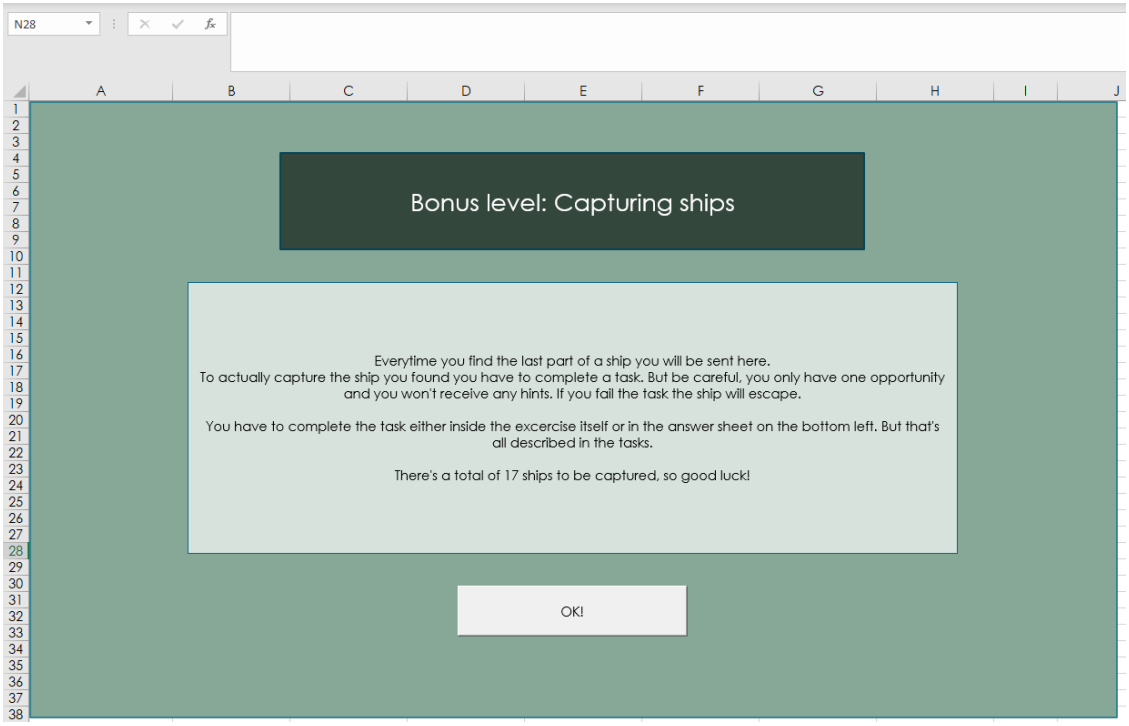
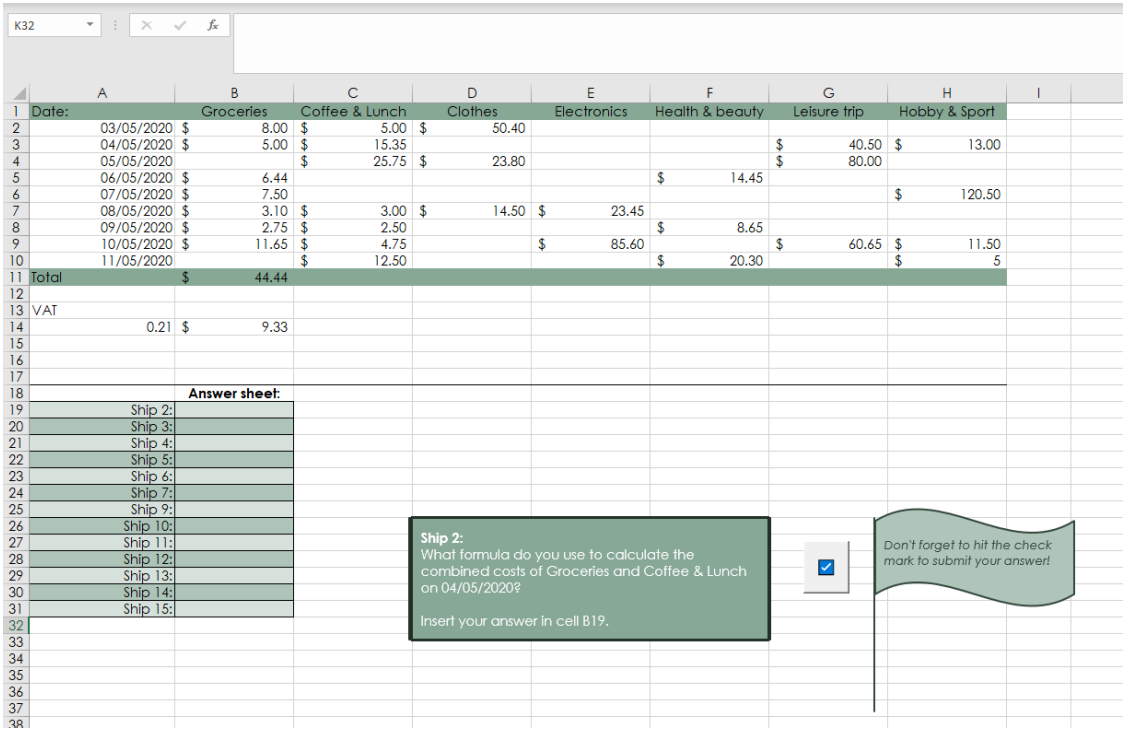



**Figure 19**

*Example Task Bonus Level*



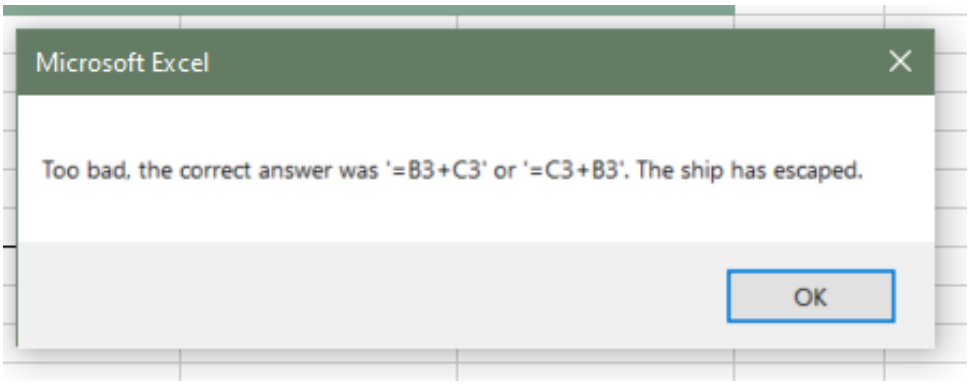

| Date: | Groceries | Coffee & Lunch | Clothes | Electronics | Health & beauty | Leisure trip | Hobby & Sport |
|---|---|---|---|---|---|---|---|
| 03/05/2020 | $ 8.00 | $ 5.00 | $ 50.40 | | | | |
| 04/05/2020 | $ 5.00 | $ 15.35 | | | | $ 40.50 | $ 13.00 |
| 05/05/2020 | | $ 25.75 | $ 23.80 | | | $ 80.00 | |
| 06/05/2020 | $ 6.44 | | | | $ 14.45 | | |
| 07/05/2020 | $ 7.50 | | | | | | $ 120.50 |
| 08/05/2020 | $ 3.10 | $ 3.00 | $ 14.50 | $ 23.45 | | | |
| 09/05/2020 | $ 2.75 | $ 2.50 | | | $ 8.65 | | |
| 10/05/2020 | $ 11.65 | $ 4.75 | | $ 85.60 | | $ 60.65 | $ 11.50 |
| 11/05/2020 | | $ 12.50 | | | $ 20.30 | | $ 5 |
| Total | $ 44.44 | | | | | | |

| VAT | |
|---|---|
| 0.21 | $ 9.33 |

| Answer sheet: | |
|---|---|
| Ship 2: | |
| Ship 3: | |
| Ship 4: | |
| Ship 5: | |
| Ship 6: | |
| Ship 7: | |
| Ship 9: | |
| Ship 10: | |
| Ship 11: | |
| Ship 12: | |
| Ship 13: | |
| Ship 14: | |
| Ship 15: | |

**Figure 20**

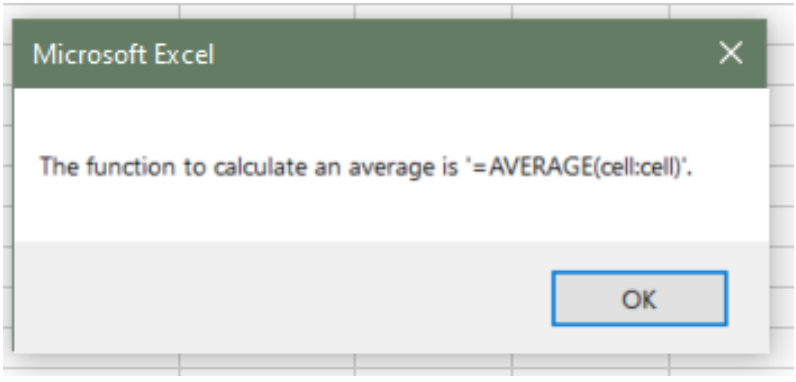
*Example Pop-Up After Failing Task in Bonus Level*




4. Finally, usability tests were done with as main goal to detect and remove errors in the game. There were a few problems with tasks about formatting. Even though participants were instructed to change the language of Microsoft Excel to English, the formatting of dates appeared to be dependent of the system settings of the computer it is installed on. Therefore, correct answers were accidentally marked wrong. The sixth level was entirely about formatting with dates, this level is mostly deleted and partly merged with level five. Also, an error button was added in case correct answers were still wrongly marked as incorrect. Players could use this button to skip the task and continue with the game. A pop-up appeared with an explanation of the correct solution (Figure 21). They were instructed to only use this button if they were sure their own answer was correct. The button was added to prevent players from getting stuck and therefore demotivated due to a technical error.

**Figure 21**

*Example Pop-Up After Using Error Button*




**Final design.** Table 3 shows the design guidelines again and whether and how they were applied in the game. Figure 22, Figure 23, and Figure 24 show some extra screenshots of the final design of the game.

**Table 3**

*Overview of design guidelines and their application in the game*

| Guideline | Application in the game |
|---|---|
| Include rules.<br><br>Include goals and objectives. | • The players were informed on the tasks they had to complete and what the rules were.<br>• The players were informed of the learning objectives and game objectives. |
| Include challenge.<br><br>The dynamics of the game should be easy to understand and interesting for the players but not obstruct or distort learning. | • The players had to solve problems which were balanced regarding their pre-knowledge.<br>• The game contained progressive difficulty in tasks, multiple goals, informational vagueness and progressive feedback.<br>• The game consisted of repetition and constant new challenge by offering new problems after completion of one set. |
| Include fantasy.<br><br>Include representation. | • The game included narrative elements in the form of introduction texts and pop-ups.<br>• The game context was an endogenous fantasy because the context was related to the learning content.<br>• The game allowed players to experience interactions in situations without facing consequences in the real world. |
| Include sensory stimuli. | • The game included animated graphics as far as possible in the form of pop-ups, appearing badges and colouring ships and parts of the sea when attacking the fleet.<br>• The game did not include sound effects due to the technical limitations of developing in Microsoft Excel. |

| | |
|---|---|
| Include mystery. | • The players encountered an information gap, they did not have enough knowledge to easily perform the activities. |
| Include active learner control.<br><br>Include agency. | • Players were not allowed to choose the amount of the activities they perform in the game due to the set time and amount of tasks each player had to perform for the study. |
| Allow for risk taking.<br><br>Students should not lose points for wrong answers. | • Players never faced high consequences of failure during the activities.<br>• Players were allowed to try as many times as needed to solve a problem.<br>• Players did not lose points for wrong answers. |
| Address important content, not trivia. | • The game content was based on a traditional form of an Microsoft Excel training and only addressed relevant and useful content. |
| The game should not be zero-sum exercises. | • Players were not dependent on or interacting with other players in the game. There was no ultimate win or comparisons with other players' achievements. |
| Winning should be based on knowledge or skills, not random factors. | • Players earned points and ships for doing exercises correctly. These exercises were related to the learning content. |
| Give adults a hand in the design and development of their learning experience. | • Usability tests were performed with adult learners to design materials based upon the needs and wants of adult learners. |
| Involve learners in diagnosing their learning needs. | • Results of the pretest were offered to the learner before starting the game in which they could see which questions they answered incorrect. |

| | |
|---|---|
| Offer a valid reason behind every course, module or educational activity. | • In the introduction of each level reasons were offered why certain learning activities needed to be completed. |
| Create learning experiences that offer minimum instruction and maximum autonomy.<br><br>Allow active learning. | • Players were able to explore a problem on their own whenever a new subject was introduced. |
| Emphasize how the subject matter is going to solve problems that an adult learner regularly encounters. | • Real world examples and scenarios were offered. |
| Make instruction task-oriented instead of promoting memorization. | • The game consisted of exercises instead of just explanations with examples. The game was interactive. |
| Take into account the wide range of different backgrounds of learners.<br><br>Use well-ordered problems. | • Learning activities for different levels of precious experience with Microsoft Excel were allowed, building up the level of difficulty, making the problems well-ordered. |
| Let the player complete the four stages of ELT. | • CE: the player played the game.<br>• RO: the player reflected on their actions in the game by reviewing their actions and by answering a reflective question.<br>• AC: an explanation was given on the concepts.<br>• AE: the player continued playing the game and practiced the learned concepts in new situations. |
| Utilize assessment.<br>Include interaction. | • Information was offered at the exact time when it was needed and players were able to access information if they wanted to. |

| | |
|---|---|
| Include just-in-time and on demand information. | |
| Offer outcomes and feedback. | • Outcomes and feedback were offered during the game.<br>• Basic/schematic designs were used.<br>• Feedback was used for skills and knowledge.<br>• Process-based feedback was used.<br>• Presenting of feedback was adjusted to the level of cognitive load in the game.<br>• The feedback was offered just-in-time.<br>• Detailed feedback was offered which was adjusted to learners with a low prior knowledge level. |

**Figure 22**

*Start Screen and Instructions Microsoft Excel Game*

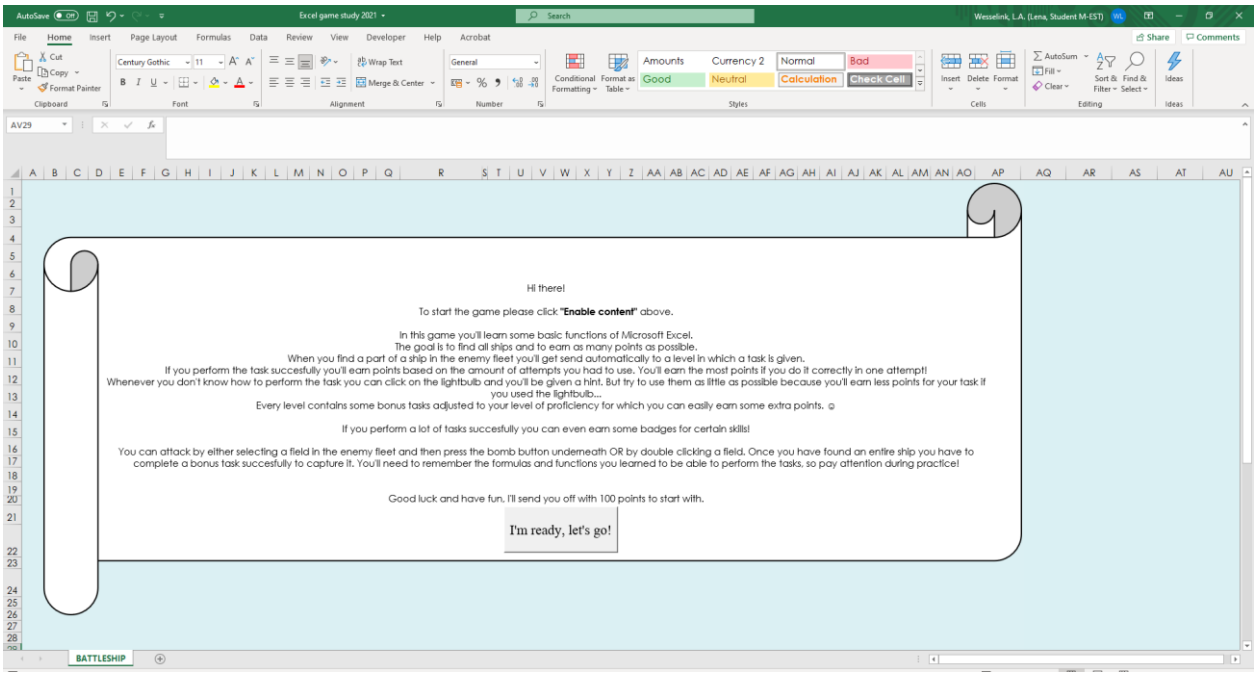


**Figure 23**

*Homepage Microsoft Excel Game*

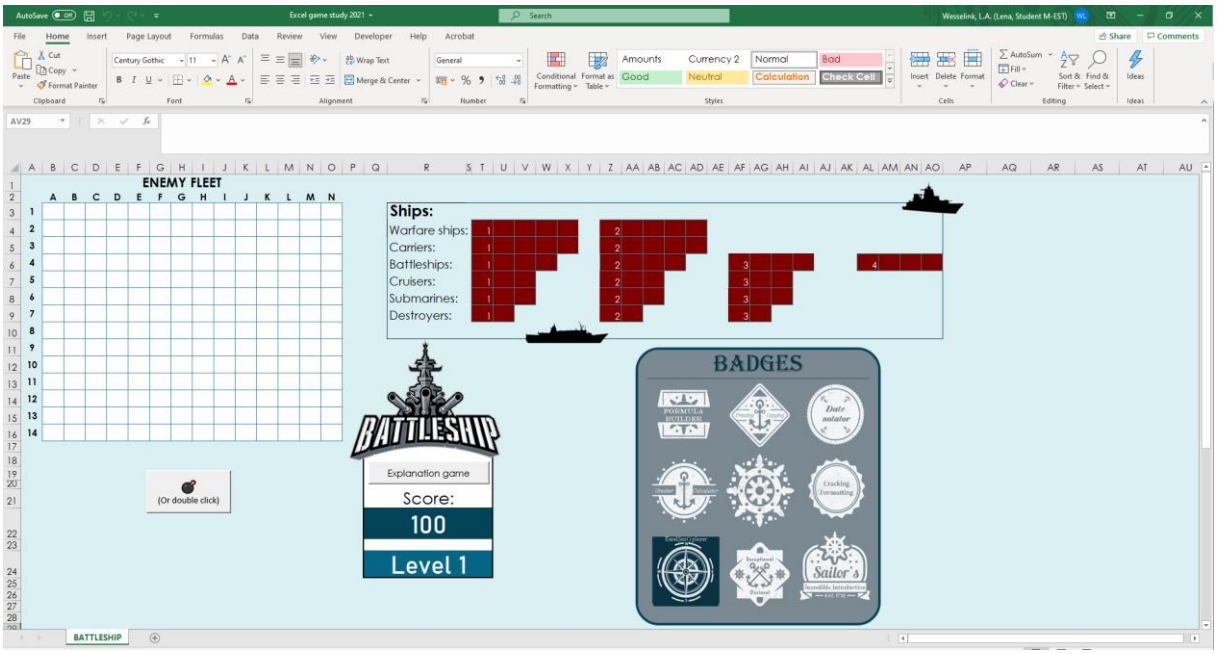
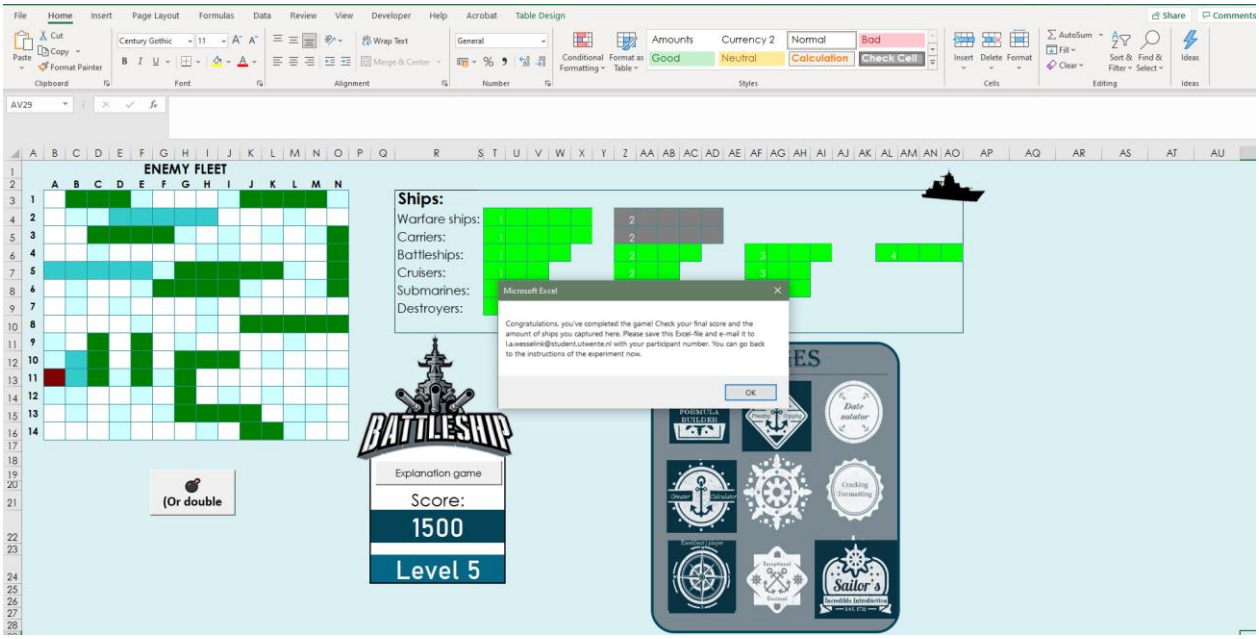



**Figure 24**

*Example Screen Game Ending*



## Research design and methods

### Implementation and evaluation

The fourth and fifth steps of the ADDIE-model are to implement the developed game and to evaluate it. The game was implemented in this research study and the effectiveness of the final product is tested by investigating the learning and motivation gains of the participants who played the game. Their results are compared to the traditional condition without GBL.

### Research design

In this study, a quasi-experiment with a pretest-posttest design and random allocation of participants to the conditions was conducted. There were two conditions, the pretests and posttests and questionnaires were part of both conditions. In condition 1, the control group, the traditional education on Microsoft Excel was followed. In condition 2, the experimental group, the Microsoft Excel game was played. In condition 2, The independent variable was the learning environment of the participant, this was either playing an educational game or learning text-based without game. The dependent variables were the learning gains score and the motivation gains score.

### Participants

Participants of this study were adults with little to no experience with Microsoft Excel, this was to limit the influence of prior knowledge on the results. The participants approached were selected from the researchers' social network based on convenience sampling, this because they needed to be able to speak English to participate. Based on a power analysis with two groups, to acquire a medium effect size, an $\alpha$ of .05, and a power of .80, the sample size should be 210 (Faul et al., 2007). However, due to the limited time and resources of this study another sample size was used. Given a medium to large effect size, 30 participants per condition should lead to about 80% power in a *t*-test, which is the minimum suggested power for an ordinary study (Cohen, 1988; VanVoorhis & Morgan, 2007). Therefore, there was aimed to be a total of 60 participants. Eventually there was a total of 62 participants between 18-58 years old (22 male, 39 female, 1 other, $M_{age}$=25.58 years, $SD_{age}$=5.53). The participants were randomly assigned to one of the two conditions. Condition 1 consisted of 31 participants (11 male, 19 female, 1 other, $M_{age}$=24.77 years, $SD_{age}$=3.74), and condition 2 consisted of 31 participants (11 male, 20 female, $M_{age}$=26.39 years, $SD_{age}$=6.84).

## Instrumentation

Two types of instruction were used in this study: traditional education and game-based education. Types of learning objectives of both types of instruction were working with formulas, working with functions and working with number formatting.

### *Traditional Education.*

The control condition followed traditional education on Microsoft Excel. An existing type of education was used and it formed the base of the learning goals. It was a module of an e-learning program of the company GoodHabitz (www.goodhabitz.com) called 'Excel 2016 - Basic'. The module was called 'Indispensable Formulas and Functions'. The module took about 40 minutes to complete, see table 4 for the subjects treated.

**Table 4**

*Subjects treated in e-learning module*

| Subject | Learning goals |
|---|---|
| Working with formulas | • Inserting a formula with the formula builder<br>• Manually inserting a formula<br>• Adjusting a formula<br>• Copying a formula<br>• Freezing cells while copying |
| Working with functions | • Determine which number in a series has the highest/lowest value<br>• Calculate the sum of a series of data<br>• Calculate the average of a series of data<br>• Calculate how many numbers are in a series of data<br>• Round a value to any number of decimals |
| Working with number formatting | • Formatting numbers as currencies<br>• Formatting numbers as decimals<br>• Formatting numbers as fractions<br>• Formatting numbers as percentages<br>• Applying a short date notation<br>• Applying a long date notation<br>• Applying an adjusted date notation |

| | |
|---|---|
| | • Setting a date as a number with which to carry out calculations |

These subjects are treated in six parts: *Start*, *Magazine*, *Smart info*, *How-to's*, *Case study*, and *Go!* (Appendix A). It consists of a mix of watching a video, reading information, answering questions, and practicing.

***Microsoft Excel Game.***

The experimental condition played an educational Microsoft Excel game which is designed in this study. The game contained clear game elements such as an interactive environment, immediate feedback, rules, challenges, and a reward system with points (Wouters et al., 2013). The game is designed and developed based on the guidelines established in the literature study in the beginning of this study.

***Measurements and Scoring.***

**Motivation questionnaire.** To determine the motivation gains, a prequestionnaire and a postquestionnaire on motivation to learn were used. The prequestionnaire score was subtracted from the postquestionnaire score to measure the motivation gains on an interval scale. Both questionnaires consisted of the same questions and used an answer-model based on Likert-scale (see Appendix B). The questionnaire *Questionnaire on Current Motivation* of Rheinberg, Vollmeyer and Burns (2001) was adjusted and used. This questionnaire was chosen because it covers and measures four important constructs of initial motivation: 'interest', 'probability of success', 'anxiety', and 'challenge'. The introduction of the questionnaires in the current study differed per condition. The task the participants had to complete was explained: either completing an e-learning module or playing a game. In the prequestionnaire the participants had to indicate how they felt about having to complete the task, in the postquestionnaire they were asked how they were feeling if they had to complete a similar task again (see Apppendix C). Each construct was covered by four or five items. An example question of the construct 'interest' was: "After having read the instruction, the task seems to be very interesting to me.". An example question of the construct 'probability of success' was: "I think I am up to the difficulty of this task.". An example question of the construct 'anxiety' was: "I feel under pressure to do this task well.". And an example question of the construct 'challenge' was: "I am eager to see how I will perform in the task.".

**Knowledge tests.** To determine the learning gains of the participants, a pretest and a posttest were used. The pretest score was subtracted from the posttest score to measure the

learning gains on a ratio scale. The pretest and posttest were mostly different but consisted of the same amount of questions with the same difficulty level. To test for potential differences in the level of difficulty half of the participants received test 1 (see Appendix D) as pretest and test 2 (see Appendix E) as posttest. The other half of the participants received test 2 as pretest and test 1 as pretest. Both tests consisted of 16 questions, of which 8 multiple-choice questions and 8 open questions. Each multiple-choice question had four answer options of which one was correct. The open questions had several correct answer possibilities. For each correct answer one point was granted. The questions could be divided into one of three categories: working with formulas, working with functions, and working with number formatting. Each category was covered by at least four questions. All questions were directly related from information presented in the game and the traditional education.

A user-friendly medium that enables asking different question types and that is able to be used remotely is Google survey, therefore the tests and the questionnaires were taken through this medium.

**Procedure**

The participants were randomly assigned to a condition. The participants were asked to perform the experiment from a place of their choice with minimum background noise and no distracting view. Due to the current situation regarding COVID-19, the participants joined the experiment from home. All participants worked with a computer or laptop.

Before the experiment, participants were asked to read and sign the informed consent (Appendix F and G). To ensure confidentiality and anonymity, all participants received a participant number which was used on all forms and in the game instead of their name. This ensured that their answers could only be led back to a participant number linked to a condition. After the informed consent they completed a pretest about Microsoft Excel skills and filled in a prequestionnaire about their motivation to learn.

During the experiment, condition 2 followed the presented traditional education. All necessary information and the exercises were presented on the screen. Condition 2 played the Microsoft Excel game. All instructions on how to play the game was embedded in the game and was presented through just-in-time information.

After the experiment, all participants completed one of the two tests as a posttest about Microsoft Excel skills and a postquestionnaire about their motivation to learn. The entire procedure took approximately 60 minutes per participant.

**Data inspection**

**Reliability knowledge tests.** Quantitative data from the two tests and the pre- and postquestionnaire were analyzed using IBM SPSS Statistics (Version 27). First, possible outliers were detected using boxplot analyses of the motivation gains and the learning gains scores in both conditions. In the traditional condition there were zero non-extreme or extreme outliers regarding the learning gains scores. However, there were two non-extreme outliers (participants 20 and 38) and one extreme outlier (participant 72) regarding the motivation gains score. This extreme outlier had a motivation gains score of 37 whereas all other participants in that condition had a motivation gains score between -14 and 14. This difference can be caused by laziness or wanting to give socially desirable answers and just filling in extreme scores. This extreme outlier is removed from the dataset because it is so divergent. In the game condition there were two non-extreme outliers (participants 3 and 33) and zero extreme outliers regarding the learning gains scores. There were zero non-extreme or extreme outliers regarding the motivation gains scores. All non-extreme outliers in both conditions are kept in the dataset.

**Reliability motivation questionnaires.** Then, the reliability of the motivation questionnaires were analysed. Before analysing the items 3 and 14 of the construct 'probability of success' were rescaled, because for these items a high score meant low motivation. Reliability analyses on the 18 item Current Motivation to learn with E-learning questionnaire were conducted for each of the four constructs. The Cronbach's alphas were .80 for the construct 'interest', .80 for the construct 'probability of success', .91 for the construct 'anxiety', and .68 for the construct 'challenge'. Removing item 6 resulted in a Cronbach's alpha .79.

Reliability analyses on the 18 item Current Motivation to learn with Educational Game were conducted for each of the four constructs. The Cronbach's alphas were .88 for the construct 'interest', .87 for the construct 'probability of success', .91 for the construct 'anxiety', and .68 for the construct 'challenge'. Removing item 6 resulted in a Cronbach's alpha .77 for the construct 'challenge'.

The reliability of all constructs could now be considered adequate for research purposes, consequently no other items were dropped from the questionnaires.

Then, to find out if the pre- and posttest were reliable and of good quality two psychometric analyses were conducted with the results of the tests. However, decisions about removing questions from the analysis were not completely based on the results of the tests. The reason for this is that psychometric values are quantitative and do not inform about the content of the questions (Van Berkel et al., 2017). Besides, all domains needed to be covered

in the pre- and posttest so not too many questions could be removed. A psychometric analysis on the first test showed that the Cronbach's alpha for the 16-item Knowledge of Excel Skills was .72. A closer examination of the test item-total statistics indicated that removing questions would not have a big positive influence on alpha: a maximum increase to .74.

Item 6 consisted of zero variance as all participants answered this question right. The item was "How do you format a cell as dollars?". However, this item was not dropped from the test because only eighteen of thirty-one participants who answered this question in the pretest answered it correctly. Thus, this indicates that the question was not too easy but instead proved that the participants learned the answer during their intervention.

A psychometric analysis on the second test showed that the Cronbach's alpha for the 16-item Knowledge of Excel Skills was .69. A closer examination of the test item-total statistics indicated that the alpha would increase from .69 to .71 if item 16 were removed. This item was "What formula do you use to add up cell B5 to cell B9?". The correct answer was "=B5+B9". All sixteen participants in the traditional condition answered this question wrong. This is probably due to the fact that the traditional condition did not cover this formula and used the SUM-formula instead. Consequently, this item was dropped from the test. Because item 16 in test 1 was a similar question covering this subject it was dropped from this test as well, resulting in α of .69.

Because α of 0.6-0.7 indicates an acceptable level of reliability no other questions were removed (Ursachi et al., 2015). All subsequent analyses are based on participants' responses to the remaining fifteen items in both tests.

**Level of difficulty tests.** To proof the two tests had the same level of difficulty the posttest results of both tests were compared using an independent *t* test. The posttest results of the participants who had test 1 as posttest ($n$ = 31) were compared to the posttest results of the participants who had test 2 as posttest ($n$ = 30). The dependent variable is the posttest scores and the independent variable is the test condition. Neither Shapiro-Wilk statistic was significant, indicating that the assumption of normality was not violated. Levene's test was also non-significant, thus equal variances can be assumed. The *t* test was non-significant, $t(59) = 0.27$, $p = .787$, two-tailed, $d = 0.07$, 95% CI of the mean difference [-1.19, 1.57], indicating that both tests were of the same difficulty level.

## Results

**Table 5.**

*Test Scores of Both Tests of the Traditional Condition (n=30) and the Game Condition (n=31)*

| **Test** | Pre-intervention | Post-intervention | Difference | |
|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | Mean (SD) | *p* |
| **Condition** | | | | |
| Traditional condition (n=30) | 3.90 (2.295) | 9.87 (3.060) | 5.967 (2.798) | **.000** |
| Game condition (n=31) | 4.13 (2.930) | 11.52 (1.964) | 7.387 (2.729) | **.000** |

**Learning gains game condition.** A paired samples *t* test with an α of .05 was used to compare the scores on the test before (*M* = 4.13, *SD* = 2.93) and after (*M* = 11.52, *SD* = 1.96) playing the educational game (see Table 5). It was concluded that the assumptions of normality and normality of difference scores were not violated after outputting and visually inspecting the relevant histograms. On average, the participants scored 7.39 points, 95% CI [6.39, 8.39], higher on the posttest than they did on the pretest. This difference was statistically significant, $t(30) = 15.07$, $p < .001$, and large, $d = 3.02$, indicating that playing the educational Microsoft Excel game leads to learning.

**Learning gains traditional condition.** Another paired samples *t* test with an α of .05 was used to compare the scores on the test before (*M* = 3.90, *SD* = 2.30) and after (*M* = 9.87, *SD* = 3.06) completing an e-learning module (see Table 5). It was concluded that the assumptions of normality and normality of difference scores were not violated after outputting and visually inspecting the relevant histograms. On average, the participants scored 6.0 points, 95% CI [4.92, 7.01], higher on the posttest than they did on the pretest. This difference was statistically significant, $t(29) = 11.68$, $p < .001$, and large, $d = 2.23$.

**Learning gains compared.** An independent samples *t* test was used to compare the learning gains of the participants in the game condition ($n = 31$) to the learning gains of the participants in the traditional condition ($n = 30$). Neither Shapiro-Wilk statistic was significant, indicating that the assumption of normality was not violated. Levene's test was also non-significant, thus equal variances can be assumed. The *t* test was statistically significant, with the game condition (*M* = 7.39, *SD* = 2.73) yielding 1.42 points higher learning gains, 95% CI [-2.84, -.01], than the traditional condition (*M* = 5.97, *SD* = 2.80), $t(59) = -2.01$, $p = .049$, two-tailed, $d = 2.76$.

**Table 6.**

*Motivation Scores for all Constructs of the Traditional Condition (n=30) and the Game Condition (n=31)*

| Construct | Pre-intervention | Post-intervention | Difference | |
|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | Mean (SD) | *p* |
| **Interest** | | | | |
| Traditional condition (n=30) | 16.73 (3.443) | 16.63 (4.351) | -.100 (2.734) | .843 |
| Game condition (n=31) | 17.13 (3.294) | 17.35 (3.860) | .226 (2.202) | .572 |
| **Probability of success** | | | | |
| Traditional condition (n=30) | 14.80 (2.497) | 15.97 (2.906) | **1.167** (2.479) | **.015** |
| Game condition (n=31) | 14.16 (3.216) | 15.55 (3.828) | **1.387** (2.906) | **.012** |
| **Anxiety** | | | | |
| Traditional condition (n=30) | 19.83 (4.450) | 20.07 (3.921) | .233 (2.738) | .644 |
| Game condition (n=31) | 18.32 (4.556) | 19.23 (4.440) | .903 (2.688) | .071 |
| **Challenge** | | | | |
| Traditional condition (n=30) | 14.43 (2.112) | 13.80 (2.369) | **-.633** (1.691) | **.049** |
| Game condition (n=31) | 14.74 (2.338) | 14.74 (2.543) | .000 (2.720) | 1.000 |

**Motivation gains game condition.** A paired samples *t* test with an α of .05 was used to compare the scores on the four constructs of the questionnaire before and after playing the educational game (see Table 6). On average, the participants scored 0.23 points, 95% CI [-0.58, 1.033], higher on the construct ‘interest’ on the postquestionnaire than they did on the prequestionnaire. However, this difference was not statistically significant, $t(30) = .57$, $p = .572$.

They scored 1.39 points, 95% CI [0.32, 2.45], higher on the construct ‘probability of success’ on the postquestionnaire than they did on the prequestionnaire. This difference was statistically significant, $t(30) = 2.66$, $p = .012$, and small, $d = 0.48$.

They scored 0.90 points, 95% CI [-0.08, 1.89], higher on the construct ‘anxiety’ on the postquestionnaire than they did on the prequestionnaire. However, this difference was not statistically significant, $t(30) = 1.87$, $p = .071$.

They scored the same, 95% CI [-1.00, 1.00], on the construct ‘challenge’ on the postquestionnaire as they did on the prequestionnaire.

It was concluded that the assumptions of normality and normality of difference scores were not violated after outputting and visually inspecting the relevant histograms.

**Motivation gains traditional condition.** Another paired samples *t* test with an α of .05 was used to compare the scores on the four constructs of the questionnaire before and after completing an e-learning module (see Table 6). On average, the participants scored 0.10 points, 95% CI [-1.121, 0.921], lower on the construct ‘interest’ on the postquestionnaire than they did on the prequestionnaire. However, this difference was not statistically significant, $t(29) = -.20$, $p = .843$.

They scored 1.17 points, 95% CI [0.241, 2.092], higher on the construct ‘probability of success’ on the postquestionnaire than they did on the prequestionnaire. This difference was statistically significant, $t(29) = 2.58$, $p = .015$, and small, $d = 0.47$.

They scored 0.23 points, 95% CI [-0.789, 1.256], higher on the construct ‘anxiety’ on the postquestionnaire than they did on the prequestionnaire. However, this difference was not statistically significant, $t(29) = 0.47$, $p = .644$.

They scored 0.63 points, 95% CI [-1.265, -0.002], lower on the construct ‘challenge’ on the postquestionnaire than they did on the prequestionnaire. This difference was statistically significant, $t(29) = -2.05$, $p = .049$, and small, $d = 0.37$.

It was concluded that the assumptions of normality and normality of difference scores were not violated after outputting and visually inspecting the relevant histograms.

**Additional explorative analyses.** Because the game condition did not gain motivation to learn, their initial motivation is inspected. An independent *t* test with an of .05 was used to compare the scores on the four constructs of the prequestionnaire of the game- and the traditional condition. However, the game condition did not score significantly higher on the prequestionnaire than the traditional condition.

## Discussion

The purpose of this study was to answer the research question: Does game-based education for adults yield higher learning and motivation gains than traditional education for adults?

The results of this study support the first hypothesis that playing an educational game leads to learning. The difference between the pretest and posttest results of the game condition was positive and statistically significant, indicating that playing the educational Microsoft Excel game leads to learning. This is in line with earlier research of Huang et al. (2010) and Wang & Chen (2010), which shows that GBL has potential to help learners improve their learning performance.

The results of this study also provide supporting evidence for the second hypothesis that playing an educational game yields higher learning gains than following traditional education. Although adults following traditional education yield a statistically significant higher score on the posttest than on the pretest as well, the learning gains of adults playing the educational game are statistically significantly higher. This pattern of results is consistent with the previous literature proving that GBL results in achieving better learning effect than traditional education for other age categories than adults (Al-Azawi et al., 2016; Chen et al., 2014).

Then, the third hypothesis that playing an educational game leads to an increase in motivation to learn, is not supported on all constructs of motivation. The adults in the game condition score significantly higher on the construct ‘probability of success’ on the motivation questionnaire after playing the game than before. Indicating that adults who play the educational game think they have a higher chance of succeeding in playing an educational game after playing the game than they were in first instance before playing. However, they do not score significantly higher on the three other constructs: ‘interest’, ‘anxiety’, and ‘challenge’. These results do not confirm the findings of Whitton (2011), where adults’ initial perspective on the motivational goal of educational goals are not positive but this perspective might change if games are perceived as being the best and most effective way to learn.

The adults following traditional education score significantly higher on the construct ‘probability of success’ on the motivation questionnaire after completing the e-learning module than before as well. Besides, they do not score significantly higher on the two constructs ‘interest’ and ‘anxiety’. Remarkable is that they score significantly lower on the construct ‘challenge’, indicating that the adults following traditional education feel less challenged after completing the e-learning than they indicated to be before the e-learning.

The different findings of this study regarding the motivation gains can possibly be explained by the initial motivation of the adults, as their motivation is already on the positive side on all of the four constructs before playing the game. They indicate an average of 3.42 on the questions about the construct ‘interest’ on a scale of one to five, where one can be interpreted as very negative and five as very positive. The averages per question on the constructs ‘probability of success’, ‘anxiety’, and ‘challenge’ are respectively 3.54, 3.67 and 3.69. This unexpected high initial motivation can be explained by the average age of the adults. The average age of the participants in the game condition is 26 years, which can be seen as young adults. This generation might already be motivated to learn with educational game (Woo, 2013). Thus, according to this study, young adults are already motivated and willing to learn with GBL. A gain in motivation is therefore not necessary for them.

However, additional explorative analyses show that there are no significant differences in any of the four constructs in the initial motivation of adults in the game condition compared to that of the adults in the traditional condition. This could be due to the fact that the traditional education in the current study is an e-learning module that is interactive as well. This will be further discussed in the limitations of this study.

**Limitations and recommendations**

Although the present results are for the biggest part in line with the expectations, positive towards GBL, it is appropriate to recognize several potential limitations. These are discussed here regarding the participants and the materials used. Based on these limitations some directions for future research are given.

***Participants and questionnaire.***

As mentioned before, one limitation of this study is that the average age of the participants is 26 years. Only six participants are thirty years or older. In the game condition specifically the average age is 26 years as well, with only three participants of thirty years or older. The game and other materials used in this study are designed for adults, which can explain the positive attitude of the adults towards the game and the e-learning. However, it might be interesting to conduct a similar study with older adults to investigate whether older adults are indeed less motivated to learn with educational games. It is advised to take into account the first language of the participants. Because the participants in this study are found through the researcher’s network, most people were Dutch and did not understand English well enough to participate. Older adults’ willingness to participate might be higher when the study is in their first language.

Furthermore, a questionnaire is used to determine the current motivation of the participants to learn with either a game or an e-learning module. Although this is a quick and easy solution to receive information from a large amount of people, it might be more fitting to use interviews to get a better image of adult perceptions on GBL.

***Traditional education.***

The type of traditional education used in the current study is an e-learning module. This module was chosen because it is of good quality, to ensure the quality of the traditional education is not of influence on the learning results. It is made by a professional company focused on adults, educational scientists have worked on the module. However, the module might be too interactive for this study. Some of the factors that make educational games more motivating are that they include interaction, goals and objectives, outcomes and feedback, and representation. The e-learning includes these factors as well. It is interactive because exercises are embedded in the module, besides direct feedback is given there. Furthermore, learning goals are presented at the beginning. Finally, some representation is offered in the exercises and questions as well. Therefore, the e-learning might cover too many similar aspects as the educational game, making the comparison regarding the motivational appeal of educational games more difficult.

***Microsoft Excel game.***

There are some limitations regarding the game as well, this is due to the fact that not all design requirements were technically possible to implement. First of all, the sensory stimuli were minimal. Sound effects were not included because this was not an option in the program Microsoft Excel. Visual stimuli were included in the form of pop-ups, appearing badges and colouring ships and parts of the sea when attacking. When developing in another program it is advised to make more use of sensory stimuli to make the game more appealing.

Secondly, although it is recommended to include active learning control and agency in the game, this is not available in the game of this study. The reason for this is that for the sake of the study it is important that every player needs to spend the same amount of time in the game and practice the same subjects and tasks to be able to make a fair comparison. When designing an educational game for other reasons than research, it is advised to include active learner control and let the players choose the amount of activities they want or need to perform. Expanding on this topic, it is advised to adjust the tasks and activities to the knowledge level of the player. In the current game only a few bonus tasks in each level are adjusted to the progress of the player in the game.

And finally, some unexpected technical issues appeared during the usability tests. The system settings of the computer the game is played on influence the formatting of dates. Therefore, some answers are automatically marked wrong even when all tasks are performed correctly. Because this was only discovered at the end of the design phase the tasks about date formatting had to be reduced. Moreover, to prevent problems such as this one, an error button was added throughout the entire game. Enabling the players to continue whenever a similar situation happened. This was a sufficient solution for the time-being to be able to continue the experiment. However, it is advised to pay extra attention to the technical components and solutions to possible problems while developing an educational game by performing usability tests on different computers as early on in the process as possible.

**Study implications.**

Despite these limitations, these results suggest several practical and theoretical implications. The Excel game is designed and developed and its effectiveness has been proven. It can therefore be used to teach adults basic Microsoft Excel skills. Young adults appear to be motivated to learn with educational games. The design guidelines formulated during this study are specifically for adult learning, however they are not specific for the content of the game, in this case Microsoft Excel skills. It is therefore interesting to research whether these guidelines are effective for other subjects as well. The design guidelines can thus be used to design and develop educational games about other subjects.

**Conclusion.**

Although the generality of the current results must be established by future research, the present study has provided clear support for the effectiveness of GBL. Not only were the learning gains of adults significantly higher when using the educational game than those of adults completing an e-learning module. Although the adults in this study did not become more motivated to learn game-based after playing the educational game, their perspective on learning with an educational game regarding their motivation was unexpectedly positive to start with. The findings of this study contribute therefore to a growing body of evidence that GBL is effective and usable for other age categories than just children.

***Student advice.***

This study is fairly unique for a final project because it is both a research and a design study. Therefore, some final recommendations are given to students who want to conduct a similar study.

Most importantly, before deciding to design and research an educational game, find out whether you have the technical abilities and a platform to actually develop the game. Or find someone who can help you. The entire process demands a lot of time, take this into account. Then, it is advised to start with an extensive literature study about game design guidelines and the characteristics of the target group to be fully prepared for the design of the game. It might be good to pay extra attention to different types of instructional support. Then, the design guidelines can be adjusted by asking the target group to indicate their needs and wishes. Besides, to improve the game it is helpful to perform several usability tests during the entire process of designing the game. Make sure enough time is planned for final testing before the start of the data collection. Do not neglect the other materials needed to conduct the study such as questionnaires and knowledge tests. If these are of bad quality, it not possible to draw good conclusions. Furthermore, keep in mind the limitations discussed in this study. Finally, it is absolutely advised to conduct a study like this one if you are motivated to learn about GBL. It is a very educational and rewarding project, having control over the entire process from designing the game to actually testing its effectiveness.

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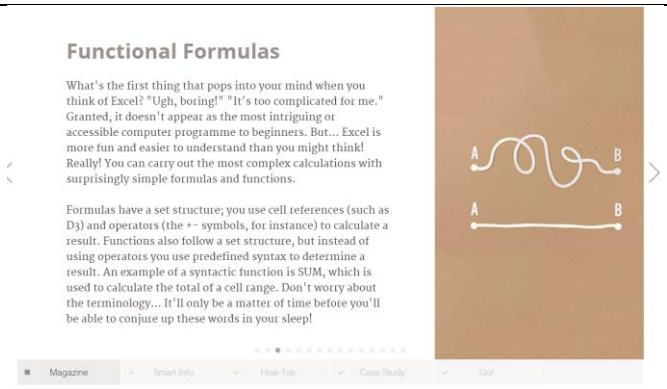
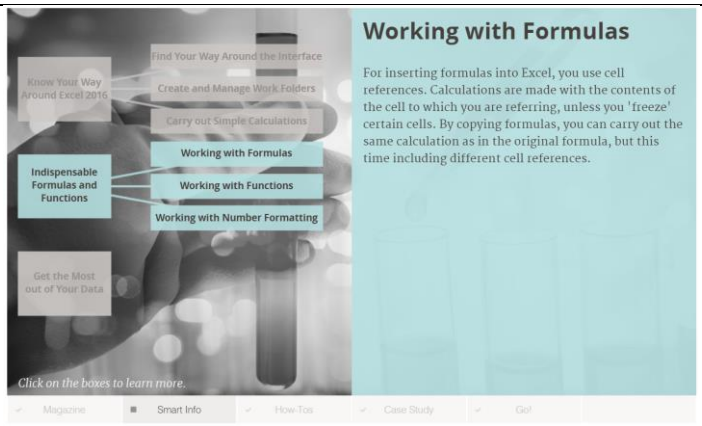
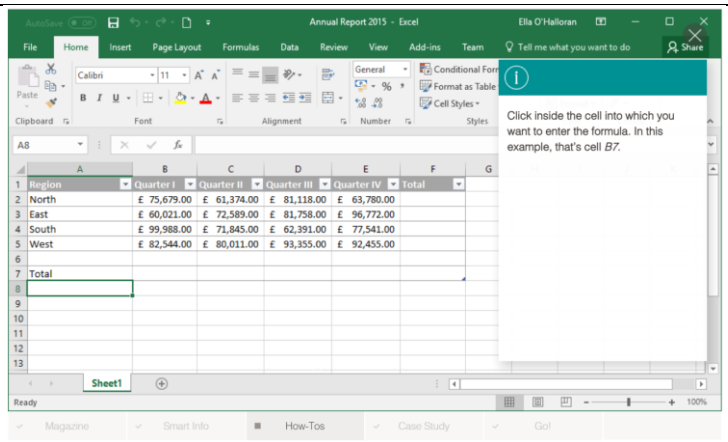
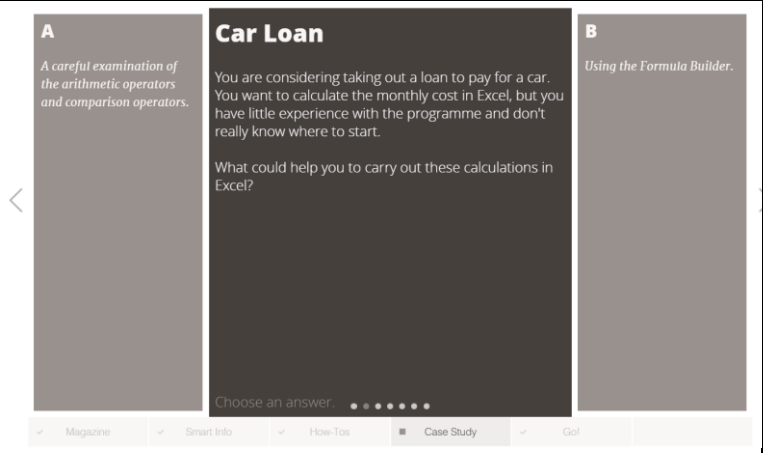
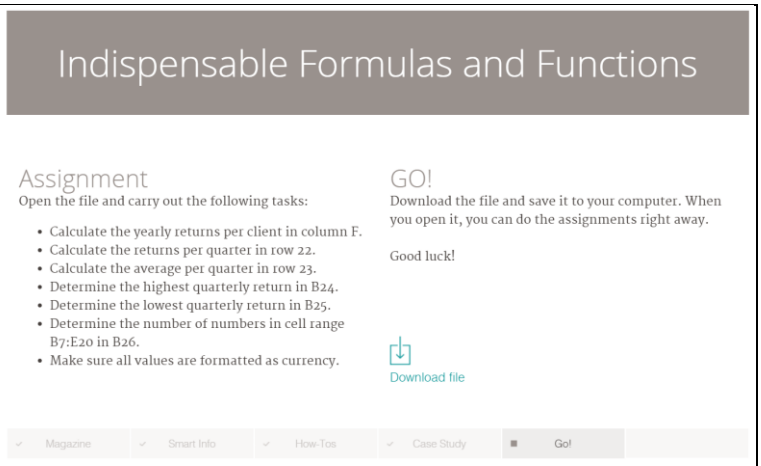
# Appendix A

| Part | Contents | Example |
|---|---|---|
| Start | • Introduction video of all treated subjects. |  |
| Magazine | • Relevance of three main subjects.<br>• Explanations and examples of all treated subjects.<br>• Recap of newly learned information. |  |

| | | |
|---|---|---|
| Smart info | • Short explanation of three main subjects. |  |
| How-to's | • Practice all treated subjects through an integrated practice situation. |  |
| Case study | • Questions about 6 practical examples. |  |

| | | |
|---|---|---|
| Go! | • Practice in an Microsoft Excel file |  |

## Appendix B

## Questionnaire on motivation to learn

| Item | Strongly disagree – Strongly agree | | | | |
|---|---|---|---|---|---|
| 1. I like to automate my everyday tasks. (I)* | 1 | 2 | 3 | 4 | 5 |
| 2. I think I am up to the difficulty of this task. (P) | 1 | 2 | 3 | 4 | 5 |
| 3. I probably won't manage to do this task. (P−) | 1 | 2 | 3 | 4 | 5 |
| 4. While doing this task I will enjoy analysing data in different contexts. (I)* | 1 | 2 | 3 | 4 | 5 |
| 5. I feel under pressure to do this task well. (A) | 1 | 2 | 3 | 4 | 5 |
| 6. This task is a real challenge for me. (C) | 1 | 2 | 3 | 4 | 5 |
| 7. After having read the instruction, the task seems to be very interesting to me. (I) | 1 | 2 | 3 | 4 | 5 |
| 8. I am eager to see how I will perform in the task. (C) | 1 | 2 | 3 | 4 | 5 |
| 9. I'm afraid I will make a fool out of myself. (A) | 1 | 2 | 3 | 4 | 5 |
| 10. I'm really going to try as hard as I can on this task. (C) | 1 | 2 | 3 | 4 | 5 |
| 11. For tasks like this I don't need a reward, they are lots of fun anyhow. (I) | 1 | 2 | 3 | 4 | 5 |
| 12. It would be embarrassing to fail at this task. (A) | 1 | 2 | 3 | 4 | 5 |
| 13. I think everyone could do well on this task. (P) | 1 | 2 | 3 | 4 | 5 |
| 14. I think I won't do well at the task. (P−) | 1 | 2 | 3 | 4 | 5 |
| 15. If I can do this task, I will feel proud of myself. (C) | 1 | 2 | 3 | 4 | 5 |
| 16. When I think about the task, I feel somewhat concerned. (A) | 1 | 2 | 3 | 4 | 5 |

| | | | | | |
|---|---|---|---|---|---|
| 17. I would work on this task even in my free time. (I) | 1 | 2 | 3 | 4 | 5 |
| 18. I feel petrified by the demands of this task. (A) | 1 | 2 | 3 | 4 | 5 |

*Item adapted to the current study
(C): Challenge
(I): Interest
(P): Probability of success
(A): Anxiety

## Appendix C

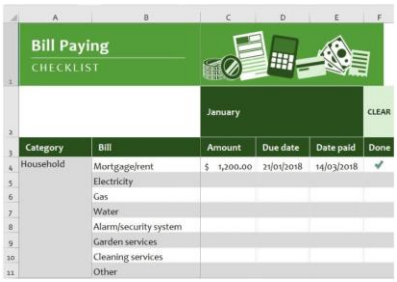
### Introductions motivation questionnaire per condition

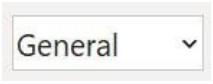
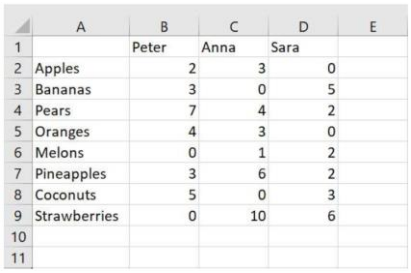
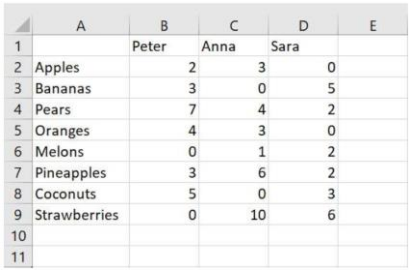
| | |
|---|---|
| Prequestionnaire traditional condition | During this study you will play follow an online course about the program Microsoft Excel. The course consists of videos, magazines and assignments. The subjects you will learn about in this course are formulas, functions and formatting numbers.<br><br>Select the numbers below to state how you feel about performing this task (following an online course about Microsoft Excel). Please fill in your first instinct, try not to think too long about it. |
| Prequestionnaire game condition | During this study you will play a game in Microsoft Excel. In the game you have to find ships and perform tasks in which you will learn about basic skills of Microsoft Excel. You have to try to find all ships and secure them by performing tasks well. If you perform a task correctly you earn a certain amounts of points. Subject you will learn about are formulas, functions and number formatting.<br><br>Select the numbers below to state how you feel about performing this task (playing the Microsoft Excel game). Please fill in your first instinct, try not to think too long about it. |
| Prequestionnaire traditional condition | You've completed the module in a e-learning course about basic Microsoft Excel skills. What if you have to complete another module? Thus, a course consisting of videos, magazines and assignments in which you will learn more Microsoft Excel skills.<br><br>Select the numbers below to state how you feel about performing this task (following an online course about Microsoft Excel). Please fill in your first instinct, try not to think too long about it. |
| Postquestionnaire game condition | You've played the game and learned about some basic skills of Microsoft Excel. What |

| | |
|---|---|
| | if you have to play another game similar to this one. Thus, a game in which you have to find ships and learn more skills of Microsoft Excel.<br><br>Select the numbers below to state how you feel about performing this task (playing the Microsoft Excel game). Please fill in your first instinct, try not to think too long about it. |

## Appendix D

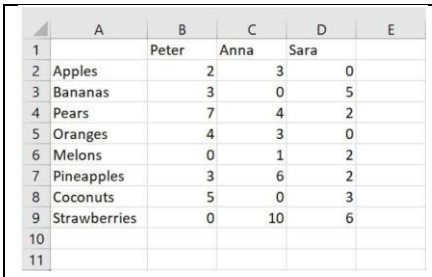
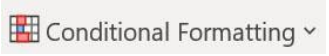
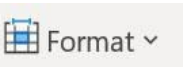
### Questions from test 1

| Item | Question type | Answer |
|---|---|---|
| 1. What function is used in Excel to calculate a total of cells with cell range B12 to B17? | Open | =SUM(B12:B17) or =SUM(B17:B12) or other versions of these answers with alternative capital use. |
| 2. Which button do you use to decrease the number of decimals? | MC | A.  C.  **B.**  D. None of the above |
| 3. What do you first have to do if you want to calculate how many days have passed between the payment due date of the rent and the actual payment date?   | MC | A. Change the date formats to "Time"<br>B. Change the date formats to "Short date"<br>**C. Change the date formats to "General"**<br>D. Change the date formats to "Accounting" |
| 4. How do you change a number to a fraction? | MC | **A. You use the therefore designated button**<br>B. You type it as a X/X format<br>C. You type it as a X.X format<br>D. None of the above |
| 5. Which sign do you add in a formula if you want to freeze a cell? | MC | A. !<br>B. #<br>**C. $**<br>D. None of the above |
| 6. How do you format a cell as dollars? | MC | **A. You select the 'Currency' button.**<br>B. You insert the '$' in front of the amount in the cell. |

| | | |
|---|---|---|
| | | C. You can't change the format of a cell to dollars.<br><br>D. You use the shortcut SHIFT + F4. |
| 7. What formula do you use to calculate the difference between cell F39 and cell F40? | Open | =F39-F40 or =F40-F39 or or other versions of these answers with alternative capital use. |
| 8. Where do you go if you want to look up a specific formula or function? | MC | A.  C.  <br><br>**B.**  D. None of the above |
| 9. What function do you use to calculate how many types of fruit Anna has bought?<br><br>  | Open | =COUNT(C2:C9) or =COUNT(C9:C2) or other versions of these answers with alternative capital use. |
| 10. What function do you use to round a number in cell B10 to three decimals? | Open | =ROUND(B10,3) or other versions of this answer with alternative capital use. |
| 11. What function do you use to calculate how many pieces of fruit Peter has bought?<br><br>  | Open | =SUM(B2:B9) or =SUM(B9:B2) or other versions of these answers with alternative capital use. |
| 12. What function do you use to calculate how many pieces of fruit Sara has bought on average? | Open | =AVERAGE(D2:D9) or =AVERAGE(D9:D2) or other versions of these answers with alternative capital use. |

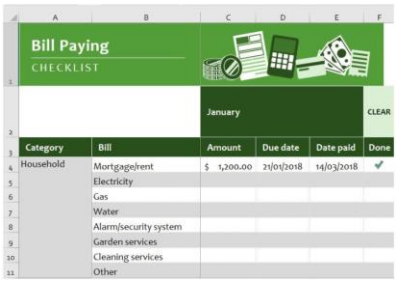
| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | | Peter | Anna | Sara | |
| 2 | Apples | 2 | 3 | 0 | |
| 3 | Bananas | 3 | 0 | 5 | |
| 4 | Pears | 7 | 4 | 2 | |
| 5 | Oranges | 4 | 3 | 0 | |
| 6 | Melons | 0 | 1 | 2 | |
| 7 | Pineapples | 3 | 6 | 2 | |
| 8 | Coconuts | 5 | 0 | 3 | |
| 9 | Strawberries | 0 | 10 | 6 | |
| 10 | | | | | |
| 11 | | | | | |

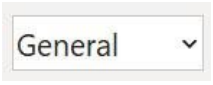
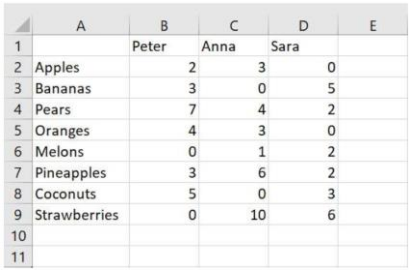
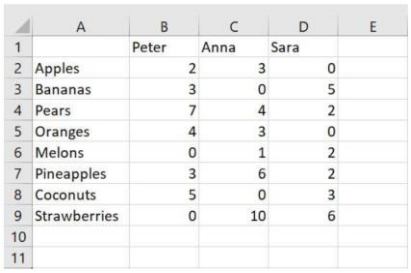
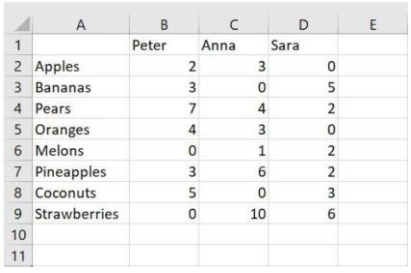

| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | | Peter | Anna | Sara | |
| 2 | Apples | 2 | 3 | 0 | |
| 3 | Bananas | 3 | 0 | 5 | |
| 4 | Pears | 7 | 4 | 2 | |
| 5 | Oranges | 4 | 3 | 0 | |
| 6 | Melons | 0 | 1 | 2 | |
| 7 | Pineapples | 3 | 6 | 2 | |
| 8 | Coconuts | 5 | 0 | 3 | |
| 9 | Strawberries | 0 | 10 | 6 | |
| 10 | | | | | |
| 11 | | | | | |

| | | |
|---|---|---|
|  | | |
| 13. Where do you go if you want to change the date format of a cell to a custom date? | MC | A.  <br>B.  <br>C.  <br>**D. None of the above** |
| 14. What function do you use to find the lowest value in cell range A2 to A15? | Open | =MIN(A2:A15) or =MIN(A15:A2) or other versions of these answers with alternative capital use. |
| 15. Which function do you use to find the highest value in cell range B2 to G2? | MC | A. =MAXIMUM(B2-G2)<br>B. =HIGH(B2:G2)<br>**C. =MAX(B2:G2)**<br>D. None of the above |
| 16. What formula do you use to add up cell A1 and cell C1? | Open | =A1+C1 or =C1+A1 or other versions of these answers with alternative capital use. |

## Appendix E

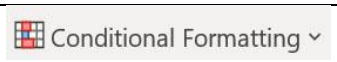
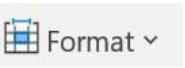
## Questions from test 2

| Item | Question type | Answer |
|---|---|---|
| 1. What function is used in Excel to calculate a total of cells with cell range A12 to F12? | Open | =SUM(A12:F12) or =SUM(F12:A12) or other versions of these answers with alternative capital use. |
| 2. What do you first have to do if you want to calculate how many days have passed between the payment due date of the rent and the actual payment date?<br>  <br> | MC | A. Change the date formats to "Time"<br>B. Change the date formats to "Short date"<br>**C. Change the date formats to "General"**<br>D. Change the date formats to "Accounting" |
| 3. Which button do you use to increase the number of decimals? | MC | **A.**  C.  <br>B.  D. None of the above |
| 4. Which sign do you add in a formula if you want to freeze a cell? | MC | A. !<br>B. #<br>**C. $**<br>D. None of the above |
| 5. How do you format a cell as euros? | MC | A. You can't change the format of a cell to euros<br>**B. You use the "Currency" button**<br>C. You insert a '€' in front of the amount in the cell.<br>D. You use the shortcut CTRL + ALT + E |
| 6. What formula do you use to calculate the difference between cell G23 and cell F23? | Open | =F23-G23 or =G23-F23 or other versions of these answers with alternative capital use. |

| | | |
|---|---|---|
| 7. Where do you go if you want to look up a specific formula or function? | MC | A.  C.  **B.**  D. None of the above |
| 8. What function do you use to calculate how many types of fruit Sara has bought?  | Open | =COUNT(D2:D9) or =COUNT(D9:D2) or other versions of these answers with alternative capital use. |
| 9. What function do you use to round a number in cell J5 to one decimal? | Open | =ROUND(J5,1) or other versions of this answer with alternative capital use. |
| 10. What function do you use to calculate how many pears are bought in total?  | Open | =SUM(B4:D4) or =SUM(D4:B4) or other versions of these answers with alternative capital use. |
| 11. What function do you use to calculate how many pieces of fruit Peter has bought on average?  | Open | =AVERAGE(B2:B9) or =AVERAGE(B9:B2) or other versions of these answers with alternative capital use. |



| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | | Peter | Anna | Sara | |
| 2 | Apples | 2 | 3 | 0 | |
| 3 | Bananas | 3 | 0 | 5 | |
| 4 | Pears | 7 | 4 | 2 | |
| 5 | Oranges | 4 | 3 | 0 | |
| 6 | Melons | 0 | 1 | 2 | |
| 7 | Pineapples | 3 | 6 | 2 | |
| 8 | Coconuts | 5 | 0 | 3 | |
| 9 | Strawberries | 0 | 10 | 6 | |
| 10 | | | | | |
| 11 | | | | | |

| | | |
|---|---|---|
| 12. Where do you go if you want to change the date format of a cell to a custom date? | MC | A.  <br>B.  <br>C.  <br>**D. None of the above** |
| 13. How do you change a number to a fraction? | MC | **A. You use the therefore designated button**<br>B. You type it as a X/X format<br>C. You type it as a X.X format<br>D. None of the above |
| 14. What function do you use to determine the highest value in cell range H1 to H10? | Open | =MAX(H1:H10) or =MAX(H10:H1) or other versions of these answers with alternative capital use. |
| 15. Which function do you use to determine the lowest value in cell range A9 to A18? | MC | A. =LOW(A9:A18)<br>B. =LOWEST(A9-A18)<br>**C. =MIN(A9:A18)**<br>D. None of the above |
| 16. What formula do you use to add up cell B5 to cell B9? | Open | =B5+B9 or =B9+B5 or other versions of these answers with alternative capital use. |

## Appendix F
## Informed consent traditional condition

You are being invited to participate in a research study titled Learning Excel through game-based learning for adults. This study is being done by Lena Wesselink from the Faculty of Behavioural, Management and Social Sciences at the University of Twente.

The purpose of this research study is to compare the effects of game-based learning to a traditional form of learning of adults. During the study you will complete two tests and two surveys. In between you will complete an online course about Microsoft Excel skills. Altogether the study will take you approximately 60 minutes to complete. The data will be used to compare the two variants of learning courses.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any question.

We believe there are no known risks associated with this research study; however, as with any online related activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by assigning you a participant number instead of using your name. Your name will not appear in any report or publication of the research. The results of the study will not show which answers you gave. Only the researcher will have access to your data and the data will be destroyed after the study.

If you have questions about the research in general or about your role in the study, please feel free to contact Lena Wesselink either by phone (+31626683595) or by e-mail (l.a.wesselink@student.utwente.nl).

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl

## Appendix G

## Informed consent game condition

You are being invited to participate in a research study titled Learning Excel through game-based learning for adults. This study is being done by Lena Wesselink from the Faculty of Behavioural, Management and Social Sciences at the University of Twente.

The purpose of this research study is to compare the effects of game-based learning to a "traditional" form of learning of adults. During the study you will complete two tests and two surveys. In between you will play an educational game about Microsoft Excel skills. Altogether the study will take you approximately 60 minutes to complete. The data will be used to compare the two variants of learning courses.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any question.

We believe there are no known risks associated with this research study; however, as with any online related activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by assigning you a participant number instead of using your name. Your name will not appear in any report or publication of the research. The results of the study will not show which answers you gave. Only the researcher will have access to your data and the data will be destroyed after the study.

If you have questions about the research in general or about your role in the study, please feel free to contact Lena Wesselink either by phone (+31626683595) or by e-mail (l.a.wesselink@student.utwente.nl).

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl